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GENERAL PRESIDENT : PROF. P. C. MAHALANOBIS, F.R.S.

Address of the General President

WHY STATISTICS ?

I naturally feel honoured at my election as General President. I remember, several years ago, I discussed with a friend of mine, at that time a member of the Executive Committee of this Association, the possibility of having a separate section for statistics. My friend, who has been always appreciative of the importance of statistics, readily agreed to have an informal talk with his colleagues. A little later he informed me that there was no chance of my proposal being accepted, and with a smile told me that some of his colleagues had remarked: "If statistics is to have a section, you may as well have a section for astrology." Evidently statistics and astrology were bracketted together in the mind of many of our scientists. The forecasting of future events is, of course, a common feature; and the basis was felt to be equally unscientific. And yet, the section for mathematics was converted into the section for mathematics and statistics in 1942; a separate section was created for statistics in 1946; and this year, a person engaged in statistical work has been elected General President. I am aware I have not been accorded this honour because of my personal attainments. I accept it as a mark of recognition of the growing importance of statistics.

2. A great change has taken place in the climate of scientific and public opinion about statistics. One may ask how has this change been brought about? In other words, why is importance being increasingly attached to statistics? It may be appropriate, therefore to try to explain: Why statistics?

DESCRIPTIVE STATISTICS

3. Historically modern statistics is the result of the fusion of two originally distinct disciplines—one primarily descriptive concerned with the collection of data; the other essentially analytic associated with the concepts of chance and probability. From time immemorial men must have been compiling information for peace and war. Statistics is in this sense as old as statecraft.[1] At each upsurge of social and political development or during war, there is a rapid growth and expansion of statistical practice. I shall give three examples from my own country.

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[1] Harald Westergaard noted : "Etymologists may find the root of the word 'statistics in the Italian word *stato, and* a *statista* would thus be a man who had to do with the affairs of the State. "Statistics" would consequently mean a collection of facts which might be of interest to a statesman, whether they were given in the form of numerical observations or not." (Contributions to the History of Statistics, London, 1932, p. 2).

Arthasāstra of Kautilya: 3rd Century B.C.

4. The *Arthasāstra* of Kautilya[2] claims to date from the period 321-296 B.C., that is, the Maurya period which reached its peak in the time of the great Asoka. It contains a detailed description for the conduct of agricultural, population, and economic censuses in villages as well as in cities and towns on a scale which is rare in any country even at the present time. The detailed description of contemporary industrial and commercial practice points to a highly developed statistical system. In Chapter XXXV (p. 158), instructions are given about the classification of villages. Specific directions are also given for a detailed census of land and field (p. 158):

> "It is the duty of Gopa, village accountant, to attend to the accounts of five or ten villages, as ordered by the Collector-General.
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> "By setting up boundaries to villages, by numbering plots of grounds as cultivated, uncultivated, plains, wet lands, gardens, vegetable gardens, fences (vata), forests, altars, temples of gods, irrigation works, cremation grounds, feeding houses (sattra), places where water is freely supplied to travellers (prapa), places of pilgrimage, pasture grounds and roads, and thereby fixing the boundaries of various villages, of fields, of forests and of roads, he shall register gifts, sales, charities, and remission of taxes regarding fields.
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> "Also having numbered the houses as tax-paying or non-taxpaying, he shall not only register the total number of the inhabitants of all the four castes in each village, but also keep an account of the exact number of cultivators, cowherds, merchants, artisans, labourers, slaves, and biped and quadruped animals, fixing at the same time the amount of gold, free labour, toll, and fines that can be collected from it (each house)."

5. In Chapter XXXVI (p. 160) similar instructions are given about the statistics of the Capital City (p. 160):

> "A gopa shall keep the accounts of ten households, twenty households, or forty households. He shall not only know the caste, gotra, the name, and occupation of both men and women in those households, but also ascertain their income and expenditure."

6. One striking feature in the *Arthasāstra* is the emphasis on the need of checking and verification by independent agents working in secret without the knowledge of the original enumerators (Chapter XXXV, p. 159):

> "Spies, under the disguise of householders (grhapatika, cultivators), who shall be deputed by the collector-general for espionage, shall ascertain the validity of the accounts (of the village and district officers) regarding the fields, houses and families of each village—the area and output of produce regarding fields, right of ownership and remission of taxes with regard to houses, and the caste and profession regarding families.
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> "They shall also ascertain the total number of men and beasts (janghagra) as well as the amount of income and expenditure of each family."

7. Detailed instructions are given in other places about the standards of weights and measures, measurement of space and time; national accounts;

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[2] Translated by Dr. R. Shamasastry, 3rd edition, Wesleyan Mission Press, Mysore, 1929.

and the duties of Government Superintendent in charge of multifarious departments such as the treasury; mining operations and manufacture; commerce; forest produce; tolls; weaving; agriculture; livestock; armoury; infantry; chariots; etc. etc. Specific duties are in fact described for no less than 25 different Superintendents by designation.

Ain-i Akbari : circa 1590 A.D.

8. In another peak period of Indian history, in the time of the great Akbar, we find a description of a highly developed statistical system in *Ain-i Akbari* which is practically the administration report and statistical returns of his government as it was in 1590 A.D. In the introduction to the second volume, H. S. Jarrett observed:[3]

> "It will deservedly go down to posterity as a unique compilation of the systems of administration and control through the various departments of Government in a great empire, faithfully and minutely recorded in their smallest detail, with such an array of facts illustrative of its extent, resources, condition, population, industry and wealth as the abundant material supplied from official sources could furnish."

9. The approach is definitely scientific. For example, the author discusses various standards for the measurement of length, and describes how Akbar "seeing that the variety of measures was a source of inconvenience to his subjects, and regarding it as subservient only to the dishonest, abolished them all," and brought the *Ilahi gaz* in general use (Vol. II, *Ain* VIII, pp. 58-61). In the same way standards are developed for the measurement of land. It is noted that "a measure of hempen rope twisted which became shorter or larger according to the dryness or moisture of the atmosphere" (pp. 61-62). Therefore, "the *jarib* was made of bamboos joined by iron rings. Thus it is subject to no variation, and the relief to the public was felt everywhere while the hand of dishonest greed was shortened." (*Ain* IX, pp. 61-62). Other measures of area and volume as well as the standardisation of currency receive minute attention.[4]

10. In *Ain* XI (pp. 62-63) a detailed account is given of the classification of land based on the yield of crops. A distinction is made between yields in the two seasons 'spring harvest,' and 'autumn harvest.' Furthermore, yields are given for three different grades of soil, "best, middling, and worst;" and the average of the three grades is calculated as "the medium

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[3] English translation by H. Blochmann (Vol. I, 1873) and H. S. Jarrett (Vol. II, Vol. III, 1894) published by the Asiatic Society of Bengal, Vol. II, p. vii.

[4] *Ain-i Akbari* gives the area, revenue valuation, strength of army, and other details for about 15 *subahs* (provinces) comprising over 130 *sarkars* (districts) and over 3000 *mahals* (townships and sub-divisions) extending from Assam and Arakan to Afganistan; the average yield of 31 crops for 3 different classes of land; annual records of rates based on the yield and price of 50 crops in 7 *subahs* (provinces) extending over 19 years (1560-61 to 1578-79 A.D.); daily wages of men employed in the army and the navy; labourers of all kinds; workers in stables, etc.; average prices of 44 kinds of grains and cereals, 38 vegetables, 21 meats and games, 8 milk produces, oils, and sugars, 16 spices, 34 pickles, 92 fruits, 34 perfumes, 24 brocades, 39 silk, 30 cotton cloths, 26 woollen stuffs, 77 weapons and accessories, 12 falcons, elephants, horses, camels, bulls and cows, deer, precious stones, 30 building materials; weights of 72 kinds of wood, etc.

It is no wonder that speaking of Abul Fazl, Jarrett has remarked (II, p. v), that "regarded as a statistician, no details from the revenues of a province to the cost of a pine-apple, from the organisation of an army and the grades and duties of nobility to the shape of a candlestick and the price of curry-comb, are beyond his microscopic and patient investigation."

product of a *bigha*." For the spring harvest, figures are given for from 10 to 20 crops; and for the autumn harvest, for 20 or 30 crops.[5]

SURVEY OF EASTERN INDIA: 1807-1815 A.D.

11. In the first decade of the 19th century, when the British regime in India was rapidly expanding and growing in strength, a comprehensive survey of Eastern India was undertaken by Dr. Francis Buchanan under orders of the Board of Directors of the Hon'ble East India Company dated 7th January 1807. The terms of reference cover an amazingly wide ground as can be seen from the extracts reproduced in Appendix (1). The Survey was pursued by Dr. Francis Buchanan for 7 years when only a portion of the territories under the Government of Bengal Presidency was investigated. The material was sent to London in 1816, and Montgomery Martin published in 1838, a selection in three volumes comprising over 2400 closely printed pages.

12. The book still makes fascinating reading. To whet your curiosity, I shall describe some of the items collected about the people of Patna city and the surrounding region. Information is given, for example, about the number and proportion of families in different consumption levels such as, families that use milk daily; that use milk in the chief season; that use milk on holidays: that use milk seldom. In the same way, information is given by categories of families according to the use of different kinds of dress, bed-sheets, blankets; the consumption of meat, fish, milk, vegetables, spices, oil, salt, rice, wheat, sweetmeats etc; different kinds of fuel and oil; different types of conveyance; state of education ; etc.

