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Spatiotemporal Variations in Urban Air Quality of Lahore, Pakistan

Anchor Academic Publishing

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Shafiq, Muhammad, Yaqub, Fouzia, Younes, Isma: Spatiotemporal Variations in Urban Air Quality of Lahore, Pakistan, Hamburg, Anchor Academic Publishing 2016

Buch-ISBN: 978-3-95489-492-5
PDF-eBook-ISBN: 978-3-95489-992-0
Druck/Herstellung: Anchor Academic Publishing, Hamburg, 2016

Bibliografische Information der Deutschen Nationalbibliothek:
Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

Bibliographical Information of the German National Library:
The German National Library lists this publication in the German National Bibliography. Detailed bibliographic data can be found at: http://dnb.d-nb.de

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Hermannstal 119k, 22119 Hamburg
http://www.diplomica-verlag.de, Hamburg 2016
Printed in Germany

Preface

This study reports the air pollution vulnerability mapping of Lahore city and provides information about the vulnerability levels of air pollutants at various places of Lahore. The air quality monitoring activities have been carried out at five places of Lahore and each location is monitored for six air pollutants which are carbon monoxide, sulphur dioxide, nitrogen dioxide, hydrogen sulphide, ammonia and chlorine by a reagent absorption method. The sources and concentrations have been discussed. The data obtained from sampling at various commercial and residential sites is compared against the past year data and the comparison graphs are plotted to show the trend of these air pollutant. The spatial patterns of monthly mean precipitation and monthly mean temperature have been studied. A public survey has been conducted that shows the public awareness in regard to basic information regarding air pollution. In the end some conclusions and recommendations are given for the purpose to maintain a healthy environment for our citizens, support the strategies, to maintain energy independence and promote an effective role in formulating the environmental policies.

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Chapter 1:
Introduction

Air pollution is an increasingly important environmental problem in the world. Emissions of sulphur dioxide, nitrogen oxides and ammonia have been rising steadily over the past few decades.

