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# Forecasting Production of Major Food Crops in Four Major SAARC Countries

**Pradip Kumar Sahu**
*Department of Agricultural Statistics*
Bidhan Chandra Krishi Viswavidyalya
Mohanpur, West Bengal, India, PIN-741252
E-mail: pksahubckv@rediffmail.com

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## Abstract

The Indian sub-continent contributes near about 145 crores to the world population. To supply balanced diet to these huge population, is a stupendous task to the planners of these countries. Reports indicate that world wide near about 600 millions people go to bed either malnourished or without having two square meals daily. IWMI has estimated a requirement of 269 million metric tones of cereals for India by 2025 under the changing consumption scenario. Major staple food being rice and wheat, pulses and vegetables also figure among the food items of the SAARC countries. Vegetables play important role in balancing human diet at a relatively cheaper rate. Thus, production of cereals, particularly rice, wheat along with that of vegetables in a sustainable manner is of prime importance. The principle of sustainable production is to meet the needs of the present generation without compromising the ability of the future generations to meet their own needs. The study of production behaviour of major food items like cereals, (especially rice and wheat) and vegetables is of much importance not only for assured food supply for present generation but also for future generations. Present work is an attempt to examine the growth and trend in area, production, productivity, waste and actual availability of cereals, rice, wheat and vegetables in major SAARC countries namely Bangladesh, India, Nepal and Pakistan with an objective to visualize the behaviour of the production process of these crops to meet the future requirement of these countries. The study reveals a wide range of variations in growth of area, production, productivity of these crops among the countries. By and large there has been an increase of productivity over the years in all the countries with respect to the above-mentioned crops. Forecasting of production behaviour for these crops with the help of Box-Jenkins method reveals that 54.53 million tones of cereals and 0.709 million tones of vegetables would be available for 18.14 crores (projected, FAO, 2006) people of Bangladesh during the year 2015. Similarly the figures could be 229 and 58.46 million tones respectively for a population of 1264 millions (FAO projection) in India during the same year. Different measures of sustainability of productivity of these crops indicate wide range of variations among the countries. Nepal shows maximum sustainability with respect to the productivity of cereals, rice and wheat (using the indices of Singh, 1990 and ICARDA, 1994). Higher sustainability of vegetables productivity is shown by India, next to World (Singh, 1990) and Nepal (ICARDA, 1994). Taking in to consideration of the percentage loss of these crops due to various reasons and thereby reducing the actual availability; the study suggests for improvement in productivity of these crops in a sustainable manner so as to meet the future requirements of the crops.

**Keywords and Phrases:** Crops, Production Behaviour, Forecasting, B-J Method, Sustainability.

**AMS Classification:** 62M10.

# 1 Introduction

"The right of everyone to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger" was the first sentence of the declaration by the committee on world food security in its $27^{th}$ session in Rome, $28^{th}$ May to 1st June 2001. On the other hand what we find is that near about 23% people of South Asia are undernourished, next to 34% of Sub-Saharan African region. In India alone, 75% of the children are under weight due to inadequate nutrition (Swaminathan, 2006), almost 200 million of Indian population go to bed daily either hungry or with out getting two square meals. As many as 45 out of 75 districts in Nepal are food deficit districts and anybody can have detailed picture of the other South Asian countries in this regard. The seven south Asian countries under SAARC (presently eight with the inclusion of Afghanistan) contribute near about one fourth of the total world population. These eight countries are to depend heavily on the production of India, Pakistan , Bangladesh and Nepal for supply of balanced food. Vegetables are considered to be cheaper source of nutrient in balancing human diet, as a result, ever since the beginning of the planning process, production of cereals, particularly rice and wheat along with that of vegetables in a sustainable manner remains the prime focal points to the planners. Though sustainability is a multifaceted and multifariously defined feature, it integrates mainly the environmental health, economic profitability, social and economic equity. Sustainable production refers to meet the need of present generation without compromising the ability of future generation to meet their own needs. One of the major components of environment is its water resources. International Water Management Institute (IWMI) indicates that there will be a need for 17% more irrigation water to feed the world population by 2025, at the same time near about 2 billion people of the world will have to face absolute water scarcity during this period. Thus, there is no option except to produce more food and other commodities per drop of water under the conditions of diminishing per capita arable land and irrigation water resources (Swaminathan, 2006). Figures indicate that though India, Bangladesh, Nepal and Pakistan contribute to 38.35% to world rice area, 16.51% to world wheat area, the productivity of rice and wheat are far below the average world productivity. Though in terms of area for rice and wheat India occupies first and second place, it ranks 35th and 32nd in terms of productivity among the countries in the world (Singh, 2006). In a study by Kumar and Mritunjay (2003) indicated that there has been a decline in per capita consumption of cereals over the time inspite of decline in rural prices and increase in income against vegetables and other foods. In India alone, the consumption of cereals for the people below poverty line (BPL) has come down to 132kg per anum per person from 147.1 kg (a decline of 10%) and incase of people 150% above BPL from 194.3 kg to 154.6kg ( a decline of 20.4%) during the period of 1983-1999-00 and the same trend is still existing. On the contrary the consumption of vegetables for people below poverty line has gone up 53.9kg per annum per person from 36kg (an increase of 49.6%) and in case of people 150% above BPL from 65.2kg to 90.8kg ( an increase of 39.3%) during the period

1983-1999-00. This trend prompted Singh and Kumar (2002) to project a demand for vegetables of around 118 million tones during the year 2007 in India. Taking all these changes in to consideration along with the change in quantum of population, IWMI with the help of PODIUM has forecasted a requirement of 269 million tones of cereals for India during the year 2025. In a study, Chandrasekhar and Ghosh (2003) revealed that the rural India is not only eating less but also eating bad. So, we are facing the twin problems of supplying adequate food to the huge population and balancing their diet to face the challenge of malnutrition.

**Percentage contribution of major SAARC countries to the world with respect to rice, wheat, vegetables and cereal**

| Crop | Country | %Area | %Production | %Productivity |
|---|---|---|---|---|
| **Rice** | **Bangladesh** | 7.25 | 6.70 | 92.42 |
| | **India** | 28.42 | 22.38 | 78.75 |
| | **Nepal** | 1.04 | 0.76 | 73.14 |
| | **Pakistan** | 1.64 | 1.24 | 75.61 |
| **Wheat** | **Bangladesh** | 0.34 | 0.31 | 91.35 |
| | **India** | 11.98 | 11.60 | 96.81 |
| | **Nepal** | 0.32 | 0.24 | 74.28 |
| | **Pakistan** | 3.87 | 3.41 | 88.27 |
| **Vegetable** | **Bangladesh** | 0.87 | 0.37 | 42.33 |
| | **India** | 13.41 | 14.18 | 105.68 |
| | **Nepal** | 0.92 | 0.77 | 82.99 |
| | **Pakistan** | 0.43 | 0.43 | 102.24 |
| **Cereals** | **Bangladesh** | 1.72 | 1.96 | 113.70 |
| | **India** | 14.58 | 11.19 | 76.70 |
| | **Nepal** | 0.49 | 0.36 | 73.82 |
| | **Pakistan** | 1.85 | 1.38 | 74.72 |

