CHAPTER I

INTRODUCTION

1.1 General

Out of the four indispensable natural resources that sustain life - air, sunshine, soil and water - the first two are substantially beyond human influence and control. Soil and water may be amended by management to provide a better or worse environment for human beings. Man derives from the soil the basic materials required for his three basic needs - food, fibre and shelter. Water is called the main spring of life because all life is dependent upon a never failing supply of water. As blood is the life of the body, water is the life of earth, for both plant and animal life. Great nations and empires of the past have degenerated to poor nations of today because of improper management of soil and water resources (10). Cities and civilizations have vanished in the past as the result of deterioration of soil (51).

Soil erosion is divided into two major types - geologic erosion and accelerated erosion. Geologic erosion occurs when the soil is in its natural environment under the protective cover of native vegetation and hence sometimes referred to as natural erosion. It includes soil forming as well as soil eroding processes which maintain the soil in a favourable balance, suitable for the growth of most plants. Soil loss in excess of geologic erosion is called accelerated erosion. Accelerated erosion is normally associated with changes in natural cover or soil conditions and is caused primarily by water or wind. Water erosion, the removal of soil from the land's surface by running water, is the prevalent type of erosion in humid areas while wind erosion is common in arid regions.

Water erosion is subdivided into raindrop, sheet, rill, gully and stream channel erosion. Raindrop erosion is soil splash resulting from the impact of water drops directly on soil particles or on thin water surfaces. Rain water, which cannot soak into the soil and therefore flows over the land carries with it the fertilizer ingredients in solution and particles of soil and manure in suspension. Sheet erosion is the uniform removal of soil in thin layers from sloping land through overland flow. This starts in an insidious way skimming the surface uniformly. If the slope of the land is more, the moving water instead of flowing evenly tends to concentrate in depressions and develops erosive power and thereby cutting the field into small incisions called rills. When this is neglected the flowing water increases sufficiently in volume and velocity and makes deep cuts in the land which are called gullies. Ultimately the field is badly cut up resulting in such a form that it remains no longer fit for economic use (82). Soil erosion results in decreased agricultural productivity, stream pollution and reduced capacities and lives of water reservoirs (56).

The unjudicious use of land continued for centuries until man recognized the evils of erosion. He tried to learn about the causes of soil erosion and control. The cause for land deterioration is the exploitative nature of man. In our avarice we have recklessly expanded cultivation on hill slopes which should better remain under forest and grass. Heavy population of cattle, goats and sheep account for excessive and uncontrolled grazing which removes the protective cover on the soil and makes it vulnerable. Inspite of the recognition of the problem of soil erosion, no scientific approach to tackle it was reported until the fourth quarter of the nineteenth century, when Wollny, a German scientist, reported the first recorded studies on soil erosion in small plots (8). Since then the general trend of research in soil erosion due to water flow has followed the applied bias resulting in several empirical equations to predict soil loss.

1.2 Magnitude of Soil Erosion Problem in India

One of the principal reasons for low productivity in agriculture is the progressive deterioration of soil due to erosion. It has been estimated that in India about 81 million hectares of land out of the total geographical area of 326 million hectares suffer from soil erosion. Out of the net cultivated area of 135.8 million hectares in our country 56.7 million hectares are affected by soil erosion in varying degrees. Of these some 40 million hectares are in an advanced stage of deterioration that need prompt attention (101). It will not be possible to maintain yields of crops, much less to increase them, if the soil is allowed to be impoverished. History of mankind shows that survival of civilization depends on the productivity of soil. Effective steps, therefore, need to be taken to plan and undertake scientific soil and moisture conservation measures on a large scale. The urgency of a nationwide policy for dealing with various problems relating to soil conservation was emphasized in the First Five Year Plan and the Central Soil Conservation Board was established in 1953 to initiate, organize and coordinate research in soil and water conservation, to train personnel and to assist States in carrying out soil conservation programmes (100).

The Central Soil Conservation Board envisaged a phased programme of treatment of all eroded areas in India in course of next 25 years. By the end of First and Second Plan periods 1.1 million hectares of agricultural lands were brought under soil conservation treatment at a cost of Rs.221 millions. By the Third Five Year Plan, various regional problems needing immediate attention were listed and programmes were drawn up for tackling the problems on a more rational basis. One of the most significant development has been the appreciation of the problem of accelerated sedimentation of major multipurpose reservoirs, constructed in post independence period. Many more multipurpose reservoirs are in design stage to be constructed in coming years for augmenting irrigation potential of India by tapping various rivers which cut across inter-state boundaries. Most of the major multipurpose reservoirs constructed uptil now in various regions of India have been designed on the basis of sediment inflow into them to the tune of 3.52 hectare metres per hundred square kilometres. The sedimentation survey of a few major multipurpose reservoirs so far taken have indicated a rate of sediment deposition to the tune of 5.05, 9.86, 15.25, 18.8, 23.5 and 28.2 hectaremetres per 100 square kilometres for Bhakra, Panchet, Maithon, Mayurakshi, Tungabhadra and Chambal reservoirs respectively against the design rate of 3.52 hectare-metres per 100 square kilometres (65). The silting up of the reservoirs at a much higher rate than that envisaged in the original designs is due to the fact that with increase of population, land use in the catchment areas of the dams is fast changing towards a more unstable conservation picture. Biotic factors are threatening the orderly use of the land resources in the watersheds and such factors must be forecast and evaluated for any future dam planning (5).

