PROLOGUE
Human maladies have been a matter of universal concern in all times of history and have attracted the attention of both the specialists and non-specialists alike. Health and disease having direct influence on man's capacity to work have always been regarded as a relevant subject of study in the field of geography.

CONCEPT OF HEALTH AND DISEASE IN GEOGRAPHICAL RESEARCH

Geography in the realm of knowledge actually holds a central position and is treated as mother of sciences. This subject has to deal with such a wide variety of phenomena that it contains many specialism with divergent interests. It is concerned with the "causal relationships existing in the complex of heterogenous phenomena at one place and the causal connections among phenomena at different places".\(^1\) Owing to the development of these processes the face of earth is marked off into distinctive areas and as a result geography seeks to interpret the significance of likeness and differences among places in terms of causes and consequences. But the distinction between natural and human phenomena is not easy to make. And often it has been argued that geography makes no such distinction, and thus it bridges the gap between the physical and social sciences.

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As man's understanding of the world increased, it enormously increased mankind's collective range of understanding both to theoretical and practical side of knowledge and with the help of expanding spheres of our scientific vision more and more attention was given to systematic studies. So many fields of learning which start with observations of the actual face of the earth turned to the study of specific processes wherever they might be located. These new disciplines were defined by the subject they investigated. There also arose conditions where increasingly many academic specializations have enhanced the chances for overlapping fields of study. It is on this interdisciplinary ground lies the common knowledge and interest between geography and medicine which is widely known as 'Medical Geography'.

An awareness of the so-called medical geography of today is traceable even amongst the early geographers. The connection between the environment in which we live and the disease from which we suffer has been studied since the time of Hippocrates. But such studies have shown many weaknesses in their approach and this weakness also explains the sporadic nature of the enthusiasm for the medico-geographical study.

Medicine in common with other sciences has developed through increasingly perfected methods of observations. Therefore in the early writings we often find the purely speculative considerations of the relation of disease to supernatural agencies, the association of medicine with
religion, the concurrence of epidemics and planetary commotions and not yet the purely metaphysical concepts of humoral changes and balances conceived by the earliest physicians. But the recent progress in chemistry and physics has invited our attention to examine the causes of biochemical disorders that are the result of disease. It gave birth to the concept that disease is a multiple phenomenon which occurs only if various factors coincide in time and space. The present-day understanding of the nature and causation of disease may be attributed particularly to the building up of two additional groups of facts, namely, the detection and appreciation of changes in diseased bodies and tissues, and demonstration of the existence of external animate agents of the disease. These basic facts have necessitated to demonstrate a relationship between the various factors of this complex phenomenon and their relationship with geographical factors, generally termed as "pathogens" and "geogens". The research conditions and related analysis in this field of geography could be based principally on the study of the relationship between the former and latter type of factors found in a region.

May (1950)\(^2\) has categorically explained that the environmental stimuli have enormous and profound effect on

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human body and duly force it to seek and reseek a proper adjustment and equilibrium with them. As these stimuli generally emanate from pathological and geographical factors, they have definite scope for the study in the field of geography. It is in this context that the modern connotation of Medical geography has basically emerged to express the principal idea of the "geography of health and disease".

The health of man is being studied geographically and often viewed ecologically whereby focussing attention on ecosystem problem in association with physical, chemical, biological, socio-psychic aspects and in full regard to multifactorial analysis of diseases. Because in reality all the aspects of this natural world which affects human life is essentially inclusive in geographical environment and can profitably be studied as it is composed of numerous diversities.

In this total system, the human environment forms a bio-sphere, where sun is tremendously active to process and form energy and form soil blocks with different chemical through water and air. The segregation of man is impossible from this bio-sphere, as he is a principal of this totality, the air he breaths, the water and food he assimilates and sun rays he enjoys, and they all together tie him to immediate bio-physical environment. Hence to be sure, the environment does not mean only the physical conditions of any
particular geographical location but it connotes the totality of the environment as: 1) the physical environment, 2) the biological environment, and 3) socio-cultural environment. In these environments numerous factors are operative which affect human life in different ways and are included invariably. All these aspects and many elements in the existing physical world are studied geographically and thus the diversities of the marked phenomena of this universe in varying magnitude are located from place to place and from time to time. In this respect medical geography seeks a rational and systematic analysis of the disease incidence and related etiology of the disease causing factors in the regional perspective of physico-cultural environment of man. The present work attempts to organise and carry out within broad conceptual framework of Medical Geography. It fairly considers the general concept of disease and medical problems as defined by May and American Geographical Society. There also Stamp, McGlashan, Park, and Learmonth, have done commendable work on the geography of health and disease.