It has already been discussed that the major food in the SAARC region is mostly cereal based and among the cereals rice and wheat are predominant, simply because of food habit of the people of this region. As far as balancing of human diet is concerned, nothing would be cheaper and easily available to the people of this region than the vegetables. Thus, production and availability of vegetables along with cereals like rice and wheat play major role in mitigating the challenge of supplying balanced food to the huge population of this region. Availability of balanced food to the ultimate stakeholders depends on two main factors viz. adequate production and assured supply/distribution of food among the people. Distribution of food mostly follows adequate production of food stuff and it is an affair of the state administration. Distribution of food is related with social, political, economic and other factors of the country concerned. It may not be wise and feasible to take care of all these in a particular exercise. In this exercise, we are interested in the first part i.e. production scenario of cereals like rice wheat, along with that of vegetables for past, present and future of these countries.

As such, examination of growth and trend in area, production and productivity of rice, wheat and vegetables (excluding potato) is of much importance, not only to visualize the path of changes in production system but also for the potentiality of the system to assure food supply. As we know agricultural goods are perishable in nature, so the production does not mean the availability of the same to the consumer. On an average 4.7% of rice, 4.3% of wheat and 31% of vegetables are being wasted due to various reasons. So keeping in view the growth in population in one hand, and the study of the production behaviour along with the availability of produce with respect to the three major food items i.e. rice, wheat and vegetables (excluding potato) on the other hand is of much importance for food and nutritional security of this region.

# 2 Material and Method

Data with respect to rice, wheat, cereals and vegetables (excluding potato) used for the study period 1961-2003 has been taken from FAO. Before analysis, as the study is dealing with time series data, each and every series have been verified for the existence of outlier in the data set.

## 2.1 Test for Outlier

A number of tests have been developed for the test of outlier Grubbs test is one of these test can be used in case of large sample. Grubbs' test is particularly easy to follow and is also called the ESD method (extreme studentized deviate). (Graph pad-2006) for outliers i.e. to detect the existence of any outlier or not; if found, have been replaced by the median of the respective series.

The test starts to quantify how far the outlier is from the others. $Z$ ratio is calculated as absolute value of the difference between the outlier and the mean divided by the SD. If $Z$ is large, the value is far from the others. It should be noted that one should use all the observations during calculation of the mean and SD from all values, including the outlier.

$$Z = \frac{|\bar{x} - x_i|}{S_x};$$

where, $x_i$, $\bar{x}$ and $S_x$ are the value of the i$^{th}$ observation, arithmatic mean and standard deviation of the variable respectively.

Since 5% of the values in a normal population are more than 1.96 standard deviation from the mean, our first thought might be to conclude that the outlier comes from a different population if $Z$ is greater than 1.96. This approach only works if we know the population mean and SD. This is rarely the case in practical situations or experimental data situations. As a result, one would calculate the mean and SD from the given set of data. The presence of an outlier increases the calculated SD. Since the presence of an outlier increases both the numerator (difference between the value and the mean) and denominator (SD of all values), $Z$ does not get very large. In fact, no matter how the data are distributed, $Z$ can not get larger than, $\frac{n-1}{\sqrt{n}}$ where $n$ is the number of values. For example, if $n = 64$, $Z$ cannot be larger than 7.88 for any set of values. Grubbs and others have tabulated critical values for $Z$. The critical value increases with sample size, as expected. If our calculated value of $Z$ is greater than the critical value in the table, then the $P$ value is less than 0.05. This means that there is less than a 5% chance that one would encounter an outlier so far from the others (in either direction) by chance alone, if all the data were really sampled from a single normal distribution. It should be noted that the method only works for testing the most extreme value in the sample (if in doubt, calculate $Z$ for all values, but only calculate a $P$ value for Grubbs' test from the largest value of $Z$. Once an outlier is identified, one may choose to exclude that value from the analyses/may retain or replace it. In this work we have replaced the outlier by median.

## 2.2 Test for Randomness

Each and every series has been analysed for their nature with the help of test of randomness. Like the test of outlier, statisticians have developed tests for randomness under different situations. As because our sample is large we use the test of turning points described as follows. This test for randomness (Kendall and Stuart, 1968) is a non-parametric test based on the number of turning points. The process is to count peaks and troughs in the series. A "peak" is a value greater than the two neighbouring values and a "trough" is a value, which is lower than of its two neighbors. Both the peaks and troughs are treated as turning points of the series. At least three consecutive observations are required to find a turning point, let $U_1$, $U_2$, $U_3$ be three points. If the series is random then these three values could have occurred in any order, viz. in six ways. But only in four of these ways would there be a turning point. Hence the probability of turning points in a set of three values is $4/6 = 2/3$.

Let $\mathrm{U}_1$, $\mathrm{U}_2$, $\mathrm{U}_3$.................. $\mathrm{U}_n$ be a set of observations and let us define a marker variable $\mathrm{X}_i$ by $\mathrm{X}_i = 1$ when $\mathrm{U}_i < \mathrm{U}_{i+1} > \mathrm{U}_{i+2}$ and

$$U_i > U_{i+1} < U_{i+2}$$

$$= 0 \text{ otherwise } \forall, \text{ i} = 1,2,3.......(\text{n-2})$$

Hence the number of turning points "$p$" is then $p = \sum_{i=1}^{n-2} x_i$

then we have $E(p) = \sum_{i=1}^{n-2} E(x_i) = 2/3(n-2)$ and

$E(p^2) = E(\sum_{i=1}^{n-2}(x_i))^2$ on simplification, which ultimately comes out to be $(40n^2 - 144n + 131)/90$, resulting in

$Var(p) = E(p^2) - (E(p))^2 = \frac{\text{16n-29}}{90}$

It can easily be verified that as '$n$', the number of observations increases the distribution of '$p$' tends to normality. Thus for testing the null hypothesis $\mathrm{H_0}$: series is random
we have the test statistic, $\tau = \frac{p \sim E(p)}{S_p} \sim N(0,1)$ where, $S_p$ is the standard deviation of '$p$'.

Thus if the calculated value of $\tau$ is greater than 1.96, we reject $H_0$: Series is random otherwise accept it.

### 2.3 Statistical Tools

It include arithmetic mean, coefficient of variation percent, simple growth rate percent. Simple Growth Rate per cent (SGR%) = $\Psi = \{(Y_t - Y_0)/Y_0.n\} \times 100$, where $Y_t$= last year, $Y_0$= initial year, $n$ = number of years . Higher value of $\Psi$ indicates higher growth during the period whereas lower value is the result of poor growth.

