important to attend to the play of different interests from different positions and in different voices." – D. Gregory (2005)

From this point of view the complete application of universality of science in geography is not possible. **Wilhem Dilthey** (1833-1911) objected the principle that valid explanations are possible only through science. **G.G. Vico** in 1725 established the superiority of the science of the human mind. Natural sciences could not reveal inner aspects of things. Dilthey, in the similar line thought that *"scientific explanation do not reach the inner nature of phenomena and it is humanistic knowledge that gives us insight into thoughts, feelings and desires"*.

Robert Sack (1980) argued that positivistic geography was a form of spatial fetishism, focusing on spatial (dimension) at the expense of everything else.

Marxist and radical critics commented that positivism put more emphasis on spatial analysis, and thus temporal, political and social processes are ignored. Man is considered as rational being devoid of irrationality, ideology and history. Man and societies are very complex and so are impossible to represent by simplified laws and models.

Harvey in 1979 argued that *"spatial science could say little about issues such as class divisions, Third World debt, geopolitical tensions and ecological problems, because it was incapable of asking and answering the questions needed to interrogate them"*.

In human geography, normative issues were not addressed in positivistic approach. By rejecting metaphysical questions, positivist approach becomes people-less, as it did not acknowledge people's beliefs, values, opinions, feelings and their role in shaping every day's geography. [Buttimer, 1976; Guelke, 1974; Tuan, 1976 and Kitchin, 2006]

In Positivism, world was considered to be universal, orderly, rational, quantifiable, predictable, abstract and theoretical [Stanley and Wise, 1993; Quoted from Kitchin, 2006] and geographer *'can separate himself from his body, emotion, values, past and so on, so that he and his thought are autonomous, context free and objective'* [Rose, 1993]. That rarely exists.

As a result of this criticism an inclination towards human geography was noticed at the end of 1960s. Humanistic geographers tried to establish geography as a social science. So geography came closer to humanities than to natural science. A greater tendency towards the research and study of welfare geography, feminist geography, etc. came to the fore, and it brought about a radical change of attitude towards geography. But it must be remembered that the process of statistical analysis in all branches of geography is still continuing.

In spite of all these limitations, positivism 'teaches us many important lessons'. It has taught us the virtue of direct observation in field and experiments in laboratories. Geography as a field oriented science has been re-affirmed in positivism. It has also trained us to think rigorously and logically. The philosophy of science is made vivid and clear to us. The methods of research and analysis become formalized and structured by positivism.

11.4 QUANTITATIVE REVOLUTION

Ian Burton (1963), geographer of University of Toronto coined this term "quantitative revolution" for the first time. From 1950s-1960s there was a dramatic shift of geographers'

attitude from regional approaches to systematic scientific approaches. It became very popular in the U.S.A. and gradually accepted in Europe and outside. This shift of standpoint or interest is called quantitative revolution by Burton. A radical change of conventional concepts (regional uniqueness) was required in the efforts to establish geography as a spatial science through constructing hypotheses, theories and models with the help of the concepts derived from the analysis of spatial distribution of geographically significant phenomenon. As a result, regional uniqueness was ignored in the quest of generalization to formulate laws and models. In this new method more emphasis was given on the quantitative aspects of a geographical phenomenon being guided by positivism. This new scientific study and research, heavily dependent upon quantifications, brought about a radical change in the existing approach. So it is called **quantitative revolution**.

Burton described quantitative revolution in the following way:

"In the past decade geography has undergone a radical transformation of spirit and purpose, best described as 'quantitative revolution'. The consequences of the revolution have yet to be worked out and are likely to involve the 'mathematization' of much of our discipline, with an attendant emphasis on the construction and testing of theoretical model." —Burton, 1963

Following **Kuhn**, it can be called the beginning of a distinct powerful paradigm, which brought about a revolutionary change in the philosophy and method of studying geography.

11.4.1 Background :

Quantitative Revolution in geography started from the debate that Schaefer and Hartshorne had. **Schaefer** (1953) argued for generalization through the study of 'spatial distribution of certain features on the surface of the earth' for formulation of laws. According to **Cox** (1995) and **Getis** (1993), quantitative revolution in geography was brought about by Schaefer's posthumous publication which caused a shift of attention from regional approach to systematic approach that initiated quantitative revolution in 1950s.

