DECLARATION

I declare that, the thesis entitled '**A Study on the Impact of Environmental Degradation on River Behaviour in Jaldhaka- Duduya Watershed, Jalpaiguri District, West Bengal'** has been prepared by me, under the guidance of Dr. Subir Sarkar, Retired Professor, Department of Geography and Applied Geography, University of North Bengal, Raja Rammohanpur, District- Darjeeling, West Bengal.

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Certificate

This is to certify that **Smt. Sriparna Sarkar** has prepared the thesis entitled '**A Study on the Impact of Environmental Degradation on River Behaviour in Jaldhaka- Duduya Watershed, Jalpaiguri District, West Bengal'** for the award of Doctor of Philosophy (Ph. D.) degree in Geography and Applied Geography of University of North Bengal, and the thesis has been prepared based on the extensive field study.

It may further be mentioned that Smt. Sriparna Sarkar has fulfilled all other requirements as per the rules of the university regarding the submission of Ph. D. thesis.

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1 A STUDY ON THE IMPACT OF ENVIRONMENTAL DEGRADATION ON RIVER BEHAVIOUR IN JALDHAKA-DUDUYA WATERSHED, JALPAIGURI DISTRICT, WEST BENGAL A Thesis submitted to the University of North Bengal For the Award of Doctor of Philosophy In Geography & Applied Geography Submitted by: Smt. Sriparna Sarkar, Research Scholar, Department of

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Geography and Applied Geography, University of North Bengal Supervisor: Dr. Subir Sarkar, Professor, Department of Geography and Applied Geography, University of North Bengal 2

CHAPTER - I INTRODUCTION Earth, the only planet in the solar system has been bestowed with a very unique element, water, which is, perhaps, the most precious gift from Nature, since time immemorial. Water in different forms not only helps existence and sustenance of life on the planet, it also plays a vital role in maintaining the mobility of the rock cycle and the cycle of erosion of the different agents of erosion and in transforming and re- creating the different landforms on the surface of the earth. Global water circulated through the processes of evaporation, condensation and precipitation leads to runoff, which in turn, leads to origin of streams and rivers, which form vital agents of erosion, transporting sediment laden water from their respective places of origin to the hydrosphere, like blood vessels of a living body. The journey of a river from its source to its destination, the mouth, is marked by several smaller runoff channels combining to form a single channel of considerable width and depth, as well as, capacity to supply water and sediments to the stretch of area washed by the main river channel and its tributaries constructing and re-constructing a variety of landforms and playing important role in economic activities of humans and influencing growth and development of human civilizations all along their respective courses. Human civilization began with development of agriculture and permanent settlements along river valleys throughout the earth. With the expanding knowledge of utilization of fertile river valleys to serve the needs of the society, the degree and magnitude of human intervention is ever increasing, affecting the fragile balance between humans and the environment, leading to several interlinked problems, specially, in developing countries. Defining 'watershed'- Watershed in geomorphology has been defined as "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community (Powell, 1869)." Therefore, watershed indicates a drainage basin of any

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PREFACE

Watersheds, also termed ‘drainage basins’ by Powell, act as vital links between atmosphere, lithosphere and hydrosphere in controlling the global hydrologic cycle, being monitored by a chain of interlinked and pre-determined variables, ranging from stratigraphic to meteorological and biological factors of a region. Any natural or human-induced alteration or change of any of these factors affect the other factors, with considerable effects on water circulation of the whole watershed and ecological and the regional environment. While alteration or changes in determinants of tectonic stability and stratigraphic and meteorological factors are beyond human control, alterations or changes of other determinants are partially or largely controlled by anthropogenic interferences like different types of economic activities, which are unavoidable. The importance of the study lies in the fact that, such changes proceed towards affecting ecological balance and economic security of an area as a whole, in a country like India.

Throughout South East Asia, intensive agriculture has been the bastion of economy since the early days of civilization. While source regions and upper catchment areas of watersheds were left to grow tropical deciduous forests and grasslands, floodplains with easy access to irrigation water and fertile alluvial and loamy soils were the first choice for agricultural practices, making them thickly populated since time immemorial. The intermediate zone between the mountains and riverside plains were considered less suitable for agriculture and human habitation. So were the areas located at the margins of big rivers, due to their susceptibility to annual flooding and inundation during periods of continuous rainfall. These areas were, thus, left to grow sprawling forests, shrubs, grasslands or swamps and wetlands. The Himalayan foothills and piedmont zone, therefore, remained under dense forest cover, with thick shrubs and grasslands marking the rivers flowing across the area.