3 May, J.M. (1950), ibid., p.10.
MEDICAL KNOWLEDGE AND HEALTH DISEASE MANIFESTATIONS

In studies of health and ill-health ultimate factor is biology, therefore social determinants are decisive in much of the mortality. The social and cultural side of geographical analysis is most difficult part to be interpreted clearly on areal pattern because the interpretation of one cause or the other remains sometimes as unknown determinant. The environmental stimuli and their implications for human beings are enormous. Human body constantly seeks proper adjustment and equilibrium between external environment and internal forces causing maladjustment to their health. Thus, good health implies two things: that human body operates efficiently in repairing the tissues, and that body enjoys a high level of energy. So the experience of feeling healthy remains endowed in vital functions of being physically and mentally well to express full range of his potentialities. It can be achieved through complete elimination of disease and less painful existence in an imperfect world where human beings are coped with numerous ills and odds of natural environment to achieve the goal of an ideal health. Therefore, the concept of degree of health makes up a continuum from the deal of a absolute physical, mental and social well-being through variations of diseasedness to death.
(a) The Concept of Disease

Basically disease is a negative concept in the sense that it refers to a disorder or want of health in body as well as in mind. The derangement or disturbance in the normal functioning of the body, its organs or the mind results from a well defined process known as disease. This process comprises fundamentally in two phases - pre-pathogenesis and pathogenesis. The former refers to the preliminary onset of the disease in which man is not actually but only potentially involved. This phase is ecologically brought about by the combined action of three factors namely, the agent, the host and the environment. Ecologically these factors form what is known as epidemiological triad. Under optimal conditions normal interaction may guarantee health, while some interaction between the agent, host and environment results in disease that ranges from single isolated case to epidemic shown in Fig.1 and 1-A.

The latter phase begins with the entry of the disease agent into the human host. A certain period of time elapses between the entry of disease agent and onset of clinical signs and symptoms, that is called the incubation period which varies from one disease to another. The patient

8 ibid., p.12.
EPIDEMIOLOGICAL TRIAD

AGENT

HOST

ENVIRONMENT

DISEASE


FIG. 1
THE EPIDEMIOLOGICAL TRIAD

IT SHOWS RELATIONS BETWEEN VIRUS GROWTH PROCESS, POPULATION IMMUNITY PROCESS AND INFECTING PROCESSES

FROM: A.A. BROWNLEA'S THEORETICAL MODEL WHICH ENVISAGES AN OPEN SYSTEM OF FRAMEWORK IDENTIFYING GENERAL PROPERTIES WITHIN IT

FIG. 1-A
during the incubation period may remain apparently healthy and ambulent but he is not free from tissue and physiological changes which occur during the incubation period. These changes are sub-clinical, i.e., it is difficult to recognise them by the usual method of diagnosis. After the period of incubation, the signs and symptoms of disease begin to appear indicating that the patient is sick. This process ultimately ends in either complete recovery from the disease or the chronicity of the ailments, disability or death of the patient. These events in the natural history of disease are shown in Fig.2.

(b) Epidemiological Triad

Epidemiology deals with the occurrence and distribution of disease among different population groups and it is mainly concerned with the study of the origin and course of disease. It lays much emphasis upon the relationship between environmental factors and disease. In general, three main set of interacting factors form the focus of the epidemiological interest.\(^9\) (1) the host or human individual varying in genetic resistance, susceptibility and degree of immunity to the disease; (2) the agent, or carrier of the disease, including any adverse process, whether

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it be an excess, deficiency, or interference of a microbial, toxic or metabolic factor, and varying according to ineffectivity, virulence and pathogenesis; and (3) the environment, or surrounding medium, social as well as physical, which affects both the susceptibility of the host, the virulence of the agent or disease process, and the quantity and quality of contact between host and agent. These three sets of factors do not exist in any simple one-to-one relationship but maintain a complex, ever-changing balance. The occurrence of disease especially mass disease, is the result of a multiplicity of casual factors, each of which contribute to, rather than accounts for, the appearance of the disease.

