Chapter-5

Interpretation and Conclusion

§ 5.1 Introduction:

The interpretations of the results / findings, obtained on analyzing the scrutinized data discussed in *Chapter-* 4, have been presented in § 5.2. The findings, obtained in this study, regarding theory / results in the field of probability theory, in the field of probabilistic projection on population of India and in the field of probabilistic forecasting of temperature and rainfall in India have been summarized in § 5.3. Limitations of the findings have been discussed in § 5.4 while the theories / results in the findings that can be recommended for acceptance have been outlined in § 5.5.

§ 5.2 Discussion:

Regarding the popular law of population growth viz. **the logistic law**, it has been found that the logistic curve cannot be fitted to the data on the total population of India since numerical computations yield an estimated value, of one of the three parameters of the curve, which lies outside the domain of definition of that parameter. Similarly **the exponential curve** though can be fitted to the data on the total population of India, yields the projected values that are not acceptable in the sense of statistical acceptance. Therefore, one can conclude that the total population of India follows none of the two popular laws viz, the logistic law and the exponential law.

It has been found that the projected point values on the total population of India (shown in Table-6.4 & Table-6.5) obtained by the methods constructed in § 2.8 and § 2.10 lie within the corresponding projected interval values of the same (shown in Table-6.3). Logically therefore, these projected point values cannot be considered to be rejectable and consequently the two methods constructed in § 2.8 and § 2.10 can be considered to be suitable to describe the total population of India. It has also been found that the projected point values on the total population of the states of India (shown in Table-6.4 & Table-6.5) lie within the corresponding projected interval values of the same (shown in Table-6.3). Logically therefore, these projected point values also cannot be considered to be rejectable and consequently the method described in § 2.7 can be considered to be acceptable for estimating / projecting the total populations of the subregions (i.e states) of India. Thus one can conclude that each of the two methods described in § 2.8 and § 2.10 alone with the method described in § 2.7 is sufficient for

estimating / projecting number of persons in India and in its states The same is also valid for estimating / projecting number of persons in India and in its states with respect to age and sex since similar findings have been found in Step-4.2.16.

Equation (2.7.4) implies that the accuracy of the estimates (and hence projections) depend on the accuracy of the value of $P(E_i)$. The value of $P(E_i)$, approximated here, is nothing but the stable value of the corresponding relative frequency. Therefore, the accuracy depends on the accuracy of the said stable value of the relative frequency (i.e. on the number of stable decimal places in the said stable value). In the instant case, the stability has been found up to three decimal places in most of the cases (and maximum of five decimal places in some cases). This stability has yielded estimates that are not rejectable in statistical sense when considered in thousand or in higher unit. Again, equation (2.7.6) implies that accuracy if the stable value of relative frequency increases with the increase in the number of observed data. In the instant case, data corresponding to six censuses only have been used in computing the stable value of relative frequency. Thus one can conclude that the method may yield more accurate projected values if more data can be used in computing the same.

It is to be noted that by the theory of stability property of relative frequency, estimated / projected value on the total population of a subregion can be determined only if the corresponding estimated / projected value regarding the associated whole region is known or determined earlier. The theory of stability property of relative frequency discussed in § 2.7 does not have the ability to determine the estimated / projected value on the total population of the whole region under study.

The findings obtained in Step- 4.3.3 imply that there is no any significant cause that influences upon the changes in temperature and in rainfall, in India, over years i.e. temperature and rainfall in India has not been changing (since 1969) over years significantly. The changes occurred in them (since 1969) are due to the chance (random) causes only. Hence the confidence intervals obtained in Step- 4.3.5 can be treated to be 99% confidence intervals and 99.73% confidence intervals of each of the six characteristics viz.