13. The utilization of land is shown by giving the areas separately for a large number of categories such as houses, trees, kitchen gardens, vegetables, etc. As regards agriculture, separate acreage figures are given for the area under 200 different combinations of crops, single and mixed. A general table is given for the value of the produce in the case of commercial crops; and both quantity and value in the case of cereals and food crops together with estimates of the marketable surplus; and number of livestock under different categories together with the annual production of milk with prices.

14. There are tables showing the proportion of rent paid by different sections of the population; the economic position of farmers with proportion of indebted families; and the number of artisans classified into 108 different categories. The manufacture of cotton cloth receives special attention; and detailed estimates are given of the number of weavers; looms; monthly production; earnings and profit for different kinds of cloth. Finally, there are tables of exports and imports (for the region surrounding Patna

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[5] One interesting practice deserves notice. The ten *ser* tax (*Dahseri*) is thus described: "His Majesty takes from each *bigha* of tilled land ten *sers* of grain as a royalty. Store houses have been constructed in every district. They supply the animals belonging to the State with food, which is never bought in the bazars. These stores prove at the same time of great use for the people ; for poor cultivators may receive grain for sowing purposes, or people may buy cheap grain at the time of famines. .... They are also used for benevolent purposes; for His Majesty has established in His empire many houses for the poor where indigent people may get something to eat." (Vol. I, 1927, p. 285).

The optional payment of revenue in the form of grain may deserve serious consideration as an alternative method of grain procurement in these days of food rationing.

city) in which separate figures are given for 140 different categories of commodities.

15. The report everywhere shows the critical attitude, keen scientific spirit, and the experimental approach of Dr. Buchanan. The wealth and reliability of the information (as far as this can be judged from internal evidence) make this report one of the most remarkable surveys of all times. There is nothing in any subsequent survey in India to approach the one conducted by Buchanan 140 years ago.

16. It is not entirely fortuitous that the three surveys mentioned above were associated with three great periods of political and socio-economic expansion in India. The statistical system is a visible mark of the political framework of each country. The statistical organization, therefore, inevitably follows the rise and fall of the wider administrative system. I shall examine later the position of statistics in the changing conditions of India at the present time.

Developments in Other Countries

17. The practice of descriptive statistics gradually developed, with ups and downs, in all countries of the world. Aristotle's work contained references to information about no less than 158 states.[6] Besides public administration, statistics was in much use in commerce. Certain forms of commercial insurance existed in Babylonia, Greece and Rome, and in the middle ages in Italy. By the end of the 18th century, life insurance was becoming prevalent in Western Europe. All this led to important statistical studies. In 1662, for example, John Graunt used the register of deaths (Bills of Mortality) in London to investigate population trends. Since then, in Europe, the study of statistics has been closely associated with actuarial science. On the break-up of the feudal system' the expanding national economies required increasing use of factual information for the formulation of financial, military and political policies. This process has continued down to the present times. In fact, the need of fighting a total war led to an unprecedented expansion in statistical activities in the last ten years to which I shall again refer.

Games of Chance and Probability

18. I must now turn to the analytic side of statistics. Curiously enough, the first phase of development occurred in connexion with games of chance, particularly the theory of the equitable division of stakes for which early solutions were given by Cardan and Galileo in the 16th century. A little later, Pascal and Fermat developed more general methods on the basis of permutations and combinations. In this way the concept of probability, based on chance, gradually became the subject of much mathematical investigations culminating in the work of Laplace in early 19th century.

The Tossing of a Coin

19. The concepts were fundamentally new and deserve consideration. A simple example is the tossing of a coin (which is assumed to have no bias in favour of turning up either heads or tails). At each throw, it is completely

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[6] H. Westergaard, *Contributions to the History of Statistics*, 1932, p. 4.

uncertain whether the coin will turn up heads or tails. And yet, if the coin is thrown a large number of times (or, alternatively, if a large number of coins is thrown at the same time), it is practically (but never absolutely) certain that heads and tails would turn up approximately in equal numbers. The larger the number of throws (or the number of coins thrown at the same time), the greater is the chance of heads and tails being equal in frequency. Starting from a situation which is entirely indeterminate and uncertain, it is thus possible to reach conclusions with considerable (but never complete) certainty.

20. Several points require to be emphasized. First, it is quite impossible to predict anything about a single toss of a single coin; the prediction (of roughly equal frequency of heads and tails) refers to one whole set of throws. That is, prediction belongs not to any individual throw but to a group or assemblage of throws as a whole. Secondly, the existence of fluctuations or variations is inherent in the very nature of the problem. The relative frequency (that is, the proportion of heads and tails) will never remain exactly equal, but will inevitably fluctuate from one throw to another. Thirdly, because of the fact of fluctuations or variations, it is never possible to make any absolutely certain prediction. For example, however large the number of throws, the coin may turn up heads (or tails) all the time. In principle, even if the coin is tossed a million or a billion (or a larger number of) times, in the very long run, sometimes the coin should (and must) turn up heads (or tails) on the million or billion (or all) occasions.[7] In other words, the prediction is essentially a prognosis which is likely to hold only "in the long run". Fourthly, and this is a very important point, although the pre-diction is never absolutely certain, it is possible to predict the limits of uncertainty.

21. The proportion of heads and tails in the tossing of a coin is thus recognized as a statistical variate which is intrinsically subject to variations or fluctuations. The proportion of male and female births is exactly analogous to the proportions of heads and tails in the tossing of a coin. Before birth, nothing is known about the sex of the individual child, and yet the prediction of a roughly equal frequency of the two sexes can be made with practically the same confidence as the equal frequency of heads and tails.[8] Any inference about the results or any prediction is, therefore, necessarily uncertain; but the margin of uncertainty is itself capable of estimation.

Theory of "Errors" of Observation

22. The position is similar in the case of physical observations. However careful the observer may be, even the simple measurements of the length of a rod have been always found to vary. The average of a number of repeated measurements, however, usually becomes more and more steady as the number of measurements increases. The deviation from the average, *i.e.*, the "error" of each individual measurement is sometimes positive and sometimes negative, and thus behaves like heads and tails in the tossing of a coin. In the 18th century the new concepts of probability began to be applied to the adjustment of astronomical observa-

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[7] This is, of course, very very unlikely to happen which merely means that the probability is extremely small but, in principle, not zero.

[8] Laplace discussed in a memoir of 1781 the number of male and female births in Paris for 26 years (251, 527 males and 241, 951 females) from the point of view of probability. (*Histoire de l'Academie* for 1778).

tions and physical measurements which led to the growth of the theory of errors culminating in the work of Gauss and Laplace.

Individual Variations and Fluctuations

23. If the height of a number of individuals is measured, these measurements again vary. This is equally true for every kind of measurement in biology. Fluctuations or variations are thus fundamental features of all measurements. In biology, variation itself supplies the material for evolution. Variation is also the outstanding feature in all social sciences.

Measurements and Observations in Science

24. A crucial point in the argument has been now reached. All contingent knowledge is based on measurements and observations. Lord Kelvin remarked long ago:

> "When you can measure what you are speaking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind." [9]

Secondly, every set of measurements (in every field of science,—physical, biological and social) is characterized by variation. The aim must therefore be to draw general conclusions from a particular set of measurements, taking variation itself into consideration and not ignoring it.

The Concept of Random Samples

25. This is exactly the aim of the theory of estimation and statistical inference. Each set of measurements (with its characteristic variation) is recognized to be only one out of many possible similar sets. Secondly, the totality of all possible sets of measurements (that is, the totality of all possible samples) constitute the "population" or "universe" in which we are interested. In order to reach conclusions about the population or universe, it is clearly necessary that a sample should be representative of the universe. The condition for such representativeness is supplied by the fundamental concept of "randomness." I do not think it is possible to define randomness, but some indication may be given as to its implications. Suppose it is desired to find the average height of a particular group of people. Obviously, it will not do to select individuals who are very tall or very short (or have any other special feature) as the results are likely to get biased. The only safe course is to choose the sample without reference to any previous knowledge about the individuals included in the sample. A random procedure ensures such selection free from bias. Once a random sample is available, it is possible to use the calculus of probability in a valid way to reach general conclusions about the statistical population or universe from which the sample was drawn. The concept of random samples is thus pivotal in statistical theory.

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[9] It is interesting to note that exactly the same idea occurs in the original meaning of the word *sankhyā* (literally, number) in Indian thought. The phrase *sankhyātā* occurs in the *Atharva-Veda* in the sense of "well-known." For more than three or four thousand years in India an intimate connexion has existed between the concepts of "number" and "adequate knowledge." This is why I chose *Sankhyā* as the name of the Indian Journal of Statistics. Further references are given in Appendix (2).

Uncertain Inference

26. Knowledge based on a statistical or random sample is however necessarily incomplete, as it relates to only one out of many possible samples. Conclusions based on a random sample, although valid, must therefore, be necessarily uncertain. It is however the great merit of the calculus of probability that although statistical inference is uncertain, it is possible to estimate a valid measure of the degree of uncertainty. In practice this is usually secured by stating the chance or odds in favour of any particular inference or result being "true" (in the sense of the prediction agreeing with subsequent observations). Suppose extensive agricultural trials have been made to compare the yield of two varieties of wheat. On available evidence it is then possible to state the conclusion in some such form that the odds are 100 to 1 (or 1000 to 1, or some other odds) that variety A would give a higher yield than variety B. The very form of the statement indicates that, "in the long run", 99 times out of 100, variety A would give a higher yield. Necessarily, therefore once in 100 trials (not in every 100 trials, but again, "in the long run") variety A would give a lower yield. This lower yield may, however, occur in the very first trial. The risk is always there. Not only this, occasionall (or once in 100 trials "in the long run") the prediction must prove wrong. If it did not, then the whole basis on which the prediction was made would itself prove to be wrong. In statistical inference we thus reach the great paradox:

If statistical theory is right, predictions must sometimes come out wrong; on the other hand, if predictions are always right, then the statistical theory must be wrong.