### 2.4 Study Method

In this study, B-J method has been used to modeling and forecast production values; also attempt has been made to compare predicted values with that of original values. The series were subjected to Auto Regressive (AR) / Auto Regressive Moving Average (ARMA)/Auto Regressive Integrated Moving Average (ARIMA) modeling followed by test of Auto Correlation Function (ACF), Partial Autocorrelation Function (PACF) for residuals of the models fitted in the process. To check whether there exists any trend or seasonality or not in the time series data, graphs of autocorrelation function and partial autocorrelation functions were drawn. Stationarity of any time series can also be judged with the help of ACF and PACF graphs. As a rule of thumb, the ACF and PACF are good estimate of the ACF and PACF of a stationary process for lag of about one third of the sample size. The horizontal line on the sample ACF and the PACF graphs are the bounds $\pm\frac{1.96}{\sqrt{n}}$. Values of the ACF that decay rapidly as the lag period ($h$) increases, indicate short term dependency in the time series, on the other hand slowly decaying values indicate long term dependency, data may have trend. Similarly, a sample ACF with very slow damped periodicity suggests the presence of periodic seasonal component. In both the above cases i.e. in presence of trend and or seasonality, data required to be transformed before ARMA model fitting.

Differencing is a technique that can be used to remove the seasonal components and the trends in a time series data. To remove the seasonal component of period 8 from the series $Y_t$ we generate the transformed series $Y_t^* = Y_t - Y_{t-8}$. This is nothing but the differencing at lag 8. On the other hand to eliminate linear trend from a time series one has to difference the series at lag1; to eliminate quadratic trend differencing twice at lag1, and higher order polynomial trend can be eliminated analogously.

The graphs of the sample ACF and PACF sometimes suggest an appropriate model for the series. As a rough guideline, if the sample ACF falls between the plotted bound of $\pm\frac{1.96}{\sqrt{n}}$ for large $h > q$ then a $MA(q)$ model is adopted, on the other hand if the sample PACF falls between the plotted $\pm\frac{1.96}{\sqrt{n}}$ for lag $h > p$ then $AR(p)$ may be tried.

## 2.5 Sustainability

Sustainability is a very complex, contested and multifariously defined concept. Despite its contested nature there is an overall agreement that it is multifaceted and therefore, needs to be assessed across several dimensions. In its simplest form, it can be assessed from economic, social and bio-physical aspects. Crop productivity and its sustainability is a major component in maintaining food safety by making provision for assured food to the masses. The study envisaged here, implies persistence and the capacity of a crop to produce continuously for a long time. Thus persistency in productivity of a crop across a long period of time implies sustainability. The sustainability index refers to measure the yield potential of the four major crops produced in the studied countries along with the world. Here four different types of sustainability measures have been used.

1. Sustainability Index (SI-1) $= \frac{\bar{y}-s}{y_{\max}}$, where $\bar{y}$ is the average yield of a performance of a country, $s$ is the standard deviation of performance over the years and $y_{max}$ is the maximum performance of a country in any year (Singh *et al.* 1990; also used by Gangwar *et al.* 2003).

2. $y_{ij} = a + b_i\bar{y}_j$, where $\bar{y}j$ is the mean of all countries in the j th year and $b_i$ is the regression coefficient for i-th country, $y_{ij}$ is the value of the performance with respect to the i-th country in j-th year and SI of i-th country as per ICARDA (1994) is $|1/b_i|$ = (SI-2).

3. $y_{ij} = a + b_it + ci\bar{y}_j$, where $\bar{y}_j$ is the mean of all countries in j-th year, $b_i$ and $c_i$ are regression coefficients and $1/|ci|$ is partial sustainable index (SI-3) of i-th country (as per Katyal *et al.* 2000).

4. Simple Achievable Growth Rate Percent (SAGR%) as given by Sahu *et al.* (2005) as Simple achieved variation (SAV) was also used to describe each series. SAGR% is defined as SI-4 = $\{(y_m - \overline{y})/(n\overline{y})\} \times 100$, where, y$_m$ = maximum value of series, $\bar{y}$= average value of the series, n = number of years. The SAGR% describes differences in what has been achieved and what could have been achieved; positive value indicates that under the given state of technology and other factors (existing scenario), realization could have been improved if the maximum potential was maintained. The closure the value of SI-4 towards zero the better is the performance and greater is the need for technological improvement. If SI-4 is zero the maximum potential has been achieved;

the present state of technology has reached its plateau, and further improvement can be made only through technological advancement

## 3 Results and Discussion

To judge the nature of each and every series Grubb's test for outlier check is followed. The result indicates that excepting for the area of vegetables in India in the year 1993 none of the series has got any outlier. The next objective is to examine whether the series under consideration follow a definite trend or observation in the series changed randomly. This is being done through the test of randomness as described in materials and method section. The result of test of randomness ( Table 5) indicates that all the parameters under consideration for rice in India, production, productivity and waste of wheat in India have changed randomly during the period of 1961-2003. This is not a good indicator for a planned economy; at the same time it is also to be noted that agriculture depends on so many other factors like weather, market, disease and pest incidence etc. besides planning and execution.

Next objective of the study is to visualize the average performance of the crops under consideration for the countries taken up for study. Table 1 to table 4 depict the pictures of production performances and availability of these crops, which indicates that India is the major country among the four in area and production with respect to all the crops under consideration followed by either Bangladesh or Pakistan. So far about the variability in production behavior measured in terms of coefficient of variation percentage is concerned, it is found to be widely spread over the countries. The variability in productivity of the crops over the period is justified because of the change in technology, management and other practices. In almost all the crops there has been a growth in productivity over the periods. But the question is whether this growth in productivity and other related parameters are sufficient to meet the challenge of food and nutritional requirement of the SAARC countries in a sustainable manner. Sustainability in productivities of different crops has been measured with the help of sustainability indices as described in materials and method section. Among the countries sustainability (table 6) varies over the indices for a particular crop. Nepal shows maximum sustainability with respect to cereals, rice and wheat as per the indices given by Singh (1990) and ICARDA (1994). Maximum sustainability of productivity in vegetables as per Singh (1990) is found in case of world followed by India and Pakistan. On the other hand, maximum sustainability according to measure 3 and 4 is found in case of Bangladesh. Thus, the study of sustainability by different measures have different results but as a whole these are able to provide an over all comparative pictures of productivity in different crops among the countries with respect to sustainability.

One of the objectives of the present study is to forecast the production behaviour of the crops under consideration, in the study areas. For the purpose we have divided the whole period of investigation in two parts: the model building period (1961-2001) and model validation period (2002-2003). Box-Jenkins methodology has been used for modeling purpose. Different auto-regressive (AR), auto regressive moving average (ARMA), auto regressive integrated moving average (ARIMA) models are found to fit well with the given series. Among the competitive models, for any particular series, the best model is selected based on the overall standard error, log likelihood value, AIC value and the significance of the coefficients in the model followed by the diagnostic check of the residuals with the help of the auto-correlation and partial auto-correlation functions and presented in tables 7(A) to 7(D). The difference between predicted and realized values for different series during the model validation period i.e. 2002-2003 is presented in table 8 to 12. It is clear from the tables that the realized values are almost nearer to the predicted values. Moreover the diagnostic check of residual also indicates that these are white noise.