(1) Mean Maximum Temperature (Monthly),

(2) Highest Maximum Temperature (Monthly),

(3) Mean Minimum Temperature (Monthly),

(4) Lowest Minimum Temperature (Monthly),

(5) Heaviest 24 Hours Rainfall (Monthly)

& (6) Number of Rainy Days (Monthly).

at the stations under study. The findings, obtained in Step- 4.3.7 and Step- 4.3.8, also justify / establish the same fact regarding the changes in temperature and rainfall in India over years. Hence, the confidence intervals, obtained in Step- 4.3.5, can be treated to be the corresponding projected intervals of each of the six characteristics mentioned above. By the same logic, the confidence intervals, obtained in Step- 4.3.9, can be treated to be 99% projected confidence intervals and 99.73% projected confidence intervals of the yearly total rainfall at the stations under study. Thus one can conclude that the area property of normal distribution is applicable (i) in detecting whether there exists any significance assignable cause in a region which forces various characteristics of temperature (and also of rainfall) of the region to be changed and (ii) then in determining forecasted interval values of the characteristics of the same with desired probability provided there exists no significance assignable cause in the region which forces the characteristics of the same to be changed. However, the technique of analysis of variances though applicable in detecting the same is not applicable in determining forecasted interval values of the characteristics of temperature (and also of rainfall) of the region.

§ 5.3 Summary of Findings:

The findings in the field of probability theory, in probabilistic projection on population of India and in probabilistic forecasting of temperature and rainfall in India obtained in this study have been summarized separately. The summary of findings has been outlined below.

§ 5.3.1 Summary of Findings in Probability Theory:

Following are the findings that may bear significant impacts in the field of probability theory:

(i) The classical definition of probability introduced by *Bernoulli* has been found to be a consequence of its empirical definition due to *Fisher* under the special

situation when / where the possible outcomes of a random experiment are equally likely.

(ii) Probability can be defined in the sense of classical approach in the situation where / when the possible outcomes of a random experiment are not equally likely. The classical definition of probability introduced by *Bernoulli* can be extended to the situation where / when the possible outcomes of a random experiment are not equally.

(iii) Probability of an event can be defined theoretically in terms of the number of occurrence of the event. There exists a theoretical definition of probability, based on an idea of perfect experimentation that can be a basis of searching for method / methods of determining the value of the probability of an event.

(iv) The exact value of the probability of an event associated to a random experiment, which is still supposed to be undeterminable, has been found to be determinable.

§ 5.3.2 Summary of Findings in Probabilistic Projection of Population:

Following are some findings in projection on population of India that may be of significant uses / applications in the field of population projection:

(i) The total population of India follows none of the two popular laws viz. logistic law and the exponential law.

(ii) Each of the two methods described in § 2.8 and § 2.10 yields statistically acceptable projected value on the total population of India.

(iii) The relative frequency approach of probability can yield the estimates of total populations of India and of its states, which are statistically not rejectable if the populations figures are considered in millions and accordingly the corresponding projected populations determined are not statistically rejectable if the population figures are considered in the same units.

(iv) Each of the two methods described in § 2.8 and § 2.10 alone with the method described in § 2.7 is sufficient for projecting number of persons in India and in its states. The same is also valid for estimating / projecting number of persons in India and in its states with respect to age and sex.

(v) The change in the total population of India over time, as the pattern since 1951 tells, can be represented by an arithmetic progression if the said change

is considered over interval of time and the length of the interval is taken as (1/5.6) year.

(vi) Projected point value on total population can be obtained if a set of underestimates and a set of overestimates are known or can be determined.

(vii) The relative frequency approach of probability can be used to estimate / project the populations of India and of its states age wise, sex wise and age-sex wise. Estimates / projections obtained by this approach are not statistically rejectable.

§ 5.3.3 Summary of Findings in Probabilistic Forecasting on Temperature and Rainfall:

Following are some findings in forecasting of temperature and rainfall in India that may be of significant importance to the meteorological and environmental scientists:

(i) It has been found that that it is possible to apply the area property of normal distribution to know whether there exists any significance assignable cause in a region which forces the temperature (also the rainfall) of the region to be changed as well as to determine forecasted interval value on various characteristics of temperature (also of rainfall) with desired probability.

(ii) There is no any significant cause that influences upon the changes in temperature, in India, over years i.e. temperature in India has not been changing (since 1969) over years significantly. The changes in temperature occurred since 1969, are due to the chance (random) causes only.