Deductive Logic and Mathematics

27. There is a sharp contrast between statistical or uncertain inference and absolutely certain deductive conclusions. It is a significant fact that the concept of probability developed very late in the history of human thought, as far I know, only during the last two or three hundred years. Deductive logic, on the other hand, is very old. Absolute certainty in fact has long been accepted as the essential characteristic of true knowledge. Pure mathematics is a great historic example. In pure mathematics the conclusions follow inevitably from the premises, and all inferences are absolutely certain. This is why Bertrand Russel described pure mathematics as the class of all proposition of the form "P implies Q". Deductive logic, therefore, includes the whole of pure mathematics.

Deterministic Views in Physical Sciences

28. An invariable sequence of cause and effect is in many ways similar to the formal-deductive process in logic and pure mathematics. In the physical sciences, with the help of the causal principle, the rigour of absolute certainty of mathematical reasoning was accepted for a long time as the ideal model. Newton in writing his great treatise on the principles of natural philosophy deliberately adopted the mathematical form. The possibility of constructing a rational model of the whole universe was a great triumph of the human mind. The growing complexity within the natural, and later in the biological and social sciences, however, led to the gradual replacement of the deterministic-mathematical model by the probabilistic-statistical view. This change was brought about not by abstract reasoning but by the force of events within the field of science itself.

The Entropy Principle

29. The Newtonian equations of motion became increasingly unmanageable with the increase in the number of particles requiring to be taken into consideration. It soon became necessary to study the properties of a system comprising a large number of particles. The object now was not to ascertain the motion of each single particle separately, but to investigate the collective properties of all the particles taken together. Concepts and results already available in the theory of errors of observation were pressed into service to develop the kinetic theory of gases. A parallel development of the subject of thermodynamics led to the emergence of the entropy principle. The central concept in the second principle of thermodynamics is again randomness, so that the principle of the increase of entropy is recognized as nothing but the increasing degree of randomness of the physical universe.

The Uncertainty Principle in Physics

30. A further shift to a statistical model occurred with the development of statistical mechanics culminating in the enunciation of the uncertainty principle by Heisenberg which denied the possibility of absolutely certain knowledge of both the position and the motion of a particle at any given instant. From a theoretical point of view, the uncertainty principle would seem to make physical science essentially statistical in nature. The belief that complete certitude is an essential condition for genuine knowledge, however, still persists in certain quarters. The uncertainty principle is looked upon as belonging to the region of the very small and therefore not inconsistent with the deterministic view of the world as a whole.

31. I doubt whether the above view is tenable. If science is based on observation and measurement and if each set of measurements is a statistical sample, then all scientific conclusions must be of the nature of uncertain inference (with, in principle, a known margin of uncertainty). The contrast can be clearly seen in the distinction between a mathematical constant and a statistical or physical quantity based on observations. The ratio of the circumference to the diameter of a circle is a mathematical abstraction and, therefore, not subject to any fluctuations. All physical quantities, on the other hand, are based on observation and measurement, and are therefore statistical estimates, necessarily subject to a margin of uncertainty. On this view, all scientific predictions must be characterized, in principle, by a margin of uncertainty.

Inductive Logic

32. It may be observed at this stage that J. S. Mills' empiricism is a departure from rationalism only in form, in as much as the aim of Mills' inductive logic still remains "certain" inference. Similar attempts were made much earlier in India to go beyond the purely formal-deductive process. Sir Brajendranath Seal has given an interesting account of the doctrine of inference in the *Positive Sciences of Ancient Hindus* (1915), from which certain extracts have been given in Appendix (3). All these attempts, however, had certitude as the aim of inference. But in Indian thought, it was recognized, in one sense, that this aim is unattainable in practice. B. N. Seal noted for example:

> "Ultimately we all have to fall back on the rational practice of thinking persons, and such persons are always content to act on practical certitude instead of hankering after an unattainable apodectic certainty

in the affairs of life. This same practical certitude is also the ultimate warrant of the Deductive-Inductive Inference by which we ascertain the characters of things without direct perception and through the medium or instrumentality of a mark."[10]

Fallibility of Scientific Knowledge

33. I have been trying to place before you the view that in all scientific knowledge (being based upon evidence which is formally incomplete) is only probable and never absolutely certain. All predictions based on scientific knowledge must, therefore, be fallible, and must in fact prove wrong, in the long run, to the anticipated extent. Ernest Nagel observes that those

> "who maintain that our knowledge of matters of fact is "probable" do not thereby maintain that such knowledge is inferior to knowledge of some other kind obtainable by methods different from those the natural sciences employ. On the contrary, they maintain that "probable knowledge" is the only kind of knowledge we can find or exhibit, and that the methods and techniques of the sciences are efficacious and dependable precisely because they make available knowledge of that character."[11]

Thus in the whole field of science, the deductive-mathematical process of absolutely certain inference is being replaced by the probabilistic-statistical method of uncertain inference. Ernest Nagel has stated the position very clearly:

> "The long history of science and philosophy is in large measure the history of the progressive emancipation of men's minds from the theory of self-evident truths and from the postulate of complete certainty as the mark of scientific knowledge."[11]

Determinism and Uncertainty

34. If the probabilistic model is accepted as a closer approach to reality, then interesting consequences are likely to follow in the field of human thought and philosophy. I have no competence to discuss such issues, but one or two observations may not be entirely out of place. All knowledge based on science, and hence all scientific predictions about the future must be recognized, in principle, as uncertain. It is possible however to admit, in principle, that knowledge about the past may be of a deterministic type. The uncertainty about the future may then be interpreted as supplying an opportunity for fresh creation (at least, as perceived by the human mind). In fact, the 'present moment' on this view is the actual occasion of an ever-continuing stream of creation which is marked in rational thought by the transition from a deductive-mathematical to a probabilistic-statistical model of reaity.

Statistical Methods in the Concrete

35. I have so far considered the statistical method in the abstract. A brief survey of the scope and range of the statistical method in the concrete is also of interest. A convenient way of doing this is to construct a kind of mental map of scientific activities. We may start with a geometrical point at the centre to represent pure mathematics. On the view which

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[10] *The Positive Sciences of Ancient Hindus*, 1915, p. 269.

[11] *Principles of the Theory of Probability*, 1939, pp. 3-4.

I have expounded, pure mathematics (being fundamentally deductive in nature) does not itself belong to the field of science; and can be, therefore, appropriately represented by a mathematical point which has "position but no dimension".

PHYSICAL SCIENCES

36. We may draw a small circle round the centre to represent classical physics in which although the form is still mathematical, actual knowledge is based on measurements subject to errors of observation and hence falling within the scope of statistical theory. A second larger circle may be drawn to represent the area of kinetic theory of gases, statistical mechanics, and thermodynamics. In this region, factors of variation are amenable to a large degree of control so that the classical method of experimentation (isolating and studying one single factor at a time) is still available.

BIOMETRY

37. A third larger circle may be drawn to demarcate an area where the factors of variation are more complex and less liable to control. This broadly represents the field of biological variation. In 1900 Karl Pearson coined a new word "biometry" to indicate broadly the methods particularly appropriate to this area. This fruitful concept of statistical correlation historically had its origin in this field.[12] In the field of biometry, the fluctuations and variations are themselves of great importance, and often supply convenient yard-sticks for purposes of measurements.

38. During the last 50 years, biometry has become a very large branch of statistical science. It covers practically the whole field of biology and genetics including agriculture and the study of livestock. Biometric methods are also being increasingly used in psychology, education, and the medical and social sciences including the study of the human factor in industry.

39. In dealing with living units, it is usually impossible to use the classical method of isolating and studying one single factor at a time. For example, in studying the increase in the yield of crops due to improved seeds or fertilizers or better method of cultivation, fluctuations in the fertility of the soil from plot to plot, the influence of weather conditions, and many other factors of variation are always present and can not possibly be isolated. A radical departure had become necessary which took place, about a quarter of a century ago, in the development of the design of experiments and the analysis of variance under the leadership of R. A. Fisher. He himself has observed:

> "No aphorism is more frequently repeated in connexion with field trials than that we must ask Nature few questions, or, ideally, one ques-

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[12] In 1877 when Sir Francis Galton measured the size of sweet peas in his studies of heredity, he found a "regression" of the size of the daughter seed, compared to the size of the mother seed, towards the general mean. He found the same thing again in connexion with his observations on the height of fathers and sons. These studies led to the development of the theory of regression and correlation by Karl Pearson and others. It is worth noting that Gauss himself had used the product term in his investigations on the theory of errors, but had failed to reach the concept of correlation. The French astronomer Bravais (1811-63) worked on what is in essence the mathematics of correlation, as early as 1846. The concept of regression and correlation, however, did not emerge until 40 years later, and this also, only under the stimulus of the study of biological variations. This perhaps is a corroboration of the view that statistics is essentially an applied science and not a branch of mathematics.

tion at a time. The writer is convinced that this view is wholly mistaken. Nature, he suggests, will best respond to a logical and carefully thought out questionnaire; indeed, if we ask her a single question, she will often refuse to answer a single question, she will often refuse to answer until some other topic has been discussed."[13]

40. The central aim of the design of experiments is to make experimental observations in such a way that the different factors of variation would have scope to come into play in a balanced fashion so that it would be possible to study the influence of single factors as well as of various combinations of factors at the same time. In fact, R. A. Fisher has remarked: "The more thorough the design of the experiment, the more meaningful is the question asked." Actual experience has shown abundantly the great advantages (in economy of effort, time and adaptability) of using appropriate designs in scientific and technological experiments of all kinds.