Forecasting of area, production and productivity, waste and availability are also made with the help of the model fitted. It is found that in Bangladesh 54.43 million tones of cereals and 0.709 million tones of vegetables would be available during the year 2015 for a projected population of 18.14 crores. Similarly for India the figures could be 229 million tones of cereals and 58.46 million tones of vegetables for a population 126.4 crores. But the important thing is that the productivity of all the crops in almost all the countries excepting for vegetables will almost remain stagnant. So far as the productivity of vegetables in Nepal is concerned it will remain constant and far below the average productivity of other countries and the world.

Under the given land and water scarcity scenario it is the need of the hour to increase productivity per unit of resource to ensure food and nutritional security to the ever increasing population of the world. Moreover in many parts of the world, the present day thrust is not only to eat but to eat quality food. Besides the above, there is trend to produce and consume more and more organically produced food in many parts of the world. Question has been raised whether it is possible to meet the demand for food through entirely organic system of production. Thus, we are facing multifarious challenges towards meeting the need for good quality of food in sufficient amount. But one thing should be noted that whatever may be the process of production, prediction of likely population and forecasting of production of food material should be done meticulously, otherwise there will be a total disaster.

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Table 1: *Per se* performance of Rice in the World and four major SAARC countries during 1961-2003

| Parameter | Item | World | Bangladesh | India | Nepal | Pakistan |
|---|---|---|---|---|---|---|
| **Area (million hectare)** | Average | 140.637 | 10.027 | 40.041 | 1.317 | 1.876 |
| | CV% | 7.155 | 5.509 | 7.338 | 11.560 | 19.247 |
| | SGR% | 0.679 | 0.642 | 0.517 | 1.008 | 2.387 |
| **Production (million tones)** | Average | 422.986 | 22.647 | 87.682 | 2.809 | 4.533 |
| | CV% | 28.807 | 30.547 | 32.740 | 25.796 | 35.641 |
| | SGR% | 3.961 | 3.976 | 3.348 | 2.590 | 7.680 |
| **Productivity (tn/ha)** | Average | 2.964 | 2.237 | 2.152 | 2.104 | 2.337 |
| | CV% | 23.026 | 26.418 | 26.228 | 14.853 | 20.129 |
| | SGR% | -1.494 | -0.221 | -1.430 | -0.046 | 0.035 |
| **Waste (million tones)** | Average | 19.737 | 1.335 | 1.465 | 0.312 | 0.099 |
| | CV% | 30.644 | 46.966 | 20.691 | 28.614 | 26.131 |
| | SGR% | 4.689 | 6.499 | -0.249 | 3.814 | 4.346 |
| **Actual availability (million tones)** | Average | 403.250 | 21.312 | 86.217 | 2.497 | 4.435 |
| | CV% | 28.722 | 29.600 | 33.441 | 25.705 | 35.896 |
| | SGR% | 3.928 | 3.843 | 3.448 | 2.479 | 7.784 |

Table 2: *Per se* performance of Wheat in the World and four major SAARC countries during 1961-2003

| Parameter | Item | World | Bangladesh | India | Nepal | Pakistan |
|---|---|---|---|---|---|---|
| **Area (million hectare)** | Average | 221.474 | 0.407 | 21.082 | 0.413 | 6.889 |
| | CV% | 3.993 | 68.856 | 21.814 | 48.573 | 16.799 |
| | SGR% | 0.037 | 26.678 | 2.147 | 11.818 | 1.702 |
| **Production (million tones)** | Average | 446.435 | 0.771 | 39.653 | 0.579 | 11.252 |
| | CV% | 26.930 | 82.175 | 52.419 | 62.544 | 45.088 |
| | SGR% | 3.543 | 122.566 | 11.441 | 20.830 | 9.371 |
| **Productivity (tn/ha)** | Average | 2.012 | 1.528 | 1.752 | 1.321 | 1.556 |
| | CV% | 26.594 | 39.727 | 36.796 | 18.469 | 31.718 |
| | SGR% | 3.451 | 7.689 | 4.833 | 1.482 | 4.429 |
| **Waste (million tones)** | Average | 18.996 | 0.081 | 1.736 | 0.059 | 0.305 |
| | CV% | 29.047 | 51.398 | 50.213 | 75.088 | 40.636 |
| | SGR% | 3.497 | 20.051 | 11.038 | 38.584 | 7.466 |
| **Actual availability (million tones)** | Average | 427.439 | 0.690 | 37.917 | 0.520 | 10.947 |
| | CV% | 27.111 | 86.448 | 52.524 | 61.352 | 45.239 |
| | SGR% | 3.545 | 206.667 | 11.462 | 19.695 | 9.430 |

Table 3: *Per se* performance of Cereal in the World and four major SAARC countries during 1961-2003

| Parameter | Item | World | Bangladesh | India | Nepal | Pakistan |
|---|---|---|---|---|---|---|
| **Area (million hectare)** | Average | 693.108 | 10.530 | 100.164 | 2.510 | 10.696 |
| | CV% | 2.983 | 7.382 | 3.803 | 22.737 | 13.382 |
| | SGR% | 0.085 | 0.790 | 0.145 | 2.219 | 1.368 |
| **Production (million tones)** | Average | 1596.379 | 23.489 | 156.216 | 4.585 | 17.464 |
| | CV% | 24.372 | 31.897 | 33.009 | 30.793 | 39.597 |
| | SGR% | 3.206 | 4.220 | 3.887 | 3.317 | 7.683 |
| **Productivity (tn/ha)** | Average | 2.299 | 2.199 | 1.554 | 1.804 | 1.576 |
| | CV% | 24.022 | 25.649 | 32.477 | 10.239 | 28.573 |
| | SGR% | 3.012 | 2.559 | 3.523 | 0.562 | 3.976 |
| **Waste (million tones)** | Average | 63.386 | 0.975 | 4.741 | 0.393 | 0.452 |
| | CV% | 26.995 | 46.499 | 22.755 | 35.815 | 33.717 |
| | SGR% | 3.611 | 6.941 | 2.981 | 4.063 | 5.500 |
| **Actual availability (million tones)** | Average | 1532.993 | 22.514 | 151.475 | 4.192 | 17.012 |
| | CV% | 24.310 | 31.304 | 33.349 | 30.454 | 39.766 |
| | SGR% | 3.191 | 4.123 | 3.918 | 3.258 | 7.752 |