The situation has changed within the last two centuries in India, especially, in the Great Northern Plains, covering the northern, eastern and parts of north-eastern states. With progress of time, the forest cover of the Himalayan foothills and the adjoining piedmont and alluvial terraces was reduced. The unused land of the piedmont and adjoining alluvial terraces were reclaimed for extension of the profitable tea industry,

construction and extension of settlements and extension of modern transport facilities, vastly changing the prevailing land use pattern, letting loose a complicated chain of consequences, which would affect the fragile ecological balance of the region shortly. Socio-economic and ethno-political events within the Subcontinent led to increase of population with demographic transition or other reasons during the last two centuries, the excess population was pushed to the so long infertile and sparsely populated tracts, ranging from the higher slopes of the Himalayas, to the once densely forested piedmont and alluvial terrace region, known as *terai and duars* region.

The Himalayan piedmont and the adjoining alluvial terrace zone, also known as the *terai* and *duars zone*, situated between the Himalayan mountain range and the Great North Indian Plains acts as the buffer zone between two major physiographic zones of the subcontinent, in respect of geology, relief and climate on one hand and ecology on the other. The zone is more unstable compared to the riverine plains of Northern India, being situated at the fringe of the Himalayan mountain chain, in terms of tectonic stability and ecological balance.

The piedmont zone and adjoining zone, known as *terai* or *duars* in the eastern and north-eastern parts, bordering Bhutan, is separated from the Himalayas by series of active fault systems running parallel to the mountain chain in the north. The neo-tectonic disturbances in the Lesser Himalayan zone of Sikkim and Bhutan and adjoining distal fan surface of Sub- Himalayas, are reflected in the fluvial dynamics of rivers flowing through the region. Abrupt decrease of relief and slope at the base of the Himalayas causes rivers originating from the mountain to deposit their sediment load at the piedmont, creating alluvial fans at the base of the mountain range. A considerable part of the sediment load is deposited within the river channels, which leads to splitting of flow of the rivers into several parts, creating braided channel pattern in all the river channels. The rivers draining the south-facing slopes of Himalayas create complicated systems of braided channels in this zone, shifting their courses frequently.

The tropical monsoon climate of the Himalayas, with high annual rainfall, with occasional high to very high intensity rainfall, high relief and gradient, neo- tectonic instability, weak strata, all combine to produce high denudation rates throughout the

Himalayas. The foothills and piedmont zone, as well as, the adjacent alluvial terraces situated at the base of the mountains are affected by high denudation rates of the upstream courses, making the watersheds of the river catchments ecologically and environmentally vulnerable.

The Himalayan piedmont and adjacent alluvial terrace zone is vulnerable to several natural hazards like moderate to severe earthquakes, landslides and floods during monsoon. Because of its vulnerability to natural hazards, this zone has a fragile ecological balance, which is being increasingly violated since the last few decades. Population explosion in this area, mostly due to migration since 1950-s, pushed the excess population to forest margins and hitherto unused lands, leading to large scale land reclamation for grazing, agriculture, mining, road construction, construction of settlements. Construction of modern transportation facilities, urbanization and industrialization since the last two decades have further affected the fragile ecological balance, enhancing the already existing problems of slope failure and landslides in the upper catchment and increased flood occurrences and soil erosion in the middle and lower catchment.

In the present day world economic activities and correlated developmental processes take place within short time intervals, especially, in under developed or developing countries, where burgeoning population creates a perpetual pressure on land. To meet the constant demand of accommodating and feeding the constantly growing population land clearance, land reclamation and river regulation are inevitable. Intervention in processes of landform development in the tectonically unstable Sub-Himalayan North Bengal disturbs the delicate structure- process- stage balance of land- building process, and in turn, the prevailing equilibrium.

Sub- Himalayan Jalpaiguri and Alipurduar districts provide typical examples of Sub-Himalayan areas located at the transitional zone between the Himalayas and the riverine plains, with fragile ecological balance and prone to natural hazards mentioned above. The Jaldhaka- Duduya Watershed located at the heart of Sub- Himalayan Jalpaiguri and Alipurduar districts is an ideal place for examining nature of environmental degradation, its causes and impacts on river behavior. Although the selected study area forms a minor part of the Lower Brahmaputra Basin, it is located

between the watersheds of two major watersheds of the Basin, formed by the rivers Tista and Torsa. The Jaldhaka- Duduya Watershed, thus, shares characteristics of land degradation and river behavior in both Tista Basin and Torsa Basin. It provides the researchers to study the nature of environmental degradation, the influencing factors and nature of fluvial adjustments and behavior within a part of Lower Brahmaputra Basin, in miniature. Findings of this research project can be applied in planning sustainable land use, development, as well as, policy making for flood control and other problems like soil erosion in this area in future.

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