"Posthumously published paper by Schaefer (1953), which is often referred to those seeking the origin of the 'Quantitative and theoretical Revolution'." — Cox, 1995 and Getis, 1993.

But we must remember that "*Central Place Theory*" which was brought out by a German researcher, **W. Christaller** in 1933, is considered the first successful geographic model. It served as the base of many research works falling into the domain of quantitative revolution during 1950s and 1960s.

Not only Schaefer's research paper in 1953 but also **Ackerman's** essay entitled "*Geographic Training, Wartime Research, and Immediate Professional Objectives*", published in 1954, argued in favour of systematic and scientific approach. Ackerman's '*Geography as a Fundamental Research Discipline*' (1958) is a classic presentation of research organisation through quantification and scientific approach leading towards formulation of laws and models by generalization (Johnston and Sidaway, 2004). These 'fundamental research' in geography should be based on quantification for the sake of accurate study and should '*furnish a theoretical framework with capacity to illuminate actually observed distributional patterns and space relation*' (Ackerman, 1958). This is also considered as another important seminal work to initiate quantitative revolution. "*Ackerman (in 1958) issued a clarion*

call for theory development, the application of quantitative methods, and a focus on laws and generalizations to form the building-block for further nomothetic research" (Johnston and Sidaway, 2004). Besides this **E.L. Ullman's** (1953) book "**Human Geography and Area Research**" proposed a kind of research suitable for the purpose of making scientific laws. Thus in the first part of the decade of 1950s, a methodological transformation started. It was an epoch-making process for studying geography.

A decade before Schaefer's work, in 1940s, 'a group of social physicists' started scientific analysis of 'human activities with a strong emphasis on space'. **G.K.Zipf** (1949) introduced the concept of *'the principle of least effort'*; **J.K. Stewart** (1947) advocated for using the principles of physics to describe human behaviour. He said *"human beings obey mathematical rules resembling the primitive laws of physics"*. Theories of space outside geography also contributed for setting the background for quantification in geography. Theory on location of industry over space by **Alfred Weber** (1929), *Central Place Theory* on distribution of settlements over space by **Walter Christaller** (1933) showing the notions of spatial regularity, *locational analysis* of **A. Losch** on space in 1954, had developed the background of generalization and nomothetic approach. Diffusion of innovation in space was proposed by **Torsten Hagarstrand** in 1952. Economists like **Walter Isard and Cumberland** (1950) developed the notion of 'space economy' using mathematical models and graph synthesis. Similar attempts of positivistic analysis of space were observed from **Edgar S. Dunn** (1954), **Walter Isard** (1956) and **Melvin L. Greenhut** (1956). They worked extensively on locational theories of A. Losch (1954) and 'Central Place Theory' of Christaller (1933). Similarly **William Garrisson** and **Duane Marbel** (1957) began to use an entirely different terminology of "rigorous proof of theorems" (Garrisson and Marble, 1957) and Patterns of City Sizes (Berry and Garrisson, 1958).

At first this scientific approach of studying started in some American Universities and soon became popular all over the world. Iowa, Wisconsin, Princton and Washington University took the leading role, which has already been discussed in details in the part related to the development of systematic geography [vide 11.2.3].

By, 1960s the quantifications and scientific nomothetic methods were so widespread, so that almost every researchers had opted for it. Thus a profound paradigm was set by the beginning of 1960s. In the year 1963, Burton had claimed that an intellectual revolution—the quantitative and theoretical revolution had occurred in Geography [Johnston and Sidaway, 2004]. *"The revolution is over, in that once–revolutionary ideas are now conventional."* — Burton, 1963

11.4.2 Circumstances :

Quantitative Revolution brought about methodological change in geographical studies and researches in the decade of 1950s. This change was necessary for various purposes, which are as follows:

(i) In the decade of 1950s, just after the World War II, the study of geography faced a deep crisis, which was as strong as to lead to the closure of the study of geography. In 1948, James Conant, the President of Harvard University, decided geography to be unsuitable for study in a university. So geographical studies in this university were ceased. Other universities of America also followed the instance. At this

critical juncture—a change in the method of studying the subject was an urgent need of the hour. The demand of the time was that geography should be considered as a science, which could ensure its study in the universities with appropriate seriousness.