(iii) Variations in each of

(1) Mean Maximum Temperature,

(2) Highest Maximum Temperature,

(3) Mean Minimum Temperature,

(4) Lowest Minimum Temperature,

(5) Heaviest 24 Hours Rainfall in the Month

& (6) Number of Rainy Days in the Month

have been found to be significant among the months.

(iv) It has been possible to determine confidence intervals on each of

(1) Mean Maximum Temperature (Monthly),

(2) Highest Maximum Temperature (Monthly),

(3) Mean Minimum Temperature (Monthly),

(4) Lowest Minimum Temperature (Monthly),

(5) Heaviest 24 Hours Rainfall (Monthly),

(6) Number of Rainy Days (Monthly)

and (7) Yearly Total Rainfall.

The 99% confidence intervals and the 99.73% confidence intervals obtained have been tabulated in Table-6.7 & Table-6.8.

§ 5.4 Limitations of Findings:

The findings obtained in this study may, however, not completely free from inaccuracy and error. These may suffer from some limitations. Some of the notable limitations of the findings, obtained in this study, have been discussed below.

§ 5.4.1 Limitations of Findings in Probabilistic Projection of Population:

The study on probabilistic projection on populations of India and of its states is based on following assumptions:

(1) The environment within which the human population in India has been changing since 1951 is identical.

(2) Interstate migration of the human population in India (i.e. the migration of population from one state to another in India) is negligible.

(3) Facts and figures on human populations of India and of its states with respect to age and sex, recorded in the census reports published by the Registrar General of India, are accurate.

(4) Current behaviour of the change in the human populations of India and of its states remains the same in the future for which projected figures have been computed.

Thus, the results on probabilistic projection on populations of India and of its states obtained in this study are reasonable if these assumptions are correct. Obviously, the study suffers from the following limitations:

(1) It has been assumed that the environment within which the human population in India has been changing since 1951 is identical. This assumption may be treated as acceptably accurate for a short period of time. However, for a long period of time this assumption may not be accurate. Accordingly, an study based on such assumption may suffer from inaccuracy in its findings. It is not known whether the present study bears this type of inaccuracy.

(2) It has been assumed that the interstate migration of the human population in India is negligible. It is not known whether this type of migration in India is negligible. It is a problem for the researchers. If this type of migration in India is not negligible, the findings of the study may suffer from inaccuracy.

(3) The facts and figures on human populations of India and of its states with respect to age and sex, recorded in the census reports published by the Registrar General of India, have been assumed to be accurate. If these facts and figures are not accurate, the findings of the study are bound to suffer from error.

(4) It has been assumed that the current behaviour of the change in the human populations of India and of its states remains the same in the future for which projected figures have been computed. If this assumption is not accurate, the findings of the study are bound to suffer from error.

§ 5.4.2 Limitations of Findings in Probabilistic Forecasting on Temperature and Rainfall:

The study on probabilistic forecasting on temperature and rainfall in India based on following assumptions:

(1) It has been assumed that the facts and figures on

(i) Monthly Mean Maximum Temperature,

(ii) Monthly Highest Maximum Temperature,

(iii) Monthly Mean Minimum Temperature,

(iv) Monthly Lowest Minimum Temperature,

(v) Total Rainfall in the Month,

(vi) Heaviest 24 Hours Rainfall in the Month

and (vii) Number of Rainy Days in the Month

collected from the stations in India are free from mechanical errors (i.e. errors due to machine / tool having unknown defect/defects and due to wrong handling of machine/tool). It has also been assumed that the facts and figures observed have been recorded correctly.

(2) Data on the characteristics mentioned in (1) are free from inconsistency.

(3) Chance errors associated to the observations in each of the characteristics mentioned in (1) are independently and identically distributed normal variates with zero mean and a common unknown variance.

(4) Current behaviours of the changes in temperature and rainfall in the 42 stations in India remain the same in the future for which projected figures have been computed.

Thus, the results on probabilistic projection on populations of India and of its states obtained in this study are reasonable if these assumptions hold good. Obviously, the study suffers from the following limitations:

(1) It has been assumed that the data collected are free from mechanical errors and from error due to fatigue in recording. If this assumption is not accurate, the findings of the study are bound to be inaccurate.