Table 4: Per se performance of Vegetable in the World and four major SAARC countries during 1961-2003

| Parameter | Item | World | Bangladesh | India | Nepal | Pakistan |
|---|---|---|---|---|---|---|
| **Area (million hectare)** | Average | 9.827 | 0.086 | 2.263 | 0.084 | 0.076 |
| | CV% | 27.430 | 32.199 | 10.010 | 62.010 | 30.631 |
| | SGR% | 3.082 | 2.397 | 0.563 | 24.502 | -0.688 |
| **Production (million tones)** | Average | 118.525 | 0.541 | 20.279 | 0.702 | 0.873 |
| | CV% | 45.407 | 29.557 | 25.291 | 75.558 | 30.500 |
| | SGR% | 6.818 | 3.499 | 4.351 | 46.503 | 2.240 |
| **Productivity (tn/ha)** | Average | 11.550 | 6.334 | 8.977 | 7.661 | 12.006 |
| | CV% | 18.756 | 10.438 | 24.671 | 17.936 | 24.948 |
| | SGR% | 1.607 | 0.543 | 3.051 | 1.907 | 4.158 |
| **Waste (million tones)** | Average | 37.257 | 0.118 | 2.881 | 0.071 | 0.121 |
| | CV% | 40.337 | 24.582 | 35.918 | 75.915 | 35.604 |
| | SGR% | 6.073 | 3.146 | 6.492 | 46.555 | 5.264 |
| **Actual availability (million tones)** | Average | 81.268 | 0.423 | 17.398 | 0.632 | 0.752 |
| | CV% | 47.824 | 31.090 | 23.864 | 75.521 | 30.888 |
| | SGR% | 7.175 | 3.603 | 4.064 | 46.497 | 1.866 |

**Table 5: Test of randomness**

**Crop: Rice**

| | | World | Bangladesh | India | Nepal | Pakistan |
|---|---|---|---|---|---|---|
| **Area (million hectare)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 22.000 | 20.000 | 25.000 | 19.000 | 15.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -1.971 | -2.710 | -0.862 | -3.080 | -4.558 |
| **Production (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 18.000 | 20.000 | 26.000 | 22.000 | 17.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -3.449 | -2.710 | -0.493 | -1.971 | -3.819 |
| **Productivity (tn/ha)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 17.000 | 21.000 | 26.000 | 21.000 | 21.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -3.819 | -2.341 | -0.493 | -2.341 | -2.341 |
| **Waste (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 18.000 | 21.000 | 26.000 | 23.000 | 19.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -3.449 | -2.341 | -0.493 | -1.601 | -3.080 |
| **Actual availability (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 18.000 | 20.000 | 26.000 | 24.000 | 17.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -3.449 | -2.710 | -0.493 | -1.232 | -3.819 |

**Cont...Table 5: Test of randomness**

**Crop: Wheat**

| | | World | Bangladesh | India | Nepal | Pakistan |
|---|---|---|---|---|---|---|
| **Area (million hectare)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 20.000 | 16.000 | 21.000 | 14.000 | 20.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -2.710 | -4.188 | -2.341 | -4.927 | -2.710 |
| **Production (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 26.000 | 14.000 | 22.000 | 13.000 | 22.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -0.493 | -4.927 | -1.971 | -5.297 | -1.971 |
| **Productivity (tn/ha)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 26.000 | 18.000 | 23.000 | 20.000 | 22.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -0.493 | -3.449 | -1.601 | -2.710 | -1.971 |
| **Waste (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 23.000 | 28.000 | 24.000 | 14.000 | 20.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -1.601 | 0.246 | -1.232 | -4.927 | -2.710 |
| **Actual availability (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 26.000 | 15.000 | 21.000 | 16.000 | 20.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -0.493 | -4.558 | -2.341 | -4.188 | -2.710 |

**Cont...Table 5: Test of randomness**

**Crop: Cereal**

| | | World | Bangladesh | India | Nepal | Pakistan |
|---|---|---|---|---|---|---|
| **Area (million hectare)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 19.000 | 17.000 | 17.000 | 18.000 | 17.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -3.080 | -3.819 | -3.819 | -3.449 | -3.819 |
| **Production (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 28.000 | 28.000 | 23.000 | 21.000 | 20.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | 0.246 | 0.246 | -1.601 | -2.341 | -2.710 |
| **Productivity (tn/ha)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 26.000 | 23.000 | 24.000 | 22.000 | 22.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -0.493 | -1.601 | -1.232 | -1.971 | -1.971 |
| **Waste (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 24.000 | 24.000 | 26.000 | 17.000 | 26.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -1.232 | -1.232 | -0.493 | -3.819 | -0.493 |
| **Actual availability (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 25.000 | 24.000 | 22.000 | 24.000 | 23.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -0.862 | -1.232 | -1.971 | -1.232 | -1.601 |

**Cont...Table 5: Test of randomness**

**Crop: Vegetable**

| | | World | Bangladesh | India | Nepal | Pakistan |
|---|---|---|---|---|---|---|
| **Area (million hectare)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 16.000 | 17.000 | 20.000 | 17.000 | 16.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -4.188 | -3.819 | -2.710 | -3.819 | -4.188 |
| **Production (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 12.000 | 11.000 | 10.000 | 6.000 | 20.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -5.667 | -6.036 | -6.406 | -7.884 | -2.710 |
| **Productivity (tn/ha)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 22.000 | 15.000 | 13.000 | 12.000 | 13.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -1.971 | -4.558 | -5.297 | -5.667 | -5.297 |
| Waste **(million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 10.000 | 15.000 | 6.000 | 5.000 | 19.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -6.406 | -4.558 | -7.884 | -8.253 | -3.080 |
| **Actual availability (million tones)** | n | 43.000 | 43.000 | 43.000 | 43.000 | 43.000 |
| | p | 11.000 | 13.000 | 11.000 | 13.000 | 23.000 |
| | E(p) | 27.333 | 27.333 | 27.333 | 27.333 | 27.333 |
| | $\sigma$ | 2.706 | 2.706 | 2.706 | 2.706 | 2.706 |
| | $\tau$ | -6.036 | -5.297 | -6.036 | -5.297 | -1.601 |

**Table 6: Yield Sustainability of rice, wheat, total cereals and vegetables in the World and four major SAARC countries during 1961-2003**

| Crop | Country | SI-1 | SI-2 | SI-3 | SI-4 |
|---|---|---|---|---|---|
| Rice | World | 0.573 | 0.736 | 21.277 | 0.762 |
| | Bangladesh | 0.473 | 0.861 | 0.536 | 1.428 |
| | India | 0.503 | 0.890 | 0.839 | 1.041 |
| | Nepal | 0.652 | 1.859 | 0.513 | 0.833 |
| | Pakistan | 0.601 | 1.224 | 5.376 | 0.733 |
| Wheat | World | 0.536 | 0.912 | 3.268 | 0.858 |
| | Bangladesh | 0.373 | 0.851 | 0.299 | 1.434 |
| | India | 0.399 | 0.757 | 2.809 | 1.362 |
| | Nepal | 0.536 | 2.525 | 2.506 | 1.212 |
| | Pakistan | 0.427 | 0.989 | 1.672 | 1.397 |
| Cereal | World | 0.561 | 0.799 | 5.917 | 0.825 |
| | Bangladesh | 0.463 | 0.775 | 0.433 | 1.409 |
| | India | 0.433 | 0.858 | 1.059 | 1.300 |
| | Nepal | 0.706 | 3.650 | 0.555 | 0.630 |
| | Pakistan | 0.468 | 0.982 | 8.772 | 1.227 |
| Vegetable | World | 0.864 | 17.241 | 19.231 | 0.676 |
| | Bangladesh | 0.436 | 4.329 | 0.626 | 0.401 |
| | India | 0.685 | 4.739 | 2.874 | 1.570 |
| | Nepal | 0.614 | 24.390 | 2.132 | 1.260 |