(ii) Not only in the university campus, geography should deserve respect in society as a science. Burton (1963) was of the opinion that geography *"needs to acquire demonstrable value as a predictive science"*.

(iii) After the World War II, geographers felt that the subject was lacking in standard theory, laws, models, etc. Other subjects, such as—sociology, biology, etc were not lacking in them. Geographers enjoyed no social importance. Under such circumstances, it seemed that geographical study and research must have a scientific approach and should be placed on a firm theoretical base.

(iv) Geography was considered unscientific because its method of study was descriptive in nature. It could not give satisfactory explanation of regional uniqueness also. Explanation was not possible because of the inadequacy of standard theories, rules or models.

(v) Geographical studies and researches remained confined to books. There was no scope for their practical use in social life.

(vi) People had confusion about the class or category in which the subject belonged to. So it was required to state clearly that geography belonged to the discipline of science.

11.4.3 Characteristics of Quantitative Revolution :

(i) According to **Chisolm** (1975), this methodical change of geography should better be termed as evolution rather than revolution. This is so because this change of system (from regional to scientific approach) gradually took place for the desire which had been felt for a long time.

(ii) According to **D. Gregory** (1981), quantitative revolution does not signify that only the laws of mathematics are widely used here but it is also concerned with constructing general laws of spatial organisation.

(iii) In an attempt to state the characteristics of quantitative revolution, **Brian Berry** (Professor, University of Chicago) in the year 1964 put forward the following inferences :

a. Like other scientists, geographers are identified not so much by the phenomena they study as by their integrating concepts.

b. The geographic point of view is spatial. Geographers attempt to understand, how things and phenomena are distributed and integrated spatially.

c. Geography's interesting concepts relate to spatial distributions, spatial integrations, spatial interaction and spatial processes.

d. These concern the worldwide ecosystems of which humans are the dominant part.

(iv) The laws of physics, geometry, statistics, and life science were applied in geographical research works. There came to notice a widespread effort for constructing general theories, hypothesis and model-making with the help of geometrical analysis of

spatial distribution of different geographical phenomena, spatial transfer of mass and energy, establishing inter-relationship among geographical factors.

For example, theories and hypotheses related to evolution of slopes, evolution of landforms, models concerned with flow, theories on transportation and erosion by a river, model related to stream order, locational theories, central place theory model, migrations theories, models on urban morphology, transport network analysis models, behavioural matrix, social area analysis theory, etc. were developed that strengthened theoretical foundation of Geogrpahy .

(v) The application of statistics in geography introduced the system of analysis of measurable data. By generalization, hypotheses are constructed and testing of hypothesis are done for determination of its truth and derivation of general theories which gradually led to the construction of laws. Thus geography became a nomothetic science. *"The quantitative revolution was inspired by a genuine need to make geography more scientific, nomothetic* (law making) *instead of idiographic* (descriptive)" – Peet, 1998.

(vi) A model is a simplified form of a complex reality. A model can also present the simplified form of a theory. As a result of quantitative revolution in geography, model-making for common spatial distribution became very popular.

(vii) It marked the beginning of proper analysis and study of spatial relation, spatial flow and spatial interaction through the analysis of input-processing-output system (Von Bertalanffy, 1951).

11.4.4 Objectives of Quantitative Revolution in Geography:

Quantitative Revolution in geography basically aims at making geography more scientific by adopting nomothetic approach of law-making through generalization of data collected by direct observation and precise measurement over space.

"That space (is) made to resemble physics, space reduced to distances between points, with spatial behaviour as distance minimization and geometry as disciplinary language. With such space, modern scientific methods could be employed, initially as statistics inductively measuring regularities, eventually as mathematical logics in a deductive science." — Peet, 1998

Thus geography becomes a spatial science as a consequence of quantitative revolution.

Following are the specific objectives of adopting quantitative techniques in geography.

I. Scientific explanation of geographical phenomena became the dominant objective on the basis of accurate quantification, generalization, law-making and logical deduction rather than describing regional uniqueness. That enables objective, value-free, autonomous, neutral and replicable studies. Outputs of such studies have more universality in application.