(2) It has been assumed that the current behaviours of the changes in temperature and rainfall in the 42 stations in India remain the same in the future for which projected figures have been computed. If the said behaviours do not remain the same in future, the findings on forecasting are bound to suffer from inaccuracy.

§ 5.5 Recommendations of Findings:

Though the findings obtained in this study are suffer from some limitations, on the basis of the derivative logic and the statistical tests applied in the study some theories / results can be recommended for acceptance. The theories / results that can be recommended have been outlined below.

§ 5.5.1 Recommendations of Findings in Probability Theory:

The following ideas / theories that may bear significant impacts in the field of probability theory can be recommended.

(i) The classical definition of probability introduced by *Bernoulli* is a consequence of its empirical definition due to *Fisher* under the special situation when / where the possible outcomes of a random experiment are equally likely.

(ii) Probability can be defined in the sense of classical approach in the situation where / when the possible outcomes of a random experiment are not equally likely. The classical definition of probability introduced by *Bernoulli* can be extended to the situation where / when the possible outcomes of a random experiment are not equally.

(iii) Probability of an event can be defined theoretically in terms of the number of occurrence of the event. There exists a theoretical definition of probability, based on an idea of perfect experimentation that can be a basis of searching for method / methods of determining the value of the probability of an event.

(iv) The exact value of the probability of an event associated to a random experiment, which is still supposed to be undeterminable, is determinable.

§ 5.5.2 Recommendations of Findings in Probabilistic Projection of Population:

The following theories/results that may bear significant impacts in the field of population projection can be recommended.

(i) The total population of India follows none of the two popular laws viz. logistic law and the exponential law.

(ii) Each of the two methods described in § 2.8 and § 2.10 yields statistically acceptable projected value on the total population of India.

(iii) The relative frequency approach of probability can yield the estimates of total populations of India and of its states, which are statistically not rejectable if the populations figures are considered in millions and accordingly the corresponding projected populations determined are not statistically rejectable if the population figures are considered in the same units.

(iv) Each of the two methods described in § 2.8 and § 2.10 alone with the method described in § 2.7 is sufficient for projecting number of persons in India and

in its states. The same is also valid for estimating / projecting number of persons in India and in its states with respect to age and sex.

(v) The change in the total population of India over time, as the pattern since 1951 tells, can be represented by an arithmetic progression if the said change is considered over interval of time and the length of the interval is taken as (1/5.6) year.

(vi) Projected point value on total population can be obtained if a set of underestimates and a set of overestimates are known or can be determined.

(vii) The relative frequency approach of probability can be used to estimate / project the populations of India and of its states age wise, sex wise and age-sex wise. Estimates / projections obtained by this approach are not statistically rejectable.

§ 5.5.3 Recommendations of Findings in Probabilistic Forecasting on Temperature and Rainfall:

The following results in forecasting of temperature and rainfall in India that may be of significant importance to the meteorological and environmental scientists can be recommended.

(i) It is possible to apply the area property of normal distribution to know whether there exists any significance assignable cause in a region which forces the temperature (also the rainfall) of the region to be changed as well as to determine forecasted interval value on various characteristics of temperature (also of rainfall) with desired probability.

(ii) There is no any significant cause that influence upon the changes in temperature, in India, over years i.e. temperature in India has not been changing (since 1969) over years significantly. The changes in temperature, occurred since 1969, are due to the chance (random) causes only.

(iii) Variation between months in each of

(1) Mean Maximum Temperature,

(2) Highest Maximum Temperature,

(3) Mean Minimum Temperature,

(4) Lowest Minimum Temperature,

(5) Heaviest 24 Hours Rainfall in the Month

& (6) Number of Rainy Days in the Month

is significant in the sense of statistical philosophy.

(iv) The figures on 99% and 99.73% confidence intervals on (1) monthly mean maximum temperature, (2) monthly highest maximum temperature, (3) monthly mean minimum temperature, (4) monthly lowest minimum temperature, (5) monthly heaviest 24 hours rainfall (6) monthly number of rainy days & (7) yearly total rainfall (shown in Table-6.8 & Table-6.9) obtained in this study are suitable for scientific and other uses.