**Table 7A: Prediction model for Rice crop in major SAARC countries**

| Country | Item | Area (million hectare) | Production (million tones) | Productivity (tn/ha) | Waste (million tones) | Actual availability (million tones) |
|---|---|---|---|---|---|---|
| World | p | 0 | 1 | 1 | 1 | 1 |
| | d | 2 | 1 | 1 | 1 | 1 |
| | q | 1 | 1 | 1 | 1 | 1 |
| Bangladesh | p | 1 | 1 | 1 | 1 | 1 |
| | d | 0 | 0 | 1 | 0 | 1 |
| | q | 2 | 0 | 1 | 0 | 1 |
| India | p | 1 | 1 | 2 | 2 | 1 |
| | d | 1 | 1 | 1 | 0 | 1 |
| | q | 0 | 2 | 1 | 1 | 0 |
| Nepal | p | 2 | 0 | 1 | 1 | 1 |
| | d | 2 | 1 | 1 | 0 | 1 |
| | q | 0 | 1 | 0 | 0 | 0 |
| Pakistan | p | 2 | 2 | 1 | 1 | 1 |
| | d | 2 | 2 | 0 | 0 | 0 |
| | q | 0 | 0 | 0 | 0 | 0 |

**Table 7B: Prediction model for Wheat crop in major SAARC countries**

| Country | Item | Area (million hectare) | Production (million tones) | Productivity (tn/ha) | Waste (million tones) | Actual availability (million tones) |
|---|---|---|---|---|---|---|
| **World** | p | 1 | 1 | 1 | 1 | 1 |
| | d | 0 | 0 | 0 | 0 | 2 |
| | q | 0 | 0 | 0 | 1 | 1 |
| **Bangladesh** | p | 1 | 2 | 1 | 2 | 1 |
| | d | 1 | 2 | 0 | 0 | 0 |
| | q | 1 | 0 | 0 | 0 | 0 |
| **India** | p | 1 | 1 | 1 | 1 | 2 |
| | d | 0 | 2 | 2 | 2 | 2 |
| | q | 0 | 2 | 1 | 1 | 0 |
| **Nepal** | p | 1 | 2 | 1 | 1 | 1 |
| | d | 1 | 2 | 0 | 0 | 0 |
| | q | 1 | 0 | 0 | 0 | 1 |
| **Pakistan** | p | 1 | 2 | 1 | 1 | 1 |
| | d | 0 | 2 | 1 | 1 | 1 |
| | q | 0 | 1 | 2 | 1 | 2 |

**Table 7C: Prediction model for Cereal crop in major SAARC countries**

| Country | Item | Area (million hectare) | Production (million tones) | Productivity (tn/ha) | Waste (million tones) | Actual availability (million tones) |
|---|---|---|---|---|---|---|
| **World** | p | 1 | 1 | 2 | 1 | 2 |
| | d | 2 | 0 | 0 | 1 | 1 |
| | q | 2 | 0 | 2 | 1 | 1 |
| **Bangladesh** | p | 1 | 2 | 2 | 1 | 0 |
| | d | 0 | 1 | 0 | 0 | 2 |
| | q | 0 | 0 | 1 | 0 | 1 |
| **India** | p | 2 | 2 | 1 | 1 | 2 |
| | d | 2 | 1 | 1 | 0 | 1 |
| | q | 0 | 2 | 0 | 0 | 2 |
| **Nepal** | p | 1 | 1 | 1 | 2 | 1 |
| | d | 1 | 0 | 0 | 3 | 2 |
| | q | 1 | 1 | 1 | 0 | 1 |
| **Pakistan** | p | 1 | 1 | 1 | 2 | 2 |
| | d | 1 | 0 | 0 | 1 | 2 |
| | q | 1 | 2 | 0 | 1 | 0 |

**Table 7D: Prediction model for Vegetable crop in major SAARC countries**

| Country | Item | Area (million hectare) | Production (million tones) | Productivity (tn/ha) | Waste (million tones) | Actual availability (million tones) |
|---|---|---|---|---|---|---|
| **World** | p | 1 | 1 | 1 | 1 | 2 |
| | d | 2 | 2 | 1 | 1 | 2 |
| | q | 0 | 0 | 2 | 1 | 0 |
| **Bangladesh** | p | 1 | 1 | 2 | 1 | 1 |
| | d | 2 | 0 | 2 | 2 | 0 |
| | q | 1 | 0 | 0 | 0 | 0 |
| **India** | p | 2 | 1 | 1 | 1 | 2 |
| | d | 0 | 1 | 2 | 2 | 2 |
| | q | 0 | 0 | 1 | 0 | 0 |
| **Nepal** | p | 1 | 1 | 1 | 1 | 2 |
| | d | 2 | 1 | 1 | 2 | 0 |
| | q | 1 | 2 | 1 | 1 | 0 |
| **Pakistan** | p | 1 | 1 | 1 | 1 | 1 |
| | d | 0 | 0 | 1 | 0 | 0 |
| | q | 0 | 0 | 1 | 0 | 0 |

**Table 8: Model validation and prediction of area, production, productivity, waste and availability of Rice, Wheat, Cereals and Vegetables in India**