II. The principal aim of science is to give logical explanation. It needs universal theory, axioms or rules on the basis of which a phenomena or a distribution can be explained. Construction of a theory or making of a model needs data derived from direct observation and measurement, their appropriate analysis to find out generalized order. Quantitative approach aims for precise data generation, accurate data analysis leading to generalization and theory formation.

III. With the introduction of mathematics and statistics in geography the use of different signs began. Signs such as 'h' for height, 'q' for inclination, 't' for temperature, 'Am' for the tropical monsoon in Kopen's climatic classification etc. were widely used. Quantification aims to enable the use of formula and equations which could easily express the relation among geographically significant elements.

IV. To understand the pattern of spatial distribution of geographical phenomena, and finding the rules governing such distribution and appreciation of spatial interaction among those phenomena became more popular among geographers.

V. Its goal was generalization and construction of theories concerning the order of different things. Generalization and construction of theories are helpful in testing the truth of hypotheses, prediction and estimation of geographical phenomena.

VI. Determination of appropriate location of economic activities, such as—agriculture, industries etc. was aimed in order to ensure the optimum use of wealth, gaining maximum utility from it and making profit, thus to provide geography a scope for application in resource use, regional planning and development.

VII. It aims to provide a solid theoretical foundation to geography and to enable scientific explanation.

11.4.5 Criticism of Quantitative Revolution:

Quantitative Revolution has given geography a scientific foundation, yet it is open to criticism from various perspectives :

I. The introduction of scientific system in geography made the subject limited to the scope of geometry that failed to explain the interaction between man and nature. In humanistic geography, geometrical models and mechanical theories failed to analyse man—nature relationship satisfactorily. For example, Gravity Model which is related to migration cannot satisfactorily explain all the aspects of movement of human beings. It can only partially present human attitudes.

II. Bultimer (1976), Guelke (1974) and Tuan (1976) criticized quantitative approach from the ground that it has reduced human beings to abstract and rational objects. They also argued that spatial science is people-less in the sense that it did not acknowledge people's beliefs, values, opinions, feelings and their role in geography [Kitchin, 2006].

III. Quantitative Revolution concerns itself only with information or statistics which are objective, measurable and collected on the basis of experience. It falls short of taking into account social attributes and practices; the measurement of which is considered not possible. For example, beliefs, awareness, likes or dislikes, customs etc. are beyond measurement, though they can control human behaviour and social processes and decisions. Economic activities depend largely on religious beliefs, morality, culture, social status, etc. For example, the Muslims hate farming of pigs, the Sikhs abhor tobacco, the Khasi community of Meghalaya and the Lushai community of Mizoram dislike dairy farming. Without considering social processes geographic understanding and explanations are incomplete and to some extent misleading.

IV. Humanistic Geography (focusing on phenomenology and existentialism) believe that human beings are complex and do not behave in ways that are easy to model. It is rational that geographers should follow the ways of enquiry sensitive to capturing the complex lives of people [Kitchin, 2006].

V. As a result of oversimplification, a model or a theory neglects some geographical phenomena which may sometime play an important role.

VI. **Spate (1960)** criticized quantitative revolution from 3 aspects :

a. The enthusiastic positivist geographers wanted to quantify everything. They are not satisfied without quantification. *"When you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind."* (Spate, 1960)

b. Much of the researches by quantification in geography is wasted on trivia, because a large section of geographical domain is unattended.

c. There was quantifier's ambition that solution of the world's problems lay just around the corner.

VII. **Sack** (1980) argued that in quantitative positivist's approach more emphasis has been put to 'space'. Marxist and Radical critics are of the opinion that, over emphasis on spatial analysis, in quantitative approach ignored temporal, social and political processes that are equally important in geographical study.

VIII. **Burton** (1963) identified five limitation of quantitative revolution:

a. "Geography was being led in the wrong direction.

b. Geographers should stick with their proven tool—the map.

c. Quantification was suitable for certain tasks only.

d. **Means** are being elevated over **ends**, with too much research on methods for method's sake.

e. Objections were not to quantification *per se* but to quantifier's attitude".