Thus, alongwith the main characteristics of the host, the elements of the physical environment, such as terrain, climate, fauna and flora also play substantial role in the natural history of disease. The observable regional variations in the nature and distribution of disease, too, may be found to be appreciably attributed to the variations in the components of physical environment. The geographical study of disease is, therefore, basically structured on the regional analysis of the role of the characteristics of the host and the elements of the physical environment on their incidence and distribution.
(c) Classification of Diseases

Diseases may be classified in various ways. But in this regard, it is generally accepted to make a true distinction between acute and chronic diseases, between infectious and degenerative diseases and between malignant and non-malignant disease. Nonetheless, among the various sets of classification of disease, we find universal acceptance only to non-communicable and communicable set of diseases. Among the various classes of diseases, however, the one set which is of direct relevance to the present work is concerned with the communicable diseases.

(d) Communicable Disease

The communicable diseases are generally regarded those, which pass from a sick person to a healthy person, are carried by tiny living things called micro-organisms or germs. These micro-organisms may be present in the blood, faces, urine, and nose and throat discharge of the persons suffering from communicable diseases. The organism may enter the body through the mouth, nose or wounds and cuts. Living germs transmitted from person to person, directly or indirectly are thus known to be the immediate cause of the principal killing diseases and as such bacteria producing most of the major diseases are commonly accepted, mosquitoes and other animal vectors are being recognised fully. Therefore "food contaminated by disease carrier or flies is an important source of infection. Water that contains untreated sewage
can cause epidemics of intestinal and virus diseases. Insect or larger animals can also transmit many kinds of diseases by biting. Fleas that have fed on the bodies of infected animals, chiefly rats can spread bubonic plague.10

The occurrence of a contagious disease in an individual is dependent on a number of factors, chief among which are the chance and frequency of exposures, the virulence among the disease producing microbes, the resistance or immunity of the individuals and the proficiency of public health and hygienic services.11 Epidemics may result from lack of protective measures by public health and other authorities or because of immunity among a large number of people.

(e) Specific Diseases

The agents of the diseases like cholera, typhoid, and dysentery include bacteria, viruses, protozoa and intestinal worms. These parasites enter the mouths of human beings with food and drink and infect any person of the intestinal canal and their progeny are discharged with the body wastes and may contaminate food, water, or fingers to

continue the cycle of infection, control of their spread requires adequate sanitary disposal of body wastes.

Of these diseases cholera, which is spread chiefly by drinking water, has often been of dramatic impact. Dysentery, which caused by a bacteria similar to the typhoid bacillus, has also dramatically declined, particularly among infants and young children, for whom it was once the principal cause of death. Amoebic dysentery, which is due to protozoa or parasite transmitted directly or through contaminated food, is probably more common than is recognised, because it generally may cause little discomfort though at times it produces an acute illness.

The agent of smallpox is the virola Borrelliota variolae. Smallpox varies from a mild disease (viriola minor), to a sever condition (variola major), having highly large fatality. This disease gradually passes through stages of macule, papule, resicle and pastule, forms crusts and, finally, scabs that fall off at about the end of the third week. This disease is highly dreaded and fatal as it has large capability to kill and create highly disabled conditions.

Malaria, probably still the commonest infectious disease on widespread basis is transmitted by the bite of anapheline mosquitoe.

Diseases spread from person to person are largely those through mouth and nose. Microbes or micro-parasites which enter the body through the mouth and nose inflict the person with the disease. Among the best known are the bacteria which cause scarlet fever, diphtheria, whooping cough, pneumonia, tuberculosis and cerebrospinal meningitis. The causative bacteria are rapidly transmitted from person to person but the characteristics of offending agent and the individual resistance determine whether an exposed person becomes ill, or carries the germ without being sick or quickly loses the infection. Other diseases of this group are caused by viruses and include in the class of smallpox is generally under control due to vaccinations but this method is not applied to chickenpox, mumps and measles, which are still major cause of illness among children. Influenza still occurs in periodic epidemics among all ages.