41. The fact of variation is as universal in the field of industrial production as in biology. Even with machines of the highest precision, no two units are identical in size or other specifications. Usually there is the additional complication of fluctuations in time, but such fluctuations themselves often supply convenient yard-sticks for diagnostic purposes. So long as the fluctuations remain stable, the system may be considered to be under statistical control. W. A. Shewhart used this fundamental concept to develop 'control limits' and 'control charts' to enable the quality or output of manufactured products being maintained at a desired level. These methods found wide applicatons during the war. In fact, without the use of such methods, war production in the United States and other allied countries could never have been sufficiently stepped up. After the war, the use of 'quality control' methods is steadily increasing all over the world, and a beginning has been made in a small way in India also.

Statistical Sampling

42. We may add a fourth circle to demarcate the region in which the appropriate tool is statistical sampling. Factors of variation are now more complex and are usually not amenable to experimental control. This is the field where the traditional method of the exhaustive census or the attempted complete count has been used for a long time. R. A. Fisher has recently described the present position:

> "The words sample and sampling, like the word random, have always been central in the development of mathematical, or theoretical statistics. With the increased understanding and integration of our science they have now, as it were, overflowed from the world of abstractions in which they were generated and refined, and have, in fact, supplied the most adaptable, rapid, economical, and, in the true sense, scientific method of factual ascertainment which we yet possess.

> "I have made four claims for the sampling procedure. About the first three, adaptability, speed and economy, I need say nothing further. Too many examples are already available to show how much the new method has to give in these ways. But, why do I say that it is more scientific than the only procedure with which it may sometimes be in competition, the complete enumeration? The answer, in my view, lies in the primary process of designing and planning an enquiry by

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[13] The Arrangement of Field Experiments, *Journal of the Ministry of Agriculture*, Vol. 33 (1926), p. 511.

sampling. Rooted as it is in the mathematical theory of the errors of random sampling, the idea of precision is from the first in the forefront. The director of the survey plans from the first for a predetermined and known level of precision; it is a consideration of which he never loses sight; and the precision actually attained, subject to well understood precautions, is manifest from the results of the enquiry".[14]

Rapid developments in this field have taken place during the last ten or twelve years in which India has made significant contributions. I shall come back to this subject a little later as it is of great current interest in India.

Free Observations

43. We may now add a fifth circle to indicate the area in which factors of variation are neither amenable to control, nor to experimentation, not even, in the usual sense of the term, to sample-surveys or sample-censuses. Here the only possible approach is the patient collection of observations followed by classification and painstaking investigation of possible statistical relationships. Experimentation is no longer possible, but it is still feasible to compare predictions with subsequent observations. Statistical methods are particularly appropriate in this field. I shall give one example from my own experience.

44. In 1926 a catastrophic flood occurred in the Brahmani river in Orissa. An expert committee of engineers appointed by the Government of India reached the conclusion that the bed of the river had risen by several feet and consequently the flood level was likely to be higher in future. The Committee naturally recommended raising the height of the embankments by several feet to give protection against higher floods. At the request of the Government of Bihar and Orissa, I made a detailed statistical study, and found a significant correlation between the rainfall in the catchment area and the height of the river flood in the delta.[15] Using the statistical relationship, I found that the abnormal rise in 1926 could be reasonably ascribed to exceptionally heavy rainfall in the catchment areas. On the basis of such statistical evidence, it was possible to advise Government that it was *not* necessary to increase the height of the embankments. This advice was given in 1930. The fact that no great change has occurred in the severity or frequency of floods during the last 20 years shows that the statistical findings were correct. Direct experimentation in such cases is out of question; the statistical method supplies the only valid tool for scientific investigation.[16]

Statistics in Everyday Life

45. The importance of statistics in the field of science is due to its supplying the general method for inductive inference. The growing im-

[14] Presidential address on "The Sub-Commission on Statistical Sampling" at the session on Sampling, International Statistical Institute, Berne, September 1949.

[15] One technical point deserves notice. The catchment area was divided into two portions, and the rainfall in the two catchments were used as two separate variates for correlation with the height of the river flood.

[16] I should like to include in the mental map the field of operational research in which the available information is either too meagre, or is not in a suitable form for the calculation of the probability involved in the problem. In such cases a decision, however, has to be reached by balancing the risks of gain and loss but without the formal use of the probability calculus. Operational research thus comes within the general scope of the statistical method.

portance of statistics in public estimation, on the other hand, is mainly due to its increasing practical applications in the affairs of everyday life. It is necessary to remember that at one time physical science itself was held in low esteem in the public eye and was often a subject of contempt and ridicule. It is interesting to observe that Thomas Sprat made the following observations in 1667, five years after the foundation of the Royal Society, London:

> "It is not to be wonder'd at if men have not been very zealous about those studies, which have been so far removed from present benefit, and from the applause of men. For what should incite them to bestow their time, and Art, in revealing to mankind, those Mysteries; for which, it may be, they would be only despis'd at last? How few must there needs be, who will be willing, to be impoverish'd for the common good? While they shall see, all the rewards, which might give life to their Industry, passing by them, and bestow'd on the deserts of easier studies?[17]

46. It is only with the great technological achievements of physical science that public opinion changed in a remarkable manner, and it rose in public esteem. It is this public esteem which enabled the physical scientists to secure sufficient leisure, support, and recognition to pursue their researches free from care and anxiety. This also led to the growth of the belief that scientific research is pure in the degree in which it is removed from practical applications.

'Pure' and 'Applied' Science

47. I am prepared to admit that a distinction may perhaps be made between 'pure' and 'applied' science. A subject like physics, for example, has a clear responsibility for developing a picture of the universe in terms of physical concepts and elements even if this picture has no practical applications. This is also true of other 'pure' sciences like chemistry, botany, zoology or geology; each has the task of supplying a world-picture in its own terms. In an applied science like engineering, the position is quite different. It has no responsibility (nor any possibility) of giving a general theory of the world in terms of engineering. Its only task is to solve a practical problem. It must, of course, undertake research in its own field. As regards mathematics, it is simply not possible to have too much help from that subject, but there is no such thing as 'mathematical engineering'.

Statistics—Essentially an Applied Science

48. In the same way, statistics is essentially an applied science. Its only justification lies in the help it can give in solving a problem.[18] Its aim is to reach a decision on a probabilistic basis, on available evidence. If the problem is one of a theoretical nature, statistics supplies a valid method for drawing general conclusions from particular experience. If the problem is a practical one, statistics supplies the basis for choosing a particular course

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[17] *History of the Royal Society*, London, 1667, p. 27.

[18] I should like to stress again that statistical theory is not a branch of mathematics. Statistics, like engineering, requires all the help it can receive from mathematics; but in my opinion, 'mathematical statistics' as a *separate* discipline cannot simply exist.

of action (in preference to other possible courses) by balancing the risks of gain and loss. This is why Clark Maxwell once remarked that "the true logic for the world is the calculus of probability."

The Social Background of Statistics

49. In statistical research the greatest stimulus has always come from the need of solving practical problems. R. A. Fisher's work on the design of experiments was due to the urgent need of solving the deadlock in agricultural field trials. W. A. Shewhart's work on quality control arose from the need of improving the efficiency of inspection in large scale production. On the organizational side also, statistical work is closely determined by the special needs of the country and by the socio-economic frame-work. Statistics is not only an applied science but is also a public science. It is because of the close connexion with public activities that big developments in statistics have always occurred only when there has been need of unified policy and co-ordinated action in times of war or peace. I shall give three examples.

50. For a long time the volume of statistical work was greater in the United States than in other country of the world. But it was only during the New Deal in the 1930's when unified governmental policy became indispensable in the economic field, that effective action was first taken for the central co-ordination of the statistical activities of the Federal Government. Other large developments took place because of the need of planning in war production, and it was only in 1942 that an Act was passed to assign definite statutory responsibilities to the special Division of Statistical Standards in the executive office of the President of the United States.

51. In the United Kingdom also, under *laissez faire*, statistics had been developing in a more or less haphazard manner without any focal centre within the governmental machinery. All this, however, changed rapidly owing to the need of total planning during the war. A Central Statistical Organization was set up and was entrusted with the duty of reviewing and making a critical appreciation of all statistical information required by the Cabinet. Although the different Ministries have their own statistical divisions, there is complete co-ordination at the top. After the war, the importance of the Central Statistical Organization has continued to increase with the growth of social and economic planning in the United Kingdom.

52. In the U.S.S.R., centralization in the statistical field has gone much further. From the beginning a Central Statistical Bureau has been an integral part of the GOSPLAN. No plan can be put into operation until it is cleared by the Statistical Bureau. The Bureau not only helps in preparing the different plans, but also submits reports on the progress of such plans on the basis of the information collected directly by the Bureau. In 1947 it had in fact a staff of 22,000 scattered all over Russia and paid and controlled directly by the Bureau. Central control by statistical methods is thus complete in the U.S.S.R.[19]

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[19] It is interesting to note that about a year ago, the Central Statistical Bureau was removed from the GOSPLAN and was placed directly under the Council of Ministers (which corresponds to the Cabinet in India). This would seem to indicate that the Bureau now has the further responsibility of submitting reports on the GOSPLAN itself.