IX. **Luckermann** (1960, 1961 and 1965) attacked the laws and models used in economic geography [Johnston and Sidaway, 2004].

a. Economic analysis ignored historical inertia, geographical momentum and the human conditions (Luckermann, 1960).

b. Much of the theory being introduced to economic geography (such as Losch's) was not based on providing understanding of, and explanation for, reality (Luckermann, 1961).

c. "Scientific explanation is far removed from the context within which the macroscopic geographers would have put it—the end product of geographic research. Science does not explain reality, it explains the consequence of its hypotheses."–(Luckermann, 1965)

X. **Peet (1998)** inferred that quantitative revolution may be termed as 'spatial revolution' as 'space' was considered central in scientific analysis. *"This 'spatial revolution' developed a dualism between 'space' and 'environment', ironically at a time when environmental problems proved to be of rising concern."* [Peet, 1998]

XI. **Johnston and Sidaway** in 2004, cited an interesting reaction of **Dudley Stamp** against quantitative techniques. Haggett's (1964) work on land use change in Brazil through quantitative analysis was termed by Stamp as *"an enormous steam hammer ..... in the cracking of nuts"*. As a result, Hagget was told by his HOD, at Cambridge, that he was *'bringing the subject of geography into disrepute by applying such mathematical methods'* [Chorley, 1995].

XII. **Jones** (1956) cited the instances of 'probabilistic quantum laws' of physics that refer to behaviour of individual particles. So, according to him, if universal laws are not possible in natural science, like physics, discovering universal laws about human behaviour is impossible.

XIII. Quantitative revolution in geography is based on positivistic or logical positivistic philosophy. Both of these philosophies are under serious criticism from humanistic standpoint [Peet, 1998]. So the methods and findings of quantifications in geography are under questions.

Reference:

1. Ackerman, E.A. (1945) Geographic Training, wartime research, and immediate professional objectives: *Annals of the Association of American Geographers* 35, 121-43.
2. Ackerman, E.A. (1958) Geography as a Fundamental Discipline. Chicago: University of Chicago, *Department of Geography Research Paper* 53.
3. Alexander, J.W. and Zahorchak, G.A.(1943) Population Density maps of the United States: Techniques and Pattern. *Geographical Review* 33, 457-66.
4. Barnes, T.J. (1989) Place space and theories of economic value: contextualism and essentialism in economic geography. *Transcations*, Institute of British Geographers. NS14, 299-316.
5. Berry, B. and Garrisson, W. (1958) Alternate Explanation of urban rank-size relationship. *Annals of the Association of American Geographers*, 48: 83-91.
6. Berry, B.J.L. (1964) Approaches to Regional Analysis: a synthesis. *Annals of the Association of American Geographers* 54, 2-11.
7. Berry, B.J.L. (2002) The Chicago School in Retrospect . *Urban Geography* 22, 559-61.
8. Bowen, M. (1981). Empiricism and geographical thought from Francis Bacon to Alexander von Humboldt. *Scottish Geographical Magazine*, 86, 222-33.
9. Bunge Willium, (1962) Theoretical Geography. Lund Studies in Geography, Series C I, Lund: C. W.K. Gleerup.
10. Burton, I. (1963) The Quantitative Revolution and Theoretical Geography. *Canadian Geographers*, 7, 151-162.
11. Buttimer, A. (1976) Grasping the dynamism of lifeworld. *Annals of the Association of American Geographers*, 66: 277-92.
12. Chalmers, A.F. (1982) *What is this thing called science?* St. Lucia: University of Queensland Press
13. Chisolm, M. (1975) *Human Geography: Evolution and Revolution?* Harmondsworth: Penguine Book.
14. Chorley, R.J. (1995) Hagget's Cambridge: 1957-1966. In A.D. Cliff, P.R. Gould, A.G. Hoare and N.J. Thrift (eds) *Diffusing Geography*, Oxford: Blackwell Publisher, 355-74.
15. Christaller, W. (1933) *Central Places in Southern Germany*, (1966, translated in English by C.W. Baskin), Englewood cliff, NJ: Prentice Hall.
16. Cox. K.R. (1995) Concepts of Space, understanding in human geography, and spatial analysis. *Urban Geography* 16, 304-26.
17. Davis, W. M. (1902) Systematic Geography, *Proceedings of the American Philosophical Society*, Vol. 41, No. 170 (Apr. 1902), pp 235-259.