The actual mechanism of the transfer of the infectious agent from sick to the healthy is not always clear and varies from disease to disease. It is commonly considered that it may occur either by direct contact of touching with fingers or lips or by the inhalation of airborne particles.¹³

These may be either droplets of secretions from the throat, nose or mouth or dust from the clothes, floor or bedding to which the offending microbe is attached.

CONCEPT OF HEALTH

Health is often taken for granted and its value is not fully appreciated until it is lost. In fact health is not merely a precious possession, but also a "resource" in which the whole community has a stake and which it is desirable to maintain and promote. The maintenance of health is, therefore, as much a social and state obligation as it is a personal concern. Health is defined to be a "a state of complete physical, mental and social well-being, and it is "not merely an absence of disease and infirmity". Yet it needs no saying that disease is the strongest indicator of temporary or long continued state of disturbed health. It then obviously follows that prevention of disease is the surest way to ward-off health from impairment. The prevention may be effectively achieved through eradication of or control over disease causing factors.

Such factors are always inherent in the environment but their identification is not always easy. Nevertheless,

the identification is an essential pre-requisite for their eradication. Geographers, being essentially concerned with relationships, therefore prefer to adopt ecological approach which emphasises the health as a state of dynamic equilibrium or adjustment between man and his environment. One can think of this graphically as a balanced scale with the pans representing the agent and human host and the fulcrum, the environment and health as a state of equilibrium between the disease agent and the human host. When this balance is disturbed for any reason, ill health results. It is the study of 'Man in the midst of disease' rather than of 'the disease in man' which forms the main thrust of geographical analysis of diseases. Rene Dubos says that "as new ways of living have been developed by man, new ecological systems, including pathogens have been formed. Urbanization, industrialization and other patterns of social organisation all have their effect upon the composition of ecological system", (Fig.3).

THE REGION AND RESEARCH METHODOLOGY

The Study Area and Selected Diseases

For the regional analysis of infectious diseases the Ganga-Yamuna Doab has been selected. The high density

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PANS AND fulcrum representing
health and disease conditions

Fig. 3
of population, notable variations in socio-cultural cross sections and historical evidences of repeated outbreaks of certain communicable diseases both endemically and epidemically are the salient features of the Doab, which have led to the selection of this region for the work of geographic investigation of the role of social and environmental factors in the incidence of communicable diseases. It needs no saying that in a time bound single man's effort it is almost impossible to study all the communicable diseases which visit the Doab or its different parts. Consequently for the purposes of the present study only the major diseases of the communicable category, namely, cholera, smallpox, malaria, dysentery, diarrhoea and tuberculosis have been selected.

Sickness and Mortality Conditions in the Doab

Despite a large rising toll of mortality, the vast majority of the Doab's population still have no access to descent health. The overview of health situations in the region shows the magnitude of sickness and resultant deaths in the form of mortality for both sexes. At present it is found that the general mortality in the Doab is 16.33 per 10017 as against about 14.21 per thousand in the country. The life expectancy at birth is estimated to be 57.6 for

17 Source: Calculations are based on the Statistics available from Director of Medical and Health Services, Uttar Pradesh, Lucknow,
males and 56.3 for females while corresponding figures for the country are about 57.3 and 56.0 respectively. Infant mortality in the Doab is estimated to be 125 per 1000 live birth but the same is estimated to be 122 per 100 live births in India. Mortality in the age group 1-4 is around 35 per 100 as against 30 per 1000 in India.\footnote{18}