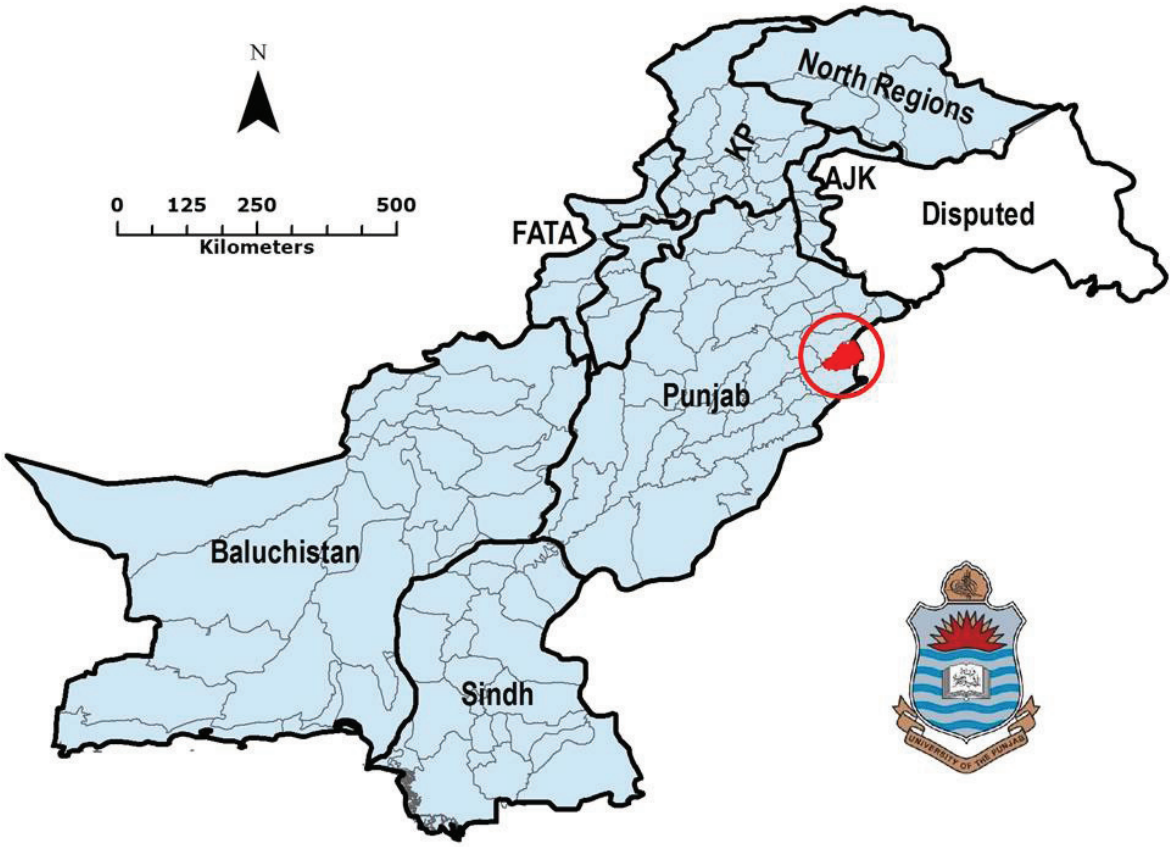

Figure 1.1: Location of the study area (Lahore City) is shown in red circle

Projections indicate that potentially large increases in emissions may occur during the next twenty to fifty years if current development patterns persist. If these occur, the impacts that have been experienced in Europe over this century will become increasingly prominent in large parts of Asia over the next century. As an initiative to facilitate the development of action plans, strategies and policies for pollution prevention and control, many countries are funding many programs on atmospheric and environmental issues in developing countries.

1.1 Study area

Lahore is a typical inland city of Pakistan. As shown in Figure 1.1, this land locked city is situated about 1100 kilometres away from the Arabian Sea.