53. In India also there was a great deal of expansion in statistical work during the war without, however, any central co-ordination. Such lack of co-ordination was inevitable in the absence of any coherent over-all economic policy. Until the Government of the country has an urgent sense of the need of statistical services in shaping policy and programme of action, little progress is possible. In spite of much talk, no action was taken for central co-ordination in India until very recently. There was indifference and even hostility to new ideas and new developments. This is typical of the struggle through which scientific innovations must pass in order to establish their worth. I may illustrate these points by briefly recapitulating the story of sample-survey in India.

SAMPLE-SURVEYS IN BENGAL

54. For a long time, crop statistics was known to be unreliable in Bengal. In 1934 I discussed with Mr. H. P. V. Townend, I.C.S., (then Development Commissioner, Bengal) the possibility of using random samples for the improvement of the Jute forecast. On his initiative, a sample survey on an area basis was conducted over the whole province in 1935. I believe this was the first area-sample in the whole world.[20] The results were not satisfactory; chiefly, I thought, because of defective field work. A little later, the Indian Central Jute Committee approved a five-year scheme for a sampling method for the jute crop. Work was started, on a very small scale, in 1937, and an efficient sampling plan was developed by the Indian Statistical Institute by a series of annual surveys, on a gradually expanding scale, until the whole province was covered in 1941.

55. Three tests had been laid down for the sampling plan which were adequately fulfilled. The method was speedy, inexpensive, and the margin of uncertainty of the provincial estimate was only about 2 per cent. Influential opinion was, however, still strongly opposed to the scheme, and it was terminated at the end of 1941. Since then it has passed through many vicissitudes.

56. The sample-survey was revived in 1942 for only one year. Since 1939 I had been pressing Government to have the sampling plan extended to rice. In view of the cessation of the supply of rice from Burma, which by this time had fallen to the Japanese, I sent to a high agricultural official in New Delhi in March 1942 a plan for a sample survey of rice in Bengal; my letter was not acknowledged. In 1943 a famine broke out in Bengal and caused the death of a million-and-a-quarter or a million-and-a-half of men, women, and children. The sample-survey was started afresh in April 1943; stopped after two months in June; and again started in August and extended to the rice crop for the first time, owing chiefly to the urgent need of food statistics.

57. The adequacy and reliability of the sample-survey was challenged on every occasion. In fact, a sample-survey of crops which had been started in Bihar in 1943-44 was discontinued after one year on the advice of the Agriculture Department of the Government of India, in spite of my earnest pleadings in personal discussions, and in a letter which I sent to New Delhi on the 23rd March 1945. In Bengal also, the position was precarious in 1944.

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[20] As far as I know, Sir John Hubback was the first person to consider random sampling for estimating crop areas; but he did not use it in practice. His own work was concentrated on statistical sampling for the yield of rice in Bihar and Orissa in the early 1920's. His original report "Sampling for Rice Yield in Bihar and Orissa" published in 1927 as Bulletin No. 166 by the Agricultural Research Institute, Pusa, was reprinted it *Sankhyā*: the Indian Journal of Statistics, Vol. 7, Pt. 3.

However, after many debates and discussions, the Government of Bengal decided to continue the sample survey and also to organize a plot-to-plot enumeration with a view to comparing the two methods.

Comparison of the Survey and the plot-to-plot Enumeration in Bengal: 1944-45

58. In accordance with the above decision, a plot-to-plot enumeration was conducted directly by the Government of Bengal in the winter (*aman*) rice season of 1944 and the jute season of 1945; while the sample survey was conducted by the Indian Statistical Institute. The sample survey was, of course, much more economical. The total cost of the plot-to-plot enumeration was about Rs. 82 lakhs (about £61,500 sterling) while the cost of the sample survey was Rs. 8 lakhs only, or just one-tenth. The intensity of sampling was unusually heavy, owing to the desire of Government to have breakdowns into 28 smaller geographical units (districts). For a provincial total, or for 3 or 4 regional breakdowns, the cost of the sample survey could have been easily reduced to Rs. 6 lakhs or even Rs. 4 lakhs. From the experience of about 12 years of work in Bengal, we have found that a sample-survey of crops can be conducted at a cost of only a fifteenth or a twentieth of that of a complete count.

59. It is, however, in the matter of precision that the sample survey has the greatest advantage. It is possible to make a direct comparison for the jute crop of 1945 in Bengal. Jute being primarily a cash crop, accurate export and trade figures become available about 15 months after the harvesting season. The sample-survey estimate, submitted to Government in September 1945, was 7,540 bales of jute.[21] The official forecast in the same month based on the plot-to-plot enumeration was 6,304 bales. According to the customs and trade figures which became available in January 1947, the Bengal production was 7,562 bales. The plot-to-plot enumeration gave an under-estimation of 16.6 per cent, while the sample-survey figure differed by only 0.3 per cent from the estimate based on trade figures. Details of the comparison are given in Appendix (4). The plot-to-plot enumeration was ten times more expensive, and yet gave entirely inaccurate results.

60. The reason for the greater reliability of the sample-survey is clear. The total staff employed in the plot-to-plot enumeration was about 33,000 against roughly about 600 or 700 in the sample-survey. Sample-surveys require a much smaller staff. It is, therefore, always possible to employ a better trained staff on higher pay, and also to maintain close supervision on their work. In consequence, the primary material in sample-surveys is usually of much better quality and furnish final estimates of greater accuracy.

61. In Bengal, the superiority of the sample-survey was finally acknowledged in January 1948, when the sample-estimates were ordered by the Government of the Province to be accepted in future as official crop-estimates. It had taken eleven years (since 1937) to achieve this result.

62. A good deal of similar evidence has accumulated in other countries of the world. I shall refer to some very recent work in Japan. At the request of the Occupation Authority, the Japanese Government con-

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[21] 1 bale = 400 lbs. of jute.

ducted in 1948 a plot-to-plot enumeration of crops throughout the country. Sample-surveys were superposed to assess the accuracy of the plot-to-plot enumeration. The sampling work was done with great care, in fact, with plane table operations with the help of surveying instruments. The combined under-estimation (due to both non-reporting of field and under-statement of crop area reported) was about 9.5 per cent for paddy rice, 20 per cent for mixed cereals, more than 26 per cent for sweet potatoes and fully 35 per cent for upland rice.[22]

Recent Changes in Attitude

63. In recent years the sampling method has won increasing recognition all over the world. In 1947 the United Nations established a Sub-Commission on Statistical Sampling which has already met three times in 1947, 1948 and 1949, and has issued three reports covering a very wide field. In India also there has been a distinct change of attitude. The Government of India are seriously considering the possibility of using sampling methods in the field of agricultural statistics. This has been brought about partly no doubt by the increasing prestige of the method outside India. But it is also symptomatic of a deeper change. The Government of India are giving increasing attention to the all round improvement of the statistical services of the country. This in its turn is due to a growing awareness of the urgent need of unified economic policy and action on the part of Government. It is the urge of solving vital national problems which is giving real strength to the progress of statistics in India. I shall now turn to some of these problems.

The Food Crisis in India

64. The biggest single problem in India at present is the shortage of food supply. On the 28th November 1949, Jawaharlal Nehru, the Prime Minister of India, is reported to have declared "I desire to make it perfectly clear that whatever happens, whether there is a cyclone or an earthquake, we are determined to stick to the target date of 1951, after which we shall not import food grains for our consumption." He stated that this decision had been forced on the country by the pressure of events, for no country could continue to live beyond its means which of course meant its production in its fields or its factories.

65. I shall try to give a statistical commentary on the Prime Minister's statement. This will serve two purposes. It will show how statistics comes into the picture, and how statistics can help in solving the problem. It will also show how inadequate is the available statistical information, and how much it requires to be improved. The figures quoted by me are, therefore, necessarily illustrative.

Increasing Pressure of Population

66. The food position can be judged only in relation to population and other resources of the country. We know the total geographical area of the Indian Union. It is about 1.22 million sq. miles or 780 million acres.[23]

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[22] United Nations document E/CN.3/Sub.1/17. Appendix C, pp. 27-32; and also an article on the "Incompleteness in a Census of Crop Areas in Japan" by Charles F. Sarle in *Agricultural Economics Research*, April 1949 (published by the United States Department of Agriculture).

[23] 3.159 million sq. kilometers.

As regards the population, the last decennial census was taken in February 1941. Since then conditions have been abnormal owing to war, the famine in Bengal in 1943, and the partition in August 1947 with subsequent large shifts of population. On the available information, the total population at present would seem to be something between 34 and 35 crores (340 and 350 millions).

67. The density of population is thus very high, something like 290 per square mile, which is bigger than the density in most countries of the world with the exception of the highly industrialized countries in Western Europe, and Japan. If we consider the individual share, in India we have only about 2.25 acres per head.[24] In comparison, China presumably has about 6 acres, the United States about 13 acres, and the U.S.S.R. nearly 28 acres for each individual. The pressure on land is many times greater in India compared to other countries with a large population.