| Crop | Year | Area (mill ha) | | Production (mill tns) | | Productivity (tn/ha) | | Waste (mill tns) | | Availability (mill tns) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted |
| Rice | 2002 | 40.280 | 44.819 | 116.500 | 132.614 | 3.490 | 3.019 | 1.101 | 1.209 | 115.400 | 132.502 |
| | 2003 | 42.410 | 42.274 | 130.500 | 131.184 | 3.611 | 2.921 | 1.300 | 1.239 | 129.200 | 126.602 |
| | 2005 | | 41.887 | | 130.788 | | 2.976 | | 1.305 | | 125.753 |
| | 2010 | | 41.766 | | 129.362 | | 3.028 | | 1.402 | | 124.665 |
| | 2015 | | 41.768 | | 128.554 | | 3.041 | | 1.415 | | 124.694 |
| Wheat | 2002 | 26.340 | 27.427 | 72.770 | 79.429 | 2.760 | 2.852 | 3.130 | 3.310 | 69.640 | 78.864 |
| | 2003 | 24.860 | 27.398 | 65.100 | 81.426 | 2.620 | 2.898 | 3.000 | 3.379 | 62.100 | 81.629 |
| | 2005 | | 27.339 | | 85.713 | | 3.003 | | 3.528 | | 88.369 |
| | 2010 | | 27.194 | | 96.367 | | 3.262 | | 3.896 | | 104.253 |
| | 2015 | | 27.049 | | 107.018 | | 3.521 | | 4.265 | | 120.385 |
| Cereals | 2002 | 92.872 | 102.238 | 214.57 | 237.128 | 2.31 | 2.376 | 5.764 | 6.365 | 208.805 | 230.946 |
| | 2003 | 97.981 | 102.309 | 233.406 | 233.045 | 2.382 | 2.413 | 6.713 | 6.355 | 226.693 | 226.933 |
| | 2005 | | 102.343 | | 236.854 | | 2.483 | | 6.334 | | 230.371 |
| | 2010 | | 102.232 | | 236.504 | | 2.659 | | 6.282 | | 230.458 |
| | 2015 | | 101.789 | | 235.601 | | 2.834 | | 6.230 | | 229.013 |
| Vegetables | 2002 | 2.310 | 2.061 | 27.180 | 29.540 | 11.766 | 14.335 | 4.540 | 5.323 | 22.640 | 28.746 |
| | 2003 | 2.310 | 2.054 | 34.740 | 33.647 | 15.039 | 14.599 | 5.427 | 5.625 | 29.313 | 30.898 |
| | 2005 | | 2.081 | | 42.700 | | 15.197 | | 6.180 | | 35.528 |
| | 2010 | | 2.042 | | 54.719 | | 16.676 | | 7.580 | | 46.983 |
| | 2015 | | 2.032 | | 67.509 | | 18.153 | | 8.982 | | 58.466 |

**Table 9: Model validation and prediction of area, production, productivity, waste and availability of Rice, Wheat, Cereals and Vegetables in Bangladesh**

| Crop | Year | Area (mill ha) | | Production (mill tns) | | Productivity (tn/ha) | | Waste (mill tns) | | Availability (mill tns) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted |
| Rice | 2002 | 10.771 | 10.723 | 37.593 | 36.225 | 3.490 | 3.388 | 2.632 | 2.528 | 34.961 | 34.191 |
| | 2003 | 10.824 | 10.786 | 39.090 | 37.547 | 3.611 | 3.500 | 2.737 | 2.620 | 36.353 | 35.403 |
| | 2005 | | 10.874 | | 38.995 | | 3.611 | | 2.731 | | 37.283 |
| | 2010 | | 11.029 | | 38.757 | | 3.597 | | 2.654 | | 39.541 |
| | 2015 | | 11.181 | | 38.520 | | 3.610 | | 2.596 | | 41.709 |
| Wheat | 2002 | 0.740 | 0.860 | 1.610 | 2.008 | 2.160 | 2.181 | 0.130 | 0.133 | 1.480 | 1.682 |
| | 2003 | 0.710 | 0.874 | 1.750 | 2.049 | 2.470 | 2.167 | 0.140 | 0.130 | 1.610 | 1.671 |
| | 2005 | | 0.900 | | 2.166 | | 2.138 | | 0.123 | | 1.648 |
| | 2010 | | 0.960 | | 2.440 | | 2.069 | | 0.108 | | 1.591 |
| | 2015 | | 1.013 | | 2.713 | | 2.001 | | 0.095 | | 1.537 |
| Cereals | 2002 | 11.564 | 11.647 | 39.234 | 39.857 | 3.393 | 3.491 | 1.895 | 0.990 | 37.339 | 38.867 |
| | 2003 | 11.576 | 11.635 | 40.876 | 40.986 | 3.531 | 3.533 | 1.984 | 0.707 | 38.892 | 40.279 |
| | 2005 | | 11.610 | | 43.245 | | 3.597 | | 0.133 | | 43.112 |
| | 2010 | | 11.549 | | 48.892 | | 3.656 | | 0.652 | | 48.240 |
| | 2015 | | 10.112 | | 54.539 | | 3.610 | | 0.106 | | 54.433 |
| Vegetables | 2002 | 15.809 | 0.173 | 0.920 | 0.907 | 6.144 | 5.695 | 0.180 | 0.189 | 0.740 | 0.734 |
| | 2003 | 17.215 | 0.187 | 0.907 | 0.905 | 6.025 | 5.858 | 0.193 | 0.197 | 0.714 | 0.732 |
| | 2005 | | 0.204 | | 0.901 | | 5.690 | | 0.212 | | 0.728 |
| | 2010 | | 0.250 | | 0.890 | | 5.524 | | 0.248 | | 0.718 |
| | 2015 | | 0.296 | | 0.880 | | 5.365 | | 0.284 | | 0.709 |

**Table 10: Model validation and prediction of area, production, productivity, waste and availability of Rice, Wheat, Cereals and Vegetables in Nepal**

| Crop | Year | Area (mill ha) | | Production (mill tns) | | Productivity (tn/ha) | | Waste (mill tns) | | Availability (mill tns) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted |
| Rice | 2002 | 1.545 | 1.542 | 4.133 | 4.088 | 2.675 | 2.726 | 0.449 | 0.476 | 3.684 | 3.720 |
| | 2003 | 1.559 | 1.524 | 4.456 | 4.112 | 2.857 | 2.707 | 0.462 | 0.445 | 3.994 | 3.684 |
| | 2005 | | 1.575 | | 4.297 | | 2.812 | | 0.454 | | 3.917 |
| | 2010 | | 1.617 | | 4.297 | | 2.799 | | 0.436 | | 3.893 |
| | 2015 | | 1.661 | | 4.297 | | 2.800 | | 0.418 | | 3.894 |
| Wheat | 2002 | 0.670 | 0.683 | 1.260 | 1.228 | 1.890 | 1.996 | 0.130 | 0.127 | 1.130 | 1.058 |
| | 2003 | 0.670 | 0.694 | 1.340 | 1.248 | 2.010 | 2.036 | 0.140 | 0.126 | 1.200 | 1.052 |
| | 2005 | | 0.717 | | 1.317 | | 2.139 | | 0.124 | | 1.040 |
| | 2010 | | 0.772 | | 1.448 | | 2.237 | | 0.119 | | 1.011 |
| | 2015 | | 0.826 | | 1.580 | | 2.402 | | 0.114 | | 0.982 |
| Cereals | 2002 | 3.324 | 3.386 | 7.215 | 6.683 | 2.171 | 2.083 | 0.612 | 0.690 | 6.603 | 6.752 |
| | 2003 | 3.351 | 3.415 | 7.684 | 6.600 | 2.293 | 2.082 | 0.632 | 0.746 | 7.052 | 6.879 |
| | 2005 | | 3.475 | | 6.437 | | 2.080 | | 0.891 | | 7.135 |
| | 2010 | | 3.624 | | 6.047 | | 2.076 | | 1.442 | | 7.775 |
| | 2015 | | 3.895 | | 5.953 | | 2.072 | | 2.264 | | 8.415 |
| Vegetables | 2002 | 0.160 | 0.152 | 1.736 | 1.528 | 10.853 | 9.995 | 0.174 | 0.155 | 1.562 | 1.323 |
| | 2003 | 0.160 | 0.156 | 1.890 | 1.560 | 11.810 | 9.989 | 0.189 | 0.156 | 1.700 | 1.318 |
| | 2005 | | 0.167 | | 1.622 | | 9.990 | | 0.165 | | 1.310 |
| | 2010 | | 0.169 | | 1.764 | | 9.993 | | 0.185 | | 1.288 |
| | 2015 | | 0.177 | | 1.890 | | 9.992 | | 0.205 | | 1.267 |