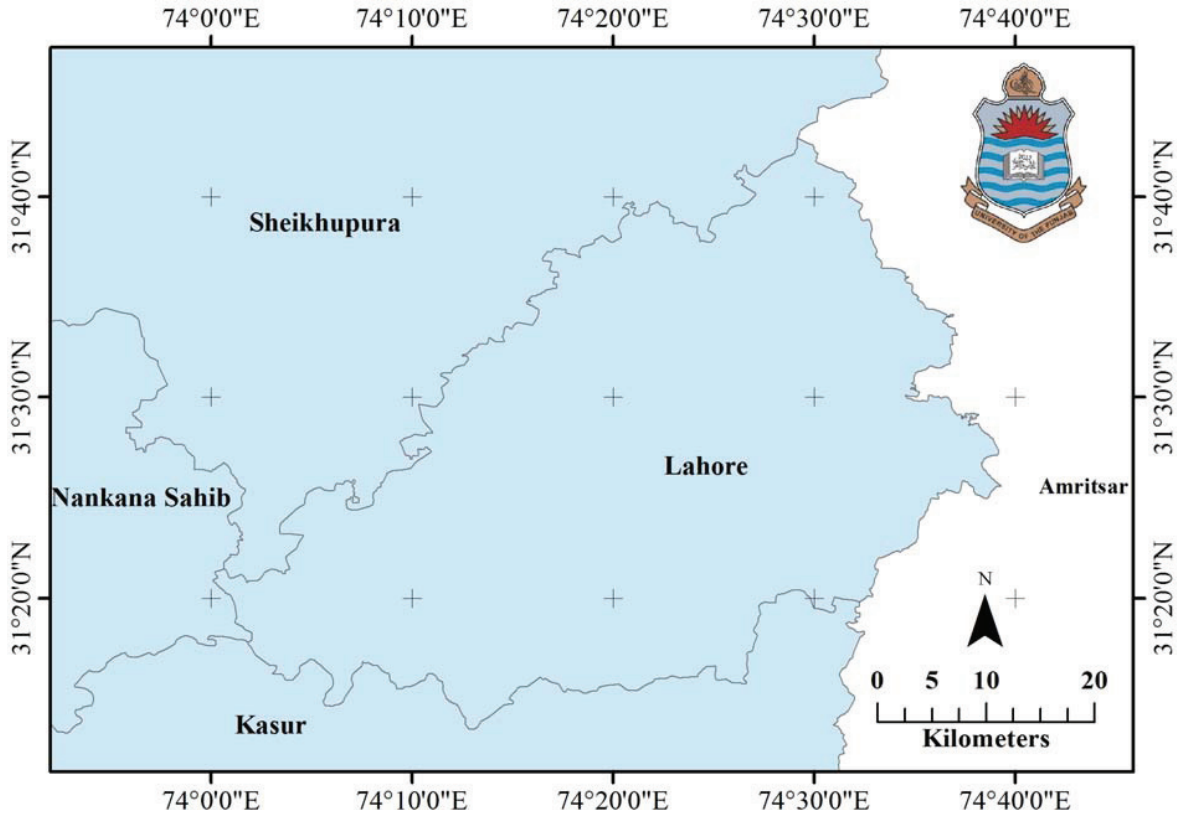

Figure 1.2: Geographical Location of Lahore City

The geographical location of Lahore is from 31° 13′ 28″ N to 31° 43′ 02″ N in latitude and 74° 00′ 00″ E to 74° 39′ 05″ N in longitude. Situated along the South bank of River Ravi, the city is bounded by Sheikhupura district in the North and Kasur District in the South. The east of Lahore city is the International Boundary Line separating Pakistani Punjab from Indian Punjab. The adjoining city on the Indian side is Amritsar (Ajnala, Tarn Taran and Patti) as shown in Figure 1.2. With a total area of 1,772 square kilometres, the Lahore city is the provincial capital of Punjab and its large area comprises of urban settlements as shown in Figure 1.3.

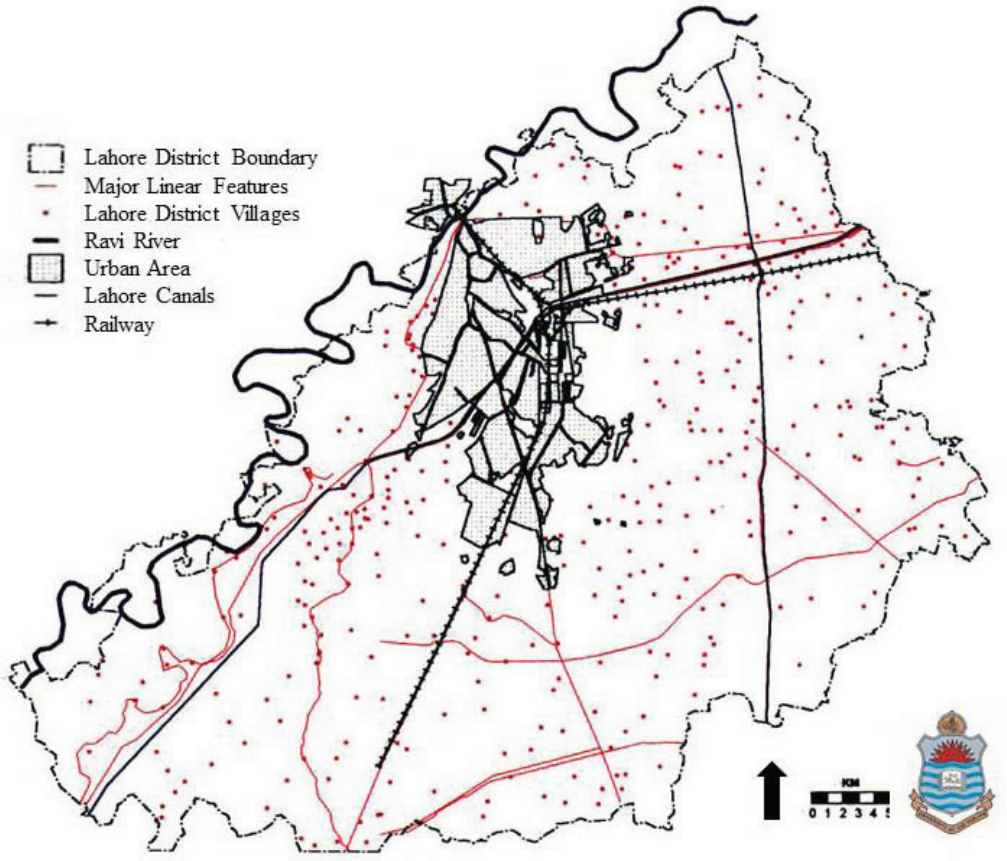

Figure 1.3: Urban area of Lahore district (Isma, 2000)