68. The population is also increasing at a rapid rate. Between 1931 and 1941 the rate of increase was about 1.4 per cent for the Indian Union.[25] If this rate is being maintained, the population of India is increasing at present by about five millions every year. This is more than the total population in each of about 24 or 25 member States of the United Nations. Owing to the adverse conditions created by the war and the partition of India, the rate of growth may have slowed down. If it is only 1 per cent, the increase is still something like 3.5 millions per year.[26]

Inadequacy of Food Statistics

69. About population we have some information. The position is much worse about food statistics. In one province, West Bengal (covering only about 2.5 per cent of the total area of India), statistical sampling is being used and can be depended upon to supply estimates of the production of rice with a margin of uncertainty of about 2 per cent. For roughly half the area, reports are available from *patwaries* (village revenue staff) or *chowkidars* (village watchmen) but nothing is known about their accuracy as no objective checks have been made. In roughly one-fifth of the whole area, reports are received from the State authorities, but nothing is known about the primary agency. No reports whatsoever are available about the food production for the remaining 30 per cent of Indian Union and a conventional figure is written down in New Delhi. In spite of the Grow More Food campaign conducted for several years, according to official estimates of the Ministry of Agriculture, apparently no appreciable increase has occurred in the production of food. It is best to confess that we really do not know the real position.

Critical Balance between Food and Population

70. There is some indirect evidence. Actuarial estimates on the basis of the decennial censuses between 1881 and 1931[27] show that there has

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[24] The total area under cultivation in India is not known accurately. It is probably something like 35 or 40 per cent of the whole area. The share of cultivated land is thus well below one acre per head.

[25] *Census of India Paper No.* 2, p. 6 (Government of India). The rate of growth during the same period in undivided India was 1.5 per cent per year.

[26] During the 40 years between 1901-1941 the average rate of increase was about 1 per cent per year in undivided India and over 0.8 per cent per year in the Indian Union. Even at this lower rate, the increase would be about 3 millions per year.

[27] No information is available for the 1941 census, as age-tables were not prepared. These are, however, now being constructed in the Indian Statistical Institute on the basis of the 2 per cent Y-sample.

not been any appreciable increase in the expectation of life at birth which hovered round or below 25 years during this period. This suggests that, although population increased at a rapid rate, there was no over-all improvement of the vitality of the people.

71. The famine in Bengal in 1943 was also an ominous indication. From the information collected in the course of a sample survey of famine conditions, I believe the total number of deaths was something between one-and-a-quarter and one-and-a-half million. The total loss (killed and missing) in the second world war was about 330,000 for the U.S.A., and 300,000 for the United Kingdom.[28] Thus the famine casualty in Bengal was double or more than double of the total war casualty for the U.S.A. and the U.K. taken together. It may be noted that in 1943, the area of the undivided province of Bengal was about 78,000 sq. miles, and the estimated population about 63 millions. The density was thus of the order of 800 per sq. mile, which was higher than that in even the most highly industrialized countries of the world. This terrific pressure of population was probably a predisposing factor in the famine.

Increasing Food Imports

72. Some further indirect information is available from export and import statistics. Before the separation in 1937, Burma provided an abundant supply of rice. During the first two or three years of the war, the net import was negligible as the following figures will show:

Net Import of Cereals per Person

financial year	extrapolated population in millions	net import of cereals in million tons	import in lbs per year per person
(1)	(2)	(3)	(4)
1941–42	390.3	0.43	+ 2.5 lbs
1942–43	395.4	−0.29	− 1.6
1943–44	400.4	0.33	+ 1.8
1944–45	405.5	0.73	+ 4.0
1945–46	410.6	0.93	+ 5.1
1946–47	415.7	2.42	+12.9
1947–48	335.2	2.18	+14.6
1948–49	337.9	2.78	+18.4

(1) Population figures for undivided India were calculated by linear interpolation with the observed growth rate between 1931 and 1941. Figures after partition are based on the *Census of India, Paper No. 2.*

(2) Up to 1942-43, net imports in col. (3) are taken from the *Food Statistics of India* (1946) published by the Food Department; from 1943-44, the figures are taken from *Indian Food Statistics* (August 1949) published by the Ministry of Agriculture. Since 1943-44 the figures relate to rice, wheat, maize, millet, barley and wheat flour, with a few minor variations.

[28] *Encyclopaedia Britannica; Book of the Year*, 1946, p. 846.

73. In 1943-44, the year of the Bengal famine and the first year of introduction of food rationing, the net import was quite small and only about 1.8 lbs. per head per year. During the last five or six years, the position has grown steadily worse. The net import rose to about 18 lbs. per head in 1948-49, and the expenditure incurred was something like Rs. 120 or 130 crores (about £100 million sterling). The significance of this figure can be appreciated when it is recalled that the total revenue budget of the Government of India in 1949-50 is of the order of Rs.320 crores (£240 million sterling).

74. Another aspect of the problem is even more serious. If the food production and the home consumption remain constant, then the surplus coming to the market would also remain constant. In this situation, the total import should increase in proportion to the growth of population. In actual fact the import rose from 0.33 million tons in 1943-44 to 2.78 million tons in 1948-49, an increase of more than eight times in five years. This definitely shows that the supply coming into the market (through procurement or otherwise) has been steadily decreasing. This is the most alarming feature of the present situation.

Statistical Basis of a Rational Food Policy

75. What is the solution? There is obviously no single remedy. The problem has to be attacked on many fronts, and statistics can help on all fronts. I shall briefly try to indicate the magnitude of the task. First, every effort must be made to increase the crop production. Fertilisers, improved seeds, irrigation, and better methods of cultivation are already being used and must be pushed much further. Experimentation at the research level in agricultural field trials must be continued and developed with closer gearing to actual conditions of cultivation. Another possibility is the improvement of varieties through fundamental research in genetics. The spectacular increase in the yield of Indian corn (maize) is a striking example of the success of such researches. Rice offers a promising field for similar work, and an increase of 25 per cent or 30 per cent in the yield is a definite possibility. Well-equipped centres for the study of rice genetics should be, obviously, established without delay. Here statistics can render effective help. In fact, in the field of agricultural experimentation and genetics, powerful methods like the design of experiments, the analysis of variance, and the theory of estimation are already available.

Increasing Difficulties in the Future

76. It is certainly necessary to attain self-sufficiency in food in 1951. But this is not enough. The production of food must keep pace with the growth of population. But not only food, it is also necessary to produce new houses, clothes, and thousands of other things in increasing quantities. Production must keep pace with population. The future trend of population in India is, therefore, a matter for serious concern. Available evidence indicates that at the existing level of production, the balance has already become adverse. A further and continual growth of population without a commensurate growth in the means of production will be disastrous. The only way is to develop our national resources.

Industrial Development

77. Rapid industrial development is one possibility. Government have already started work on a number of big multi-purpose dams for both

irrigation and power. A beginning has also been made with machine tools and other basic industries and heavy chemicals. The building of houses, electricals, and other innumerable industries (including production of consumer goods) must be stepped up. All this would require capital goods in the way of plant and equipment, land and buildings, and labour.

78. It will be useful to obtain even a very rough idea of the capital requirement. The ratio of the gross value of the annual product to the capital investment varies widely from one industry to another. The ratio would be small in the case of iron and steel or basic industries; the gross value of the annual product may be something like one-third, or one-fourth, or even one-fifth of the invested capital. In electricals and lighter industries the ratio may be unity or even higher. Unfortunately very little information is available.[29] At a rough guess, the over-all value of the ratio is likely to be something between half and unity.

79. It is also necessary to take into consideration what the economists call the 'multiplier' effect. To put it crudely, the multiplier stands for the additional value of products, and business and other activities stimulated by the increase in the primary product. (For example, an increase in the production of steel and cement may be expected to lead to an increase in the building of houses and construction work and other industries in an indirect way). No information is available about the value of the 'multiplier' in India. It is sometimes guessed that the multiplier may be something like 1.5 or so. To get a dimensional figure, we may perhaps assume that an investment of, say, one crore of rupees would lead to an increase of an equal amount in the national product (inclusive of the 'multiplier' effect). The actual ratio may be somewhat higher or somewhat lower, but this would give a rough dimensional picture.

80. Consider the implications. To increase the value of the national product by one rupee per head per month or, say, twelve rupees per head per year, it is necessary to invest 420 crores of rupees (=Rs. 12×35 crores) or £310 million sterling. Compare this figure with the budget of the Government of India which is something like Rs. 320 crores (£240 million sterling) in 1949-50. Even if this whole amount is used for industrial development, the value of the national product is not likely to increase by more than, say, twelve annas or a rupee per head per month. It is clear that the Government of India alone can do very little. The industrial development of India depends entirely on the efforts which the people of the country are prepared to make.

THE NATIONAL INCOME

81. The next question which arises is the extent to which the people can afford to contribute to industrial development. Investing one rupee would bring a return of one rupee in future years; but whether one can afford to invest even one rupee depends on his income. This brings us to the question of the national income of India. Again, little reliable information is

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[29] It may be noted that the over-all ratio of the annual value of the product to the invested capital is about 1.6 in the case of the industries covered by the Industrial Census of 1946 (Ministry of Industry and Supply). It must be remembered, however, that most of the capital investment took place long ago, while the annual product was valued at 1946 prices. If the value of the plant, machinery, and building is re-calculated at 1946 or current prices the total amount of capital investment would be much higher than that actual shown in the returns. That is, the ratio would certainly fall much below 1.6.

available.[30] Again one can only guess. Perhaps, the monthly income is Rs. 12/- or may be. Rs. 15/- per head. We do not know, but this may be the right order. We have also the other guess, of 'a rupee for a rupee,' that is, a future national dividend of one rupee for a present investment of one rupee. The choice is definitely between jam today and jam tomorrow. We cannot have both. Indeed, unless we save and invest for the future, we may have less and less in future.