Information on causes of death is very scanty and incomplete. However, record show that infective and parasitic diseases account for 16 to 25 per cent deaths in the region. Among all selective causes of deaths in the Doab, sex-wise mortality from five selected diseases is as follows: from cholera about 0.47 males and 0.45 females; from smallpox about 0.41 males and 0.38 females; from malaria 12.97 males and 11.10 females; from dysentery and diarrhoea 2.03 males and 1.71 per cent females; and tuberculosis mortality 5.99 males and 4.32 per cent females; whereas the proportion of deaths in the remaining causes for both male and female was 32.81 and 27.39 per cent in the total male and female deaths in the Doab during 1971 and 1981.\footnote{19}

Health Facilities

The health standard and available facilities in the region in 1981 were so poor that there were only about 3.3

\begin{itemize}
  \item \footnote{18} Park, J.E. and K. Park, Op. Cit (1980), pp.10-20
  \item \footnote{19} Director of Medical and Health Services, U.P. Lucknow, 1984-85.
\end{itemize}
doctors per 100,000 population, whereas available number of nurses per hundred thousand persons was about 6.3. Similarly hospitals were available in the ratio of 2.5 per 100,000 and bed ratio was nearly 55 per 100,000 population in the above mentioned period. As against this the bed population ratio in India was about 61 per 100,000 population.

The basic requirements for health promotion such as safe drinking water and excreta disposal are lacking in almost every district of the Doab. About 98 per cent of the rural population use the open fields for defecation. The attention of the Government is still lacking in the field of health services, as the total expenditure on primary health needs are between 3 to 4 per cent of the total expenditure incurred.

TECHNIQUES OF ANALYSIS

Appropriate operational techniques fall under two heads: multivariate regionalisation and factorial ecology. The methodology of multivariate regionalisation has developed and spread rapidly after the publication of Ginsburg's Atlas of Economic Development. Many an earlier attempt has employed simple additive techniques involving ranking and

classification of indicators according to some theoretically
determined criteria. Later this methodology was modified
under 'social indicators' approach that reacted sharply to the
overemphasis on economic criteria as the measure of human well-being. As a result, more and more social
indicators have been incorporated in the regional analysis of
the development. Since the relationship among these varied
indicators of development have become uncertain by now, procedures of standardisation have been adopted so that
transformation of indicators may entail their addition into various categories of the development.

Factorial ecology employs a variety of mathematically
vigorous methods of factor analysis to reduce a large number of socio-economic and environmental indicators into a few
underlying dimensions. Unlike the methodology of multivariate regionalisation and social area analysis which structure
variables according to some theoretical constructs, it allows the constructs to emerge from the interrelations of the
variables themselves. It starts with the matrix of inter-
correlations of original variables from which such a set of smaller number of variables is derived that reproduce original relationships with the restriction that derived variables are independent (orthogonal) of each other. By combining standardised original variables and their loadings on computed
variables (factors), original variables may be aggregated
to exhibit regional distribution of the new variables.

The methods of classification of variables into
major dimensions in the two traditions have their relative
advantages. These methods provide lengthy solutions to the
problem. This problem is, therefore, largely solved by the
factor analysis because the loadings of variables on a
factor (category) are their weights which are derived from
their factual interrelationships. But factor analysis
procedure starts with a solution which is not mathematically
unique. Therefore, there is no assurance that factors
obtained would conform with the theoretically relevant or
most important aspects of the reality. Generally, apart
from the first factor that is understood as an overall index,
all other factors remain uninterpretable. Hence, factors
are subjected to rotation to some theoretical criteria to
make factor structure more interpretable.

Under present circumstances this study has employed
the technique of factor analysis to derive 'meanings' from
virtually 'unstructured' variables. Besides this, linear and

23 Gould, R.P., "On the Geographical Interpretation
of Eigenvalues, Transactions of Institute
of British Geographers, Vol.42, 1967,
pp.53-86.

24 Ress, P.H., "Factorial Ecology: Extended Definition
Survey, and Critique of the Field; Economic
multiple regression technique has also been employed for
the explanatory analysis of the incidence and distribution
of selected diseases on the basis of the selected 22-variables.