Lahore occupies a fertile alluvial plain formed by the deposits of the river Ravi and Sutlej and their tributaries. The river flows along the north-western boundary of

the city, and its seasonal floods have inhabited the city's growth towards the North and Northwest.

1.2 Climatological Conditions

Climatically, the city of Lahore experiences three seasons, cold, hot, and rainy. Winter season extends from mid-November to the mid-February. In this season the cold sunny days are alternated with cloudy rainy days. Rainy days are usually followed by clear days with frost at night in the countryside. Early morning and evening mist is also common.

The winter rain usually stops by the end of February but sometimes continue through March. The monsoon burst over Lahore sometimes in the mid of the June or the last week of the June. It usually results in the heavy downpour and the showers continue with the short intervals till September.

1.2.1 Spatial Patterns of Precipitation in the Punjab Province

Most of the rainfall in Lahore occurs in the monsoon months. The monsoons are at their peak in July. In the rainy season, it is pleasant, but during the day following rains, the still air, high temperature, and high humidity create a condition of extreme discomfort. On the average there is no month without rainfall in Lahore. The driest months are October and November, which together receive on an average 0.34 inches of the rainfall. From December to March is the season of winter rains, which the entire four months period receive 3.72 inches of rainfall an amount although meagre, but of great importance for its value to agriculture and the weather. April and May receive rainfall either through western disturbances or locally generated thunderstorms. May to October account for only about 25% of the annual rainfall. The remaining 75% takes place in the monsoon season.

The monsoons are at their peak during July and August. On the average July is the month of the maximum and November is of minimum rainfall. The most intensive recorded cloudburst in Lahore occurred on September 24, 1954 which about 9 inches rainfall in 24 hours. Such cloudbursts seriously affect the daily life of the city by flooding the low-lying areas due to inadequate drainage system. The heaviest rainfall on Lahore occurred in the 1882 when recorded 37.43 inches of rainfall was recorded. The driest year was 1899 when only 6.21 inches of rainfall.

Here the data from WorldClim database has been used to identify the estimates of the spatial patterns of precipitation in the Punjab province. As the WorldClim data grids are of 1 kilometres resolution, a small city may contain only a few pixels. In order to better visualize the patterns it is important to consider / map a larger area. Therefore, the precipitation maps have been prepared on the province level scale.

The WorldClim database is based on the data interpolated over the larger areas (near global) from obtained from the multiple weather stations (WMO) during the period 1960-90. The resampled SRTM digital elevation model data at a resolution of 1 kilometre has been used for spline interpolating the point data over the larger spatial surfaces.

Traditionally the units for the measurement of rainfall are mm (millimetre) which is the amount of rain per square meter in one hour. The amount of 1mm of rainfall means one litre of water in a square meter area. The unit used for the precipitation values here is in mm equivalent of rainfall.

The maps of rainfall in the Punjab province indicate heavy rainfalls in the northern part which is adjacent to the mountainous northern areas of Pakistan comprising of State of Azad Jammu and Kashmir (AJK), North West Frontier Province (NWFP), and Shumali Ilaqajat. The southern parts of Punjab receive very little rainfall.

The rainfall values presented here comprise of modelled data and may contain inaccuracies and/ or over-estimations. The values of monthly cumulative precipitation averaged for 1060-90 period (lowest and highest values of rainfall in the Punjab province) are summarized in the following table.