The Statistical Position

82. With meagre material I have constructed a dimensional picture which is admittedly very rough. It will have served its purpose, if it has conveyed to you some idea about the magnitude of the task in front of us. Secondly, if it has made you feel the urgent need of having more and better statistics. Along with the efforts to increase food production, attempts must be made to improve the statistics not only of the production of food but of its consumption and distribution. A gap of 10 years between population censuses is no longer tolerable. It is necessary that we should have information about the growth of population every year. We require information about the distribution of income and expenditure in different sectors of national economy, and in different strata of the population. We must, in fact, set about earnestly to develop a comprehensive system of social accounting for the whole nation.

83. Of capital requirements I have given a sombre picture. In one sense it is, however, not as dark as it looks at first sight. The capital investment is broadly of three kinds. First, machinery and equipment (and technical personnel) which we must import from abroad and must pay for ultimately in hard cash. Secondly, land and water, minerals, forests, livestock and animals, which we have in the country, and buildings and material equipment which we have or which we can produce in India. And finally, man-power and labour which we have in abundance. In the beginning, the share of imported equipment from abroad must be necessarily heavy; but as the basic industries develop, this item should become smaller and smaller. The other two items, man-power and material resources, are our own. The imputed value entering into the capital account is, in a real sense, a matter of book-keeping. We can make what we like of these items. If the people and the Government are united in one common endeavour, then the human labour and the material resources in the country are entirely at our disposal for national development.

84. If the statistical picture I have placed before you is not hopelessly wrong, then we are in difficult times and are probably facing greater difficulties than we have ever done in the past. The united effort of the Government with the people can save us. Such united effort can be brought about only by concerted action. To prevent waste of money, effort, resources, and most critical of all, to prevent, waste of time, planning on a national scale is essential.

National Planning

85. National planning has several aspects. First, there is the preparation of plans at the technical level requiring the help and cooperation

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[30] Pioneer work was done by Dr. V. K. R. V. Rao who gave in 1940 an estimate of the natonal income for1931-32; and in 1944 gave a tentative estimate for 1942-43. No authoritative estimates for recent years are yet available. The Government of India have appointed a National Income Committee in August 1949, to review the position and make such estimates as may be possible.

of workers in every branch of science and technology. Statistics is indispensible at this stage for the supply of basic information. Secondly the individual plans have to be built into a general plan. Here statistics is the common denominator, and supplies the common binding medium for the whole. Thirdly, the plan has to be implemented. At this stage also, statistics can help in two ways. Firstly, by establishing scientific controls to ensure the programme of action proceeding on efficient lines. Secondly, by conducting continuous assessments of the results by keeping account of the input of money, effort, and resources, and measuring what is obtained in return. The process is never-ending. In the actual working of the plan, defects are revealed, and new possibilities emerge requring consequential changes. Statistics is again invaluable in diagnosing weaknesses, in guiding controlled experiments, and in suggesting improvements. Statistics is thus an integral part of the dynamics of national planning. I hope this is a proper answer to the question: Why statistics?

Recent Developments in India

86. As I have already indicated, the progress of statistics must, therefore, depend upon and is closely determined by socio-economic trends. In India, we have seen during the last one year, hopeful signs of advance. A Standing Committee of Departmental Statistics with representatives from the different Ministries of the Government of India was established in October 1948. A Central Statistical Unit was created, under the charge of a Statistical Adviser to the Cabinet on the 28th January 1949. For the first time a permanent office for the Census and Vital Statistics was established under a Registrar-General and ex-officio Census Commissioner in May 1949. A first comprehensive report on the industrial census of 1946 was published in July 1949. A National Income Committee was set up in August to review the position in this field and make such estimates as may be possible. And the Central Statistical Unit was converted into a Central Statistical Organization on the 21st December 1949. All this indicates a move towards a more comprehensive review and formulation of the economic policy of the country. We may also hope to reach again, of course, in a more modern form, the state of development in statistics which was reached in India in the days of the survey of Eastern India in early 19th century, in the days of Akbar at the close of the 16th century, or in the days of Asoka in the third century B.C..

The Choice Before Us

87. Our vast population is a great asset, but only in a potential form. In India we have every year a vast quantity of water in the form of rainfall. Most of it is wasted. Sometimes, in times of flood, it becomes a menace. But, by building dams and hydrels we can put it to work and make it a source of power for fruitful production. In the same way our vast man-power is at present lying mostly stagnant. A great deal remains idle, and a great deal is wasted in inefficient production. Perhaps it is wise to remember that, out of control, it may also become a menace fraught with grave dangers of self-destruction. But, if we can harness this living reservoir of power, there is nothing which we cannot accomplish.

88. So far attempts have been made to hire this power in a market place. We should think seriously whether we have the means, or the time, to continue to do so. Conditions are changing rapidly. It is a matter

for serious thought whether or not the wiser policy would be to rally the common man into a great effort for national welfare. We look to our political leaders for guidance, decision, and action.

89. In a national plan, scientists and technologists also have to make their contributions. They can give the labour of their thought, and by the skill of their research and experimentation, show how to overcome difficulties and open out new possibilities. The statisticians have a humble role, but they also can help in reaching vital decisions. To this greatt ask I call all my friends and colleagues.

APPENDIX 1

SURVEY OF EASTERN INDIA : 1807-1815

The following extracts are taken from the Introduction to "The History, Antiquities, Topography, and Statistics of Eastern India" by Montgomery Martin, London, 1838 :

The Survey of the districts of Behar and Patna, of Shahabad, Bhagulpoor, Dinajepoor, Goruckpoor, Puraniya, Rungpoor, and Assam, forming the Eastern territories of British India, and containing upwards of 60,000 square miles and nearly 15,000,000 of British subjects, was executed by the Supreme Government of Bengal, under orders from the Court of Directors of the Honourable East India Company, dated the 7th of January, 1807, wherein the Honourable Court observe, "We are of opinion that a statistical survey of the country, under the immediate authority of your Presidency, would be attended with much utility; we therefore recommend proper steps to be taken for carrying the same into execution."

The extent of the investigation will be seen from the directions issued for the guidance of the survey by the Supreme Government under date 11th Sept. which were as follows :—

"Your inquiries are to extend throughout the whole of the territories subject to the immediate authority of the Presidency of Fort William.

"The Governor General in Council is of opinion that these inquiries should commence in the district of Rungpur, and that from thence you should proceed to the westward through each district on the north side of the Ganges, until you reach the western boundary of the Honourable Company's provinces. You will then proceed towards the south and east, until you have examined all the districts on the south side of the great river, and afterwards proceed to Dacca, and the other districts towards the eastern frontier.

"Your inquiries should be particularly directed to the following subjects, which you are to examine with as much accuracy as local circumstances will admit.

'I. A Topographical account of district, including the extent, soil, plains, mountains, rivers, harbours, towns, and subdivisions : together with an account of the air and weather, and whatever you may discover worthy of remark concerning the history and antiquities of the country.

"II. The Condition of the Inhabitants; their number, the state of their food, clothing and habitations ; the peculiar diseases to which they are liable ; together with the means that have been taken or may be proposed to remove them ; the education of youth ; and the provision or resources for the indigent.

'III. Religion ; the number, progress and most remarkable customs of each different sect or tribe of which the population consists ; together with the emoluments and power which their priests and chiefs enjoy ; and what circumstances exist or may probably arise that might attach them to Government, or render them disaffected.

'IV. The Natural Productions of the Country, animal, vegetable, and mineral ; especially such as are made use of in diet, in medicine, in commerce, or in arts and manufactures. The following works deserve your particular attention :

'1st. The fisheries, their extent, the manner in which they are conducted, and the obstacles that appear to exist against their improvement and extension.

'2nd. The forests, of which you will endeavour to ascertain the extent and situation, with respect to water conveyance. You will investigate the kinds of trees which they contain, together with their comparative value and you will, point out such means, as occur to you, for increasing the number of the more valuable kinds, or for introducing new ones that may be still more useful.

"3rd. The mine and quarries are objects of particular concern. You will investigate their produce, the manner of working them, and the state of the people employed.

"V. Agriculture, under which head your inquiries are to be directed to the following points :

"1st. The different kinds of vegetables cultivated, whether for food, forage, medicine, or intoxication, or as raw materials for the arts : the modes of cultivation adopted for each kind ; the seasons when they are sown and reaped ; the value of the produce of a given extent of land cultivated with each kind. The profit arising to the cultivator from each, and the manner in which each is prepared and fitted for market. Should it appear that any new object of cultivation could be introduced with advantage you will suggest the means by which its introduction may be encouraged.

'2nd The implements of husbandry employed with the defects and advantages of each, and suggestions for the introduction of new ones, that may be more effectual.

"3rd. The manure employed for the soil, especially the means used for irrigation.

"4th. The means used for excluding floods and inundations, with such remarks as may occur to you on the defects in their management.

"5th. The different breeds of the cattle, poultry, and other domestic animals reared by the natives. The manner in which they are bred and kept; the profits derived from rearing and maintaining them ; the kinds used in labour ; whether the produce of the country be sufficient, without importation, to answer the demand, or to enable the farmer to export ; and whether any kinds not now reared might be advantageously introduced.

"6th. Fences the various kinds that are used, and that might be introduced, with observations concerning the utility of this part of agriculture in the present state of the country.

"7th. The state of farms : their usual size, the stock required, with the manner in which it is procured ; the expense of management the rent, whether paid in specie or in kind ; the wages and condition of farming servants and labourers employed in husbandry ; tenures by which farms are held, with their comparative advantages, and the means which, in your opinion, may be employed to extend and improve the cultivation of the country.

"8th. The state of the landed property and of the tenures by which it is held in so far as these seem to affect agriculture.