**Table 11: Model validation and prediction of area, production, productivity, waste and availability of Rice, Wheat, Cereals and Vegetables in Pakistan**

| Crop | Year | Area (mill ha) | | Production (mill tns) | | Productivity (tn/ha) | | Waste (mill tns) | | Availability (mill tns) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted |
| Rice | 2002 | 2.225 | 2.008 | 6.718 | 5.801 | 3.091 | 2.750 | 0.134 | 0.115 | 6.583 | 5.666 |
| | 2003 | 2.461 | 2.163 | 7.271 | 6.236 | 2.955 | 3.015 | 0.145 | 0.133 | 7.126 | 6.535 |
| | 2005 | | 2.589 | | 7.430 | | 2.947 | | 0.143 | | 7.023 |
| | 2010 | | 3.128 | | 8.474 | | 2.928 | | 0.139 | | 6.773 |
| | 2015 | | 3.651 | | 9.660 | | 2.909 | | 0.135 | | 6.531 |
| Wheat | 2002 | 8.060 | 8.452 | 18.230 | 20.395 | 1.890 | 1.996 | 0.460 | 0.526 | 17.770 | 20.323 |
| | 2003 | 8.030 | 8.446 | 19.180 | 21.616 | 2.010 | 2.036 | 0.480 | 0.506 | 18.700 | 20.813 |
| | 2005 | | 8.435 | | 22.092 | | 2.139 | | 0.507 | | 21.785 |
| | 2010 | | 8.407 | | 24.509 | | 2.237 | | 0.523 | | 24.173 |
| | 2015 | | 8.379 | | 26.817 | | 2.402 | | 0.510 | | 26.501 |
| Cereals | 2002 | 12.016 | 12.866 | 27.173 | 31.039 | 2.261 | 2.402 | 0.655 | 0.738 | 26.518 | 32.226 |
| | 2003 | 12.482 | 12.974 | 28.964 | 31.760 | 2.320 | 2.400 | 0.696 | 0.742 | 28.269 | 34.475 |
| | 2005 | | 13.190 | | 33.194 | | 2.394 | | 0.767 | | 37.201 |
| | 2010 | | 13.728 | | 36.727 | | 2.380 | | 0.824 | | 45.242 |
| | 2015 | | 14.461 | | 38.614 | | 2.367 | | 0.879 | | 53.179 |
| Vegetables | 2002 | 0.074 | 0.072 | 1.076 | 1.064 | 14.566 | 15.275 | 0.193 | 0.204 | 0.882 | 0.858 |
| | 2003 | 0.074 | 0.071 | 1.076 | 10.450 | 14.550 | 15.415 | 0.197 | 0.203 | 0.879 | 0.840 |
| | 2005 | | 0.069 | | 1.008 | | 15.692 | | 0.201 | | 0.805 |
| | 2010 | | 0.065 | | 0.992 | | 16.360 | | 0.195 | | 0.723 |
| | 2015 | | 0.061 | | 0.843 | | 16.998 | | 0.189 | | 0.650 |

**Table 12: Model validation and prediction of area, production, productivity, waste and availability of Rice, Wheat, Cereals and Vegetables in the World**

| Crop | Year | Area (mill ha) | | Production (mill tns) | | Productivity (tn/ha) | | Waste (mill tns) | | Availability (mill tns) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted | Actual | Predicted |
| | 2002 | 147.693 | 152.560 | 577.989 | 604.930 | 3.913 | 3.971 | 28.763 | 29.431 | 549.226 | 575.399 |
| | 2003 | 149.205 | 147.952 | 583.002 | 582.598 | 3.907 | 3.942 | 28.578 | 29.182 | 554.425 | 553.268 |
| Rice | 2005 | | 149.896 | | 592.072 | | 3.955 | | 29.362 | | 562.493 |
| | 2010 | | 151.623 | | 613.553 | | 4.065 | | 31.305 | | 581.476 |
| | 2015 | | 153.350 | | 633.430 | | 4.163 | | 33.225 | | 598.876 |
| | 2002 | 214.070 | 215.255 | 574.390 | 584.799 | 2.680 | 2.718 | 19.610 | 19.770 | 554.780 | 578.153 |
| | 2003 | 207.450 | 215.185 | 561.120 | 583.542 | 2.700 | 2.715 | 19.270 | 19.647 | 541.850 | 584.444 |
| Wheat | 2005 | | 215.046 | | 579.785 | | 2.705 | | 19.403 | | 609.006 |
| | 2010 | | 214.699 | | 573.577 | | 2.690 | | 18.805 | | 648.979 |
| | 2015 | | 214.353 | | 567.436 | | 2.674 | | 18.225 | | 688.993 |
| | 2002 | 663.621 | 667.459 | 2042.390 | 2056.451 | 3.078 | 3.123 | 77.254 | 1.896 | 1965.136 | 2047.378 |
| | 2003 | 671.649 | 663.790 | 2085.774 | 2054.476 | 3.105 | 3.135 | 80.060 | 1.892 | 2005.714 | 2075.801 |
| Cereals | 2005 | | 656.147 | | 2050.532 | | 3.148 | | 1.884 | | 2128.970 |
| | 2010 | | 636.404 | | 2040.705 | | 3.141 | | 1.862 | | 2262.507 |
| | 2015 | | 630.512 | | 2010.399 | | 3.103 | | 1.842 | | 2395.747 |
| | 2002 | 15.809 | 16.402 | 233.745 | 256.123 | 14.786 | 14.470 | 70.149 | 71.704 | 163.595 | 183.659 |
| | 2003 | 17.215 | 17.197 | 244.970 | 274.866 | 14.230 | 14.561 | 73.023 | 74.773 | 171.947 | 198.279 |
| Vegetables | 2005 | | 18.759 | | 313.952 | | 14.740 | | 80.534 | | 230.001 |
| | 2010 | | 22.670 | | 411.301 | | 15.176 | | 92.973 | | 308.873 |
| | 2015 | | 26.583 | | 508.570 | | 15.594 | | 103.038 | | 387.519 |