Month	**Monthly Rainfall (lowest value in Punjab) in mm**	**Monthly Rainfall (highest value in Punjab) in mm**
January	2	109
February	2	112
March	3	137
April	1	112
May	1	83
June	4	107
July	23	255
August	24	255
September	8	179
October	0	55
November	0	29
December	2	47

Table 1.1: Seasonal variation of precipitation in the Punjab province

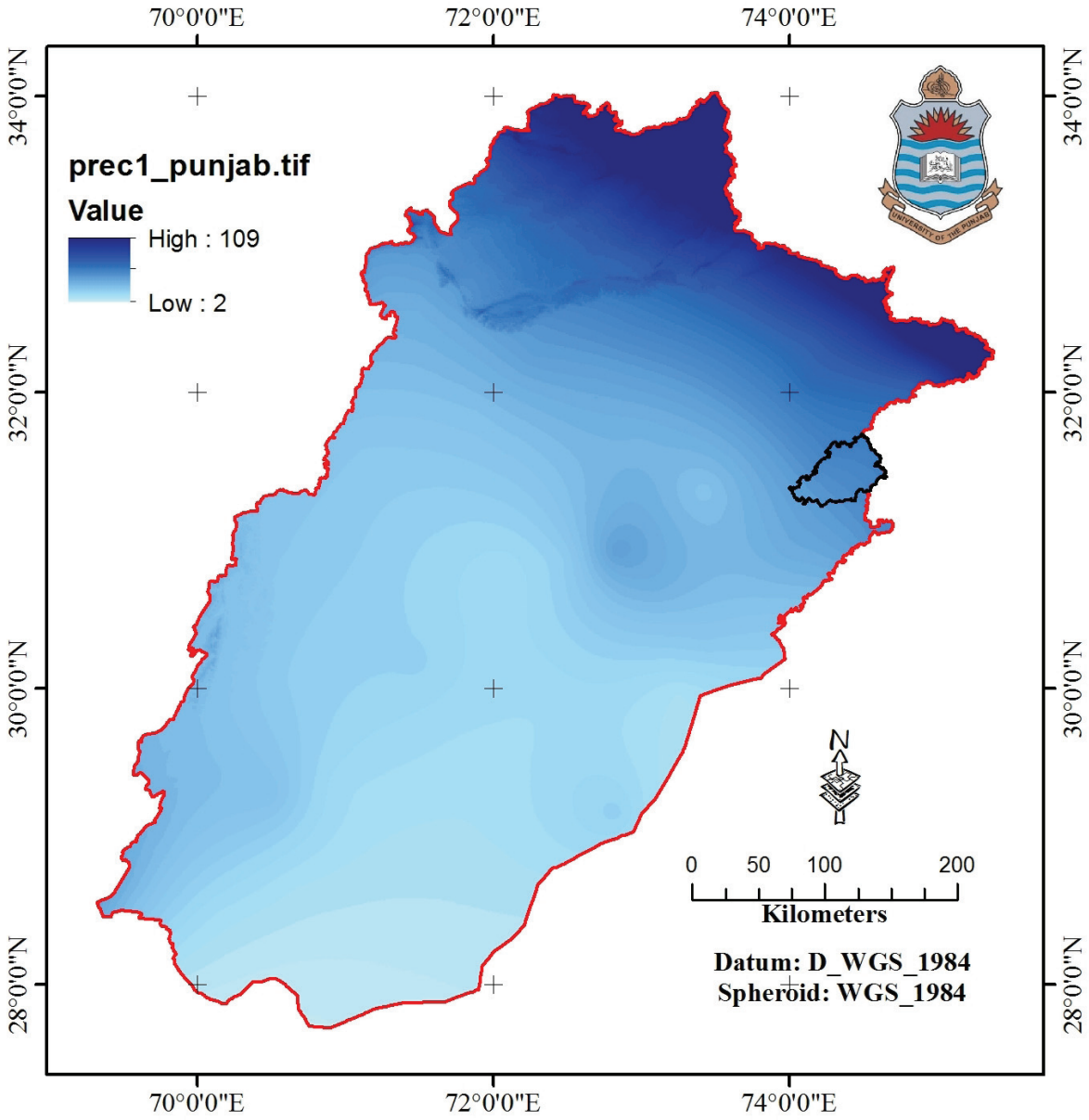

Figure 1.4: Spatial distribution of mean monthly precipitation (in mm) for the month of January for Punjab province