"VI. The progress made by the natives in the fine arts in the common arts and the state of the manufactures : you will describe their architecture sculpture and paintings and inquire into the different processes and machinery used by their workmen and procure an account of the various kinds and amount of goods manufactured in each district. It should also be an object of your attention to ascertain the ability of the country to produce the raw materials used in them ; and what proportion, if any is necessary to be imported from other countries and under what adnvantages or disadvantages such importation now is, or might be made ; you will also ascertain how the necessary capital is procured, the situation of the artists and manufactures, the mode of providing their goods the usual rates of their labour ; any particular advantages they may enjoy, their comparative affluence with respect to the cultivators of the land, their domestic usages, the nature of their sales, and the regulations respecting their markets. Should it appear to you that any new art or manufacture might be introduced with advantage into any district, you are to point out in what manner you think it may be accomplished.

"VII. Commerce ; the quantity of goods exported and imported in each district the manner of conducting sales, especially at fairs and markets ; the regulation of money, weights, and measures ; the nature of the conveyance of goods by land and water and the means by which this may be facilitated, especially by making or repariing roads.

"In addition to the foregoing objects of inquiry, you will take opportunity of forwarding to the Company's Botanical Garden at this presidency, whatever useful or rare and curious plants and seeds you may be enabled to acquire in the progress of your researches with such observations as may be necessary for their culture."

APPENDIX 2

THE IDEA OF DETERMINATE KNOWLEDGE IN ANCIENT INDIA

The following is reproduced from the Editorial, Sankhyā, Vol. 1, Part 1 (June 1933), pp. 3-4:

We are convinced that statistics represents a fundamental method of analysis of data in the mass which is applicable to any science of observation, and we feel that it is desirable to emphasize this essential unity in the methodology of statistics.

We believe that the idea underlying this integral concept of statistics finds adequate expression in the ancient Indian word *Sankhyā.* In Sanskrit the usual meaning is 'number,' but the original root meaning was 'determinate knowledge'. In the Atharva-Veda a derivative form *Sankhyātā* occurs both in the sense of 'well-known' as well as 'numbered.' The Lexicons give both meanings. Amara-kosa gives *sankhyā* = *vicāranā* (deliberation, analysis) as well as 'number;' also *sankhyāvān* = *panditah* (wise, learned).

The same dual sense is attached to its derivative form *Sānkhya* which is the name of the most famous analytic philosophy of ancient India. The name of the philosophical system is explained in both ways: as a philosophy based essentially on enumeration of the categories beginning with Nature or Root Cause. Or else a philosophy by which is revealed the adequate knowledge of reality. The root meaning is also met with in the Mahabharata in the Gitā portion where the *Sānkhya* system of philosophy is classifed with the Vedanta as being based on *jnana* (or intellectual cognition) as distinguished from the Yoga systems. Sridhara in his commentary on the Gitā explains *Sānkhya* as *samyag-jnana*, that is 'proper cognition' or 'adequate knowledge.'

The history of the word *sankhyā* shows the intimate connexion which has existed for more than 3000 years in the Indian mind between 'adequate knowledge' and 'number.' As we interpret it, the fundamental aim of statistics is to give determinate and adequate knowledge of reality with the help of numbers and numerical analysis. The ancient Indian word Sankhyā embodies the same idea, and this is why we have chosen this name for the Indian Journal of Statistics.

APPENDIX 3

THE DOCTRINE OF INFERENCE IN INDIA

The following extracts are taken from Brajendranath Seal's "The Positive Sciences of the Ancient Hindus", 1915

The Doctrine of Inference: Anumāna (Inference) is the process of ascertaining, not by perception or direct observation, but through the instrumentality or medium of a mark, that a thing possesses a certain character. Inference is therefore based on the establishment of an invariable concomitance (*Vyapti*) between the mark and the character inferred. The Hindu Inference (Anumāna) is therefore neither merely formal nor merely material, but a combined Formal-Material Deductive-Inductive process. It is neither the Aristotelian Syllogism (Formal-Deductive process), nor Mill's Induction (Material-Inductive process). But the real inference which must combine formal validity with material truth, inductive generalization with deductive particularisation. (pp. 250-251).

As a safeguard against this radical vitiation of the Method, the later Buddhists formulated the canon of a modified Method, termed the Panchakarani, a Joint Method of Difference, which combines the positive and the negative Methods of Difference (The Method of Addition and the Method of Subtraction) in a series of five steps, and which equally emphasises the unconditionality and the immediateness of the antecedents as essential moments of the causal relation. This is neither agreement in specre nor agreement in presence as well as absence (the foundation of J. S. Mill's Joint Method of Agreement), but the Joint Method of Difference. The Panchakarani runs thus:—

The following changes being observed, every thing else remaining constant, the relation of cause and effect is rigorously established:—

First step— The "cause" and the "effect" phenomena are both unperceived.

Second step— Then the "cause" phenomenon is perceived.

Third step— Then, in immediate succession, the "effect" phenomenon is perceived.

Fourth step— Then the "cause" phenomenon is sublated or disappears.

Fifth step— Then in immediate succession, the "effect" phenomenon disappears. (pp. 258-259)

APPENDIX 4

COMPARISON OF ESTIMATES OF JUTE ACREAGE IN BENGAL : 1945

ACCOUNT OF THE JUTE CROP FOR THE YEARS 1944-45 AND 1945-46

ITEM	1944-45 (thousand bales)	1945-46 (thousand bales)
(1) Consumption during the season:		
(1.1) in jute mills (actual)	6,000	6,308
(1.2) exports (actual) - . - . - . -	1,050	2,213
(1.3) in villages (estimate)	600	600
total	7,650	9,121
(2) Subtract quantity consumed from previous year's stock - . - . -	– 324	– 697
(3) Subtract jute crop in other provinces	– 598	– 862
(4) Balance: Bengal crop from trade figures - . - .	6,728	7,562
(5) Bengal crop : official forecast (complete count)	4,895	6,304
(6) Bengal crop : sample-survey	6,480	7,540
(7) Discrepancy of official forecast on (4)	–27.2%	–16.6%
(8) Discrepancy of sample-survey on (4)	– 3.6%	– 0.3%

Source : Figures used in this table were taken from the *Final Review of the Jute Crop* (published by the Government of Bengal) ; and the *Monthly Summary of Jute and Gunny Statistics*, August 1946 and 1947 (issued by the Indian Jute Mills Association).

NOTES ON CALCULATION (Paragraph numbers refer to serial numbers of items in the above table.)

(1.1) *Consumption in Jute Mills*: The Indian Central Jute Committee (ICJC) which is a statutory organization established by the Government of India, collects and publishes these figures every year. The Indian Jute Mills Association collects the figures from the member mills, and supply a consolidated statement to the ICJC. Mills outside the Association send their figures direct to ICJC. These figures are consolidated in the office of the ICJC, and two figures are published, one for the Association Mills and the other for the other Mills. The total is published in both the publications mentioned above, but as the *Final Review* was not published after 1946, the revised figures published by the IJMA were used in the present table.

(1.2) *Exports:* As exporters of raw jute have to pay a duty depending on the weight of jute exported, a very accurate account of the quantity of jute exported is kept by the Customs authorities. A daily list of exports showing quantities exported is published by the Customs authorities; and the consolidated annual figure is published in the "*Seaborne Trade of India*" by the Government of India.

(1.3) *Consumption in villages*: Several years ago this figure was fixed at 5 lakhs of bales by the IJMA, but on what basis is not known. In 1941 a survey was conducted by the ICJC in collaboration with the Indian Statistical Institute to estimate the consumption in villages by a sample enquiry, and the figure was changed to 6,00,000 (6 lakhs) bales on the basis of the above enquiry. Both IJMA and the Government of Bengal accepted this figure, and used it in the two publications mentioned above.

(2) *Quantity consumed from previous year's stock*: The next step is to deduct the quantity consumed from previous year's stock from the total consumption during the year.

According to an Act passed by the Government of Bengal in 1941 all jute mills, jute balers, and jute dealers have to submit a return showing the stocks of jute with them on the 30th June every year. For several years there was a Special Officer (Jute) in the Government of Bengal, in whose office these figures were compiled. Actual figures were collected from the mills and balers and dealers of Calcutta and the neighbouring industrial area while estimates were prepared for the stocks held by muffasil dealers and growers on the basis of reports received from the District Agricultural staff.

Calculation of consumption from previous year's stock

	1944–45	1945–46
	(thousand bales)	
(2.1) Stock at the beginning of the season:		
(2.11) with IJMA mills	2,342	2,712
(2.12) with other mills	83	114
(2.13) with growers	466	150
(2.14) with muffasil dealers	816	475
(2.15) with Calcutta balers and dealers	643	575
total	4,350	4,026
(2.2) Stock at the end of the season:		
(2.21) with IJMA mills	2,712	2,604
(2.22) with other mills	114	105
(2.23) with growers	150	82
(2.24) with muffasil dealers	475	160
(2.25) with Calcutta balers and dealers	575	378
total	4,026	3,329
Decrease in stock: (2.1) — (2.2) (consumption of old stock during the year)	324	697

(3) *Jute crop in other provinces*: This is estimated by the respective Provincial Directors of Agriculture. Plot-to-plot enumeration of the jute crop alone was undertaken in these provinces during the years 1939-43; and the subsequent estimates were prepared on the basis of the above plot-to-plot enumeration and local information obtained every year through the staff deputed for this work. The figures for Bihar include the crop from Nepal which finds its way to the Indian market through Bihar. The figures were taken from the *Final Jute Forecast*.

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