OBJECTIVES AND METHODOLOGY

The principal aim of the present research project
is to compute and examine the correlations between the
incidence and distribution of the selected diseases and the
physical and socio-cultural environment in the Doab, and
thereby identify the relatively disease prone and disease-free
areas of this region. In order to achieve this objective
it is proposed to devide the region into sub-regions on the
basis of indices of correlations. Though there is a large
variety of factors which is involved in the incidence of
diseases, but in the context of present research only the
geographic and socio-economic factors will be invoked for the
determination of correlation coefficients. Both the single
and multiple variable correlations will be used for
regionalization and the regions so obtained would form the
basis for the final synthesis leading to the assessment of
spatial behaviour of diseases and indicate certain conclusions
and suggestions.

DATA ANALYSIS

Extensive use of computer and well established
programme packages is, however, indispensible in the application
of Factor Analysis and Linear Multiple Regression Techniques. In the present study the sub-routine package (SSP) in FORTRAN-IV programming language has been used. All these computations have been made on the VAX-11/780 computer system of DIGITAL Corporation, the U.S.A., installed at Aligarh Muslim University Computer Centre. For these computations raw-data was transformed into different suitable and appropriate indices so as to suit the requirements of health and disease study at required level in the study area.

Data Collection Method

The writer has collected some relevant data for the purpose of study of health and diseases from the Government Agencies and Special Departments authorized to keep periodical records and publish such important statistics very regularly.

1) The data about health: These causes of deaths are categorically defined as i) cholera, ii) smallpox, iii) fevers, iv) dysentery and diarrhoea and v) respiratory diseases.

2) Meteorological and climate data have been taken from the yearly records and memoris of the Indian Meteorological Department, New Delhi.

3) Statistical information about food situations in the Doab districts have been obtained from the Agricultural Statistics Department, Lucknow and also from District Agricultural Department Office, Aligarh (U.P.). The data collected in this connection pertain to cultivated areas,
arable and non-arable lands, irrigation facilities, size and type of holdings, production and yield of crops, particularly food crops.

4) Some relevant demographic data such as urban-rural composition, age and sex structure, literacy level, work-force and occupational classes, socio-cultural groups and religious groups have been obtained from the Indian Census records published for the years 1951, 1961, 1971 and 1981.

Selection of Variables

For the transformation of the raw-data, collected from the above mentioned sources, into required types of indices, computer programming has been profusely used. For making the use of channels the entire data was first computed as percentages and was organised into 22-variables among which 17-variables were related to socio-environmental factors and 5-variables were related to selected communicable diseases.

The seventeen variables used in the statistical analysis are:

1. Rainfall
2. Mean Maximum Temperature
3. Mean minimum temperature
4. Standard Food Nutrition Unit or (SNU)
5. Rural/Urban Ratio
6. Male/Female Ratio
7. Dependency Ratio
8. Literacy Ratio
9. Juvenile Age Group 0-14
10. Working Age Group 15-40
11. Senile Age Group 41 and above; Socio-cultural Group
12. Hindu
13. Muslim
14. Christian
15. Sikh and other; Health Facilities
16. Available Hospital Beds, and
17. Available Number of Hospitals.

These seventeen variables are taken as 'Independent' variables, while the five selected diseases (cholera, smallpox, malaria, dysentery and diarrhoea, and tuberculosis) are treated as 'Dependent Variables'. For interpretation of the data a matrix analysis has also been attempted. For this purpose the data sheet for 31 years from 1951 to 1981 for fourteen districts of the Doab has been prepared. Besides this, each districtwise sheet has been organised into 22-columns for obtaining combined variable. As each factor has its own particular significance in terms of time and space distribution of the diseases in the area, all listed factors have been used for correlation matrix. All these figures in the aggregate chart have been used to compute correlation at the required level by set computer programming system.
Factor Analysis Employed

On the basis of prepared indices a factor analysis has been conducted. This analysis comprises three major steps. They are:

1. the preparation of the correlation matrix for the variables,
2. the extraction of the initial factors - the exploration of possible data reduction, and
3. the rotation to a terminal solution - the search for simple and interpretable factors.