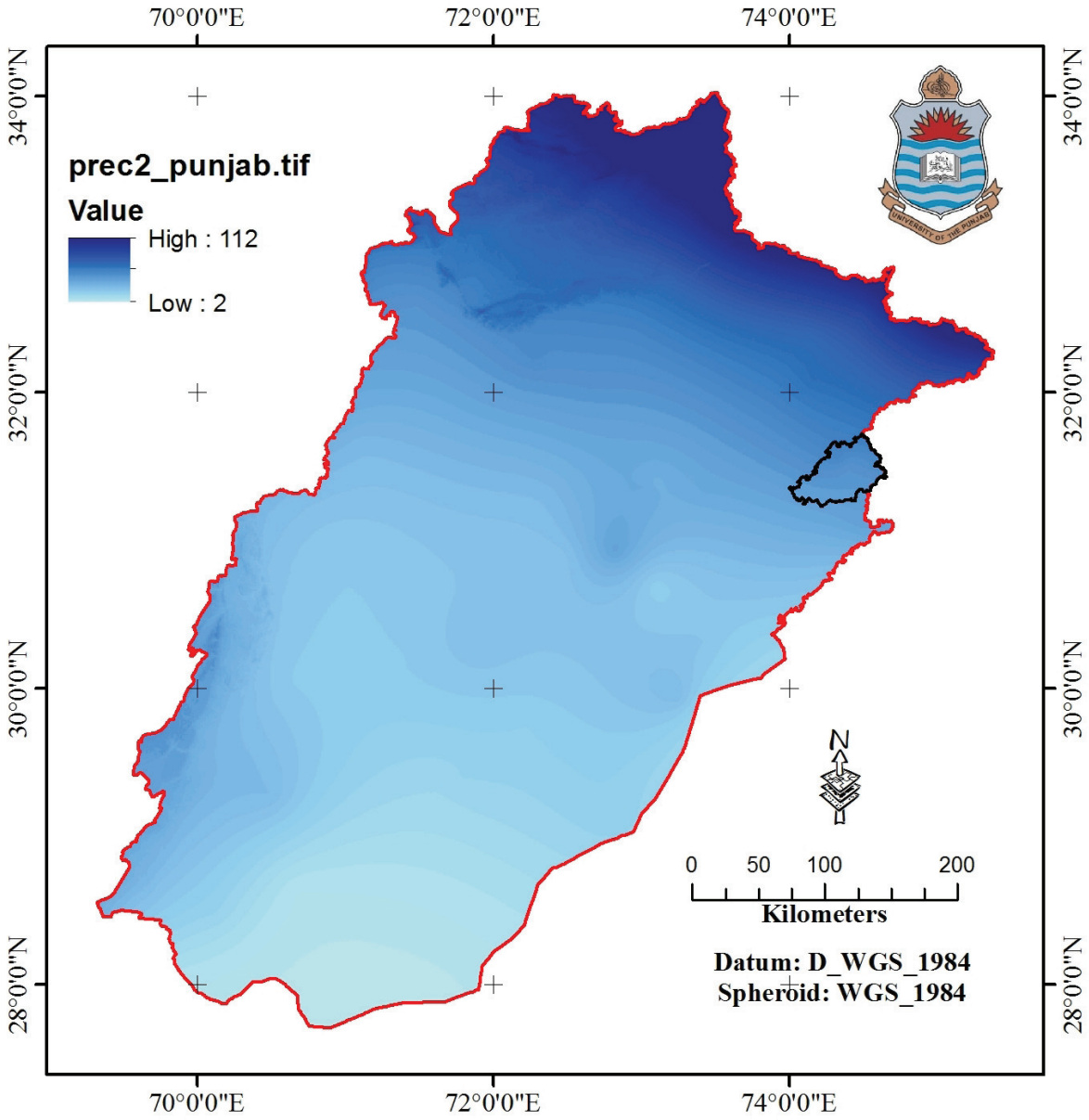

Figure 1.5: Spatial distribution of mean monthly precipitation (in mm) for the month of February for Punjab province