It is estimated that 6 million hectares out of total area of 15 million hectares comprising the catchment in River Valley Project areas are in need of immediate soil conservation programmes. In high rainfall areas in River Valley Projects and elsewhere, the effect of conservation practices is required to be judged by the protection afforded in terms of reducing sediment outflow and contributing to increase in production of food and fibre depending on the capability of soils. The importance of reduction in sedimentation contribution of catchment areas need not be overemphasized and the problem can be tackled in a scientific footing only if the knowledge concerning the possible loss of soil from a cultivated field and the effect of conservation and cropping treatments on a quantitative basis are available. Land treatment to completely eliminate soil movement, though an ideal solution to prevent soil erosion, is impracticable. The reduction of soil erosion to a tolerable level by adoption of properly planned soil conservation measures should be the goal. The selection of such soil conservation practices demands a knowledge of the effect of causative factors such as soil, water, plants and topography on the resulting erosion. The soil loss prediction equation

$$A = R\ K\ \underline{LS}\ C\ P \qquad .. (1.1)$$

where A = average annual soil loss, t/ha

R = average annual rainfall erosion index, known as rainfall factor, 100 m-t-cm/ha-hr

K = soil erodibility factor, hr/100 m-cm

$\underline{LS}$ = topographic factor for length and steepness of slope, dimensionless

C = cropping management factor, dimensionless

and P = conservation practice factor, dimensionless

proposed by Wischmeier and Smith (111) in 1960 is by far the best equation to predict soil erosion due to rainfall.

1.3 Research Problem and Objectives

The equation demands properly evaluated values of the various factors listed in the equation. This information is available for all geographic locations in the U.S.A., but the values cannot be simply applied to India unless their applicability is established by properly planned and conducted investigations on similar lines. The urgency of the need of such information was strongly felt and the problem " Some Aspects of Soil Erosion Due to Rainfall " was undertaken at the Agricultural Engineering Department, Indian Institute of Technology, Kharagpur with the following objectives :

1) to evaluate the rainfall erosion index for Kharagpur;
2) to evaluate the cropping management factors for cowpea (*Vigna sinensis*), paddy (*Oryza sativa*), maize (*Zea mays*), pigeon pea or arhar (*Cajanus cajan*) and dub (*Cynodon dactylon*); and
3) to study the characteristics of individual rain storms affecting soil erosion so as to suggest a workable method to predict soil erosion from the knowledge of rainfall information alone, if possible.

The need for proper information on the effectiveness of various cropping management factors need not be overemphasized. Also the evaluation of rainfall erosion index is of fundamental importance as far as soil loss prediction is concerned. If a suitable method could be found to predict soil erosion from rainfall characteristics alone expensive and time consuming procedures like runoff plot studies can be dispensed with.

1.4 Procedures

Automatic raingauge charts available in the Department of Agricultural Engineering for a period of 15 years (1956-1970) were analysed for various rainfall characteristics. Experiments for the evaluation of cropping-management factors have been conducted over a period of 5 years on seventeen runoff plots of 25 m to 60 m lengths on 2 to 5 per cent slopes. Statistical procedures like analysis of variance, correlation analysis and multiple regression analysis have been performed using Digital Computer, IBM-1620.

High rainfall intensities were found to occur demanding the provision of high hydraulic capacity of soil conservation structures. Rainstorms each contributing 50 mm of rainfall or more are found to account for about 50 per cent of total soil loss. No direct relationship was observed between annual rainfall and erosion index. Among the crops studied, dub grass provided the maximum and maize provided the minimum protection. Any of the five erosion indices can explain about 70 per cent variation in annual soil loss.

The need for assembling of rainfall and soil loss data, available with agencies like India Meteorological

Department and Central Soil Conservation Board, at places where computational facilities and expertise are available to obtain rainfall intensity duration frequency curves and factors in soil loss prediction equation for various geographic locations in India is stressed.

The results of this research are intended primarily to serve as a model for similar research at other places in India so that conservation farm planning can be affected on a scientific basis.