From the various methods of factor analysis available, method of Principal Factoring with Iteration followed by Varimax Rotation Method has been used in the present study. This method is widely used and is capable of handling most of the initial factoring needs of the user. Under this method, firstly an 'Initial Factor Matrix' is prepared in which the columns represent eigen vectors of the principal factors corresponding to the final (acceptable) iteration. The initial factor matrix is then rotated by the varimax rotation technique with a view to simplify the factor structure so that a variable may load high on one factor and almost zero on all the others. The varimax rotated matrix is then used to obtain the factor score coefficient using the following relationships:

\[ C = \text{STR} - 1 \]
where

\[ C \text{ is the factor score coefficient matrix,} \]
\[ ST \text{ is the transpose of rotated factor matrix and} \]
\[ R^{-1} \text{ represent the inverse of the original} \]
\[ \text{correlation matrix.} \]

A factor score scale is then built for each factor in the final solution. For each data case a vector of factor \( f \) is calculated:

\[ f = CZ \]

where

\[ Z \text{ is the vector of standardized value of the} \]
\[ \text{variables which have been subject to factor} \]
\[ \text{analysis.} \]

Multiple Regression Analysis Employed

A Multiple Regression Analysis has been fairly performed in order to develop better comprehensions about the relationship to various variables considered in the present analysis. This technique has been utilized in order to develop quantitative model showing relationship between causal variables and non-causative variables. Because a continuous theme in geographical research is that of analysing functional relationship among two or more variables. In the present analysis there are recognized several determinants of disease and mortality. Therefore, there is need to apply such a statistical method which gives the variability in deaths.
explained by the postulated determinants and their relative strength in explanation of the variability. Obviously, this problem lies in the realm of multivariate statistical analysis. In the multiple analysis the technique most suited to the problem is that of multiple regression.

General Model

The general model of multiple regression can be expressed as:

\[ Y = a + \sum_{j=1}^{K} b_j + e, \]

where \( a \) is intercept, \( b_j \) is \( j \)th partial regression coefficient and \( e \) is error term. The problem is that to fit a linear surface that the sum of squared divisions from this surface is minimized. This is called the least-square solution. In the least square solution, beta weights or **Standard partial regression coefficients** are calculated using the following equation:

\[ B_j = \frac{1}{\sum_{i=1}^{K} r_{ij} - r^{-1}_{ij}} \sum_{i=1}^{K} r_{ij} Y_i - r^{-1}_{ij} \]

where

- \( r_{ij} \) = intercorrelation of \( i \)th interdependent variable and dependent variable
- \( r^{-1}_{ij} \) = the inverse of intercorrelation \( r_{ij} \)

\( j = 1, 2, 3, \ldots, K \) are independent variables.
The partial regression coefficients are calculated as follows:

\[ b_j = B_j \cdot \frac{S_y}{S_j} \]

where

\[ S_y = \text{Standard deviation of dependent variables} \]
\[ S_j = \text{Standard deviation of jth independent variable} \]
\[ j = 1, 2, 3, \ldots K. \]

The intercept, \( a \) is found by the following equation:

\[ a = \bar{Y} - \sum_{j=1}^{K} b_j \bar{X}_j \]

where

\[ \bar{Y} = \text{mean of dependent variable} \]
\[ \bar{X}_j = \text{mean of jth independent variable}. \]

The coefficient of determination is found by the following equation:

\[ R^2 = \sum_{j=1}^{K} b_j - \frac{r}{1} \]

Greater emphasis usually is placed on testing significance of the individual partial regression coefficient. This requires the calculation of the standard errors of these regression coefficients. This can be calculated with the help of inverse of the sums of squares and cross product matrix, \( P_j^{-1} \). The elements of this inverse matrix can be referred as \( C_{ij} \), where \( i=1,2,3,\ldots (K-1) \) and \( j = 1,2,3,\ldots(K-1) \).
Then the estimated error of $b_j$ is $[C_{ij} \sum U^2 / (N-K)]^{1/2}$ where $\sum U^2 / (N-K)$ is mean sum of square of residuals. Once $b_j$ has been computed, then the significance of the $j$th variable in the regression can be tested using "t" statistics:

$$t = b_j / \delta, \text{ degrees of freedom } = M - K$$

where $N$ is number of observations.