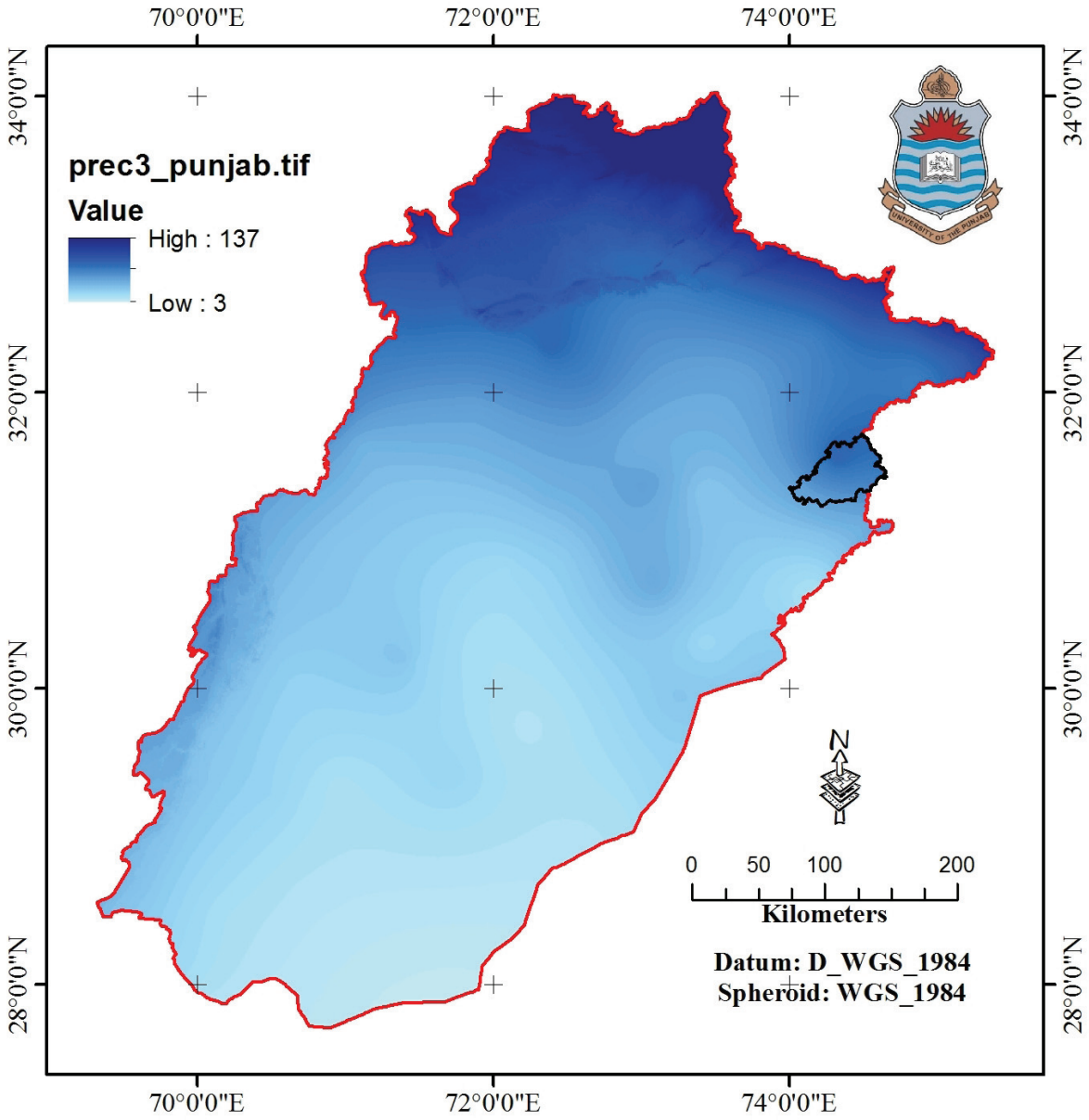

Figure 1.6: Spatial distribution of mean monthly precipitation (in mm) for the month of March for Punjab province