Thus this technique has been used in order to develop a quantitative model showing so it may be seeking relationship between causal variables ($X_1$ to $X_{17}$) and the dependent variables ($X_{18}$ to $X_{22}$). The results as obtained through the programming packages have been used finally on 5-dependent variables and the respective coefficient associated with independent variables considered for each regression model found with 5 models for each communicable disease in total. Similar models have been developed for each of the 14 districts as well as for the Doab as a whole in order to identify the causal relationship in each district separately.

**Organisation of the Study**

The present study is basically organised into three broad sections: Section I deals with the conceptual framework of the Research Project as well as physical, socio-economic and demographic personality of the Doab; Section II deals with the Analysis of Geography of the Selected Diseases; and Section III contains synthesis and conclusion.
The first part, which consists of five chapters, provides a physical, socio-economic and demographic perspective on the study. Introduction is mainly concerned with the identification of the problem of health and disease, the basic research design and the organisation of the study. Chapter I, is devoted to a brief discussion of the aspects of Geo-Medical study and survey of main literature and its principal objectives in context of the present research work.

The Chapter II starts with brief description of the location and general geographic features of the environment of Ganga-Yamuna Doab, the soils and overview of climate highlighting its main characteristic features. Chapter III provides a general discussion of the historical socio-cultural forces in the structuring of the society, its particular standard of living, conservatism and superstitions as affecting people and creating health problems in the region. And it also describes the demographic landscape and scenario of the region with reference to growth, distribution and other principal characteristics of the population. Chapter IV, deals with the basic problem of health and hygiene and a general discussion of infant mortality, general mortality situations, age and sexwise mortality incidences and brief appraisal of past and present communicable diseases as found in the region. Chapter V, is the culminating component of this part of study and principally devoted to the requisite details pertaining to the general intake of calories as are
available from its very base and poor food resources and consequent effect of poor agricultural economy in a highly growing population. A brief discussion on the circumstance causing poor health and high disease incidence has been presented under the chapter.

The second part constitute the core of this thesis. It comprise five main chapters. Chapter VI outlines briefly the historical outline of diffusion and ecology of the selected five communicable diseases in Ganga-Yamuna Doab. Chapter VII is devoted to give a comparative assessment of the prevailing main characteristic features in the regional pattern on the basis of quartile indices used for the study of each kind of five diseases between three successive decades for explaining the decennial and interdistrict positions across the Doab. Chapter VIII also deals with the regional perspective of all five combined diseases in overall pattern of the three decades in fourteen districts of Ganga-Yamuna Doab. Both these chapters apparently give highlights of the main notable characteristic features which are consequently the result of particular type of susceptibility to disease between interdistrict and decennial relative positions in the high prone and low prone districts over regional pattern of the Doab. Chapter IX devoted to Factor Analysis. It is based on varimax rotated factor matrix result and is intending to show causal relationship between various factors of the disease and their related regional
patterns of mortality. Chapter X also embodies a thorough analysis of the regional causative factors to be studied through a popular method available with linear regression for the actual pursuit of the geography of diseases among various districts of the Doab.

Since it is rather difficult to pin-point exact correlation of a large variety of factors of socio-economic and geographical environment which are directly or indirectly related to the general incidence and distribution of five important diseases, therefore, the available result of factor analysis and multiple linear regression provide possible models for the solution of this problem. The first part in this chapter would provide probable indices of correlation with many variables as affecting occurrence and the incidence of these diseases. The second part would deal with regression models for each of the five diseases. The indices obtained from these statistical calculations and computer programmes would be used for the preparation of the thematic maps showing main diseases like cholera, smallpox, malaria, dysentery, diarrhea and tuberculosis. It explains the occurrence and behaviour of these diseases in relation to various social and environmental factors which appear to be influencing the incidence and distribution of above noted communicable diseases over the general pattern of Doab. In fact, the tenth chapter embodies the explanatory analysis of five communicable diseases. On the basis of indices obtained,
the Doab has been divided into disease intensity regions and a reasonably detailed regional study of the five diseases has been presented.

The third part embodies the outcome of this research in the form of general synthesis and conclusion. It serves as an epilogue to this research and is followed by three or more appendices containing detailed tables as well as by a classified bibliography.