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Modelling and Forecasting of Area, Production, Yield and Total Seeds of Rice and Wheat in SAARC Countries and the World towards Food Security

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Abstract In this paper, under the background of overall food security situation in the SAARC countries, attempts have been made to analyse the production behaviour along with the total seeds of two major food crops rice and wheat. This will help to draw up strategies and programmes for regional cooperation in ensuring food security and reducing hunger and malnutrition in the region. Forecasting of area, production, yield and total seed production will not only help to solve the food security problem but also seed security in these SAARC countries in future. In addition to descriptive statistics, the Box – Jenkins ARIMA modelling technique has been used to analyse the information from 1961 through 2010. The forecast shows that rice and wheat production for the year 2020 would be about 794 and 777 million tons respectively in the world. In-spite of increase in production the study reveals that the yield of rice and wheat in world would be 4.35 t/ha and 3.4 t/ ha in 2020 but the yield of these two crops in SAARC countries, barring one country in each, will remain far below the world projection. Thus, under the given remote possibility of horizontal expansion, the study emphasises the need for quantum jump in the per hectare yield of these two crops for this region. The study also advocates that good quality of seeds in good amount be made available to the farmers, otherwise the whole food security of this part of the Globe would be under tremendous risk.

Keywords: *ARIMA, forecasting, production, yield, seed, SAARC countries*

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1. Introduction

World population particularly the population of developing world is increasing at an alarming rate. To feed this ever increasing human population always remains a challenging task to the planners of the individual countries and also the world bodies. The planners should know the likely population behaviour of the countries under changing scenario. At the same time they should have an idea about the likely demand for food and other commodities. Thus, forecasting production behaviours of the major crops play vital role towards the planners for food and nutritional security. The planners should have idea about the likely production scenario of the major crops. Food crops like wheat, rice play important roles in solving food and nutritional security problem. About two third of wheat production in the world is used for human food and one sixth is used as livestock feed. It is grown on 216.70 million hectares with production of 651.40 million tonnes in the world during year 2010. India ranks second largest producer of wheat, next to China, accounting 11.63 percent of total wheat production in the world. Wheat is a staple food for about one third of population and major supplement in the human diet containing protein, niacin and thiamine. Rice is another major staple food and a mainstay for the rural population and their food security. Rice is vital for the nutrition of most of the population in Asia, as well as in Latin America and the Caribbean and in Africa; it is central to the food security of over half the world population, (C. Calpe,(FAO, Rome, Italy) 2002). Rice is the predominant staple food in at least 33 developing countries, providing 27 percent of dietary energy supply, 20 percent of dietary protein and 3 percent of dietary fat. Rice can contribute nutritionally significant amounts of thiamine, riboflavin, niacin and zinc to the diet, and also smaller amounts of other micronutrients. Many factors influence the nutrient content of rice (Kennedy *et al.,* FAO, Rome, Italy, 2002). Rice is the staple food for nearly 70% of the Indian population. During the year 2010-11 rice with 94.01 million tonnes of production contributed to 40.5% of the total food grain production of the country. Wheat is the second staple food of Bangladesh (Rabbani *et al 2009.)* Rice and wheat are the principal sources of food, calorie, and protein intake for most of the people of Bangladesh (Karim *et al*. 2010). Wheat has now become an indispensable food item of the people of Bangladesh and it continues to fill the food gap caused by possible failure of rice crop. Wheat is the main staple food item in Pakistan also. Among rural households wheat is the largest single consumption item, while among urban households it is the second largest consumption item following housing.(Azhar *et al*. 1974). Crops with major significance for Nepali people, including the resource poor, are rice, maize, wheat, potato, millet and various legumes (mainly lentil and soybean), as they make up the primary food in the diet.(Shrestha and Wulff, 2007).

SAARC or South Asian Association for Regional Cooperation is a group of eight countries consisting India, Pakistan, Sri Lanka, Afghanistan, Maldives, Bhutan, Bangladesh, and Nepal heavily depend on the production of these two crops for food and nutritional security. As for instance, India imposed a ban on export of wheat in 2007 and non-basmati rice in 2008 to stabilise domestic prices and contain food price inflation in the country. In 2010, wheat production touched 82.4 million tonne and rice production at 95 million tonne. As on June 1, the country's wheat and rice stock stood at 65.4 million tonne and 37.8 million tonne respectively, according to the Union ministry of food and public distribution.

Seed is the basic and critical input in crop production. In modern agriculture, seed is a vehicle to deliver almost all agriculture-based technological innovations to farmers so that they can exploit the genetic potential of new varieties. The availability, access and use of seed of adaptable modern varieties is, therefore, determinant to the efficiency and productivity of other packages (irrigation, fertilizers, pesticides) in increasing crop production to enhance food security and alleviating rural poverty in developing countries. For seed to play a catalytic role, it should reach farmers in a good quality state, i.e. high genetic purity and identity, as well as high physical, physiological and health quality. In contrast to fertilizers and pesticides, farmers select and save seed to plant the next year’s crop, and any off-farm seed from the formal sector should be of a better quality for farmers to invest on it. Therefore, the best production techniques need to be followed to produce good quality seed. Laverack (1994) described different arrangements and management approaches for breeder seed production that can be useful and adopted in developing countries. Ascher *et al*. (1994) concluded that seed nutrition combined with soil nutrition gave better yields and better seed quality. In Morocco, a separate Seed Unit has been established within the Institute National de la Recherché Agronomy to maintain and produce breeder seed of public varieties. McDonald Nelson (1986) described for seed production fields, a lower seed rate may be recommended because lower seed rates lead to higher multiplication factors. Following table will provide an example as to how the seed rate is related to production of crop taking example from wheat.

Effect of seed rate on multiplication factor of wheat

Seed rate (kg/ha)	Yield (kg/ha)	Multiplication ratio
25	4 081	157
50	4 907	98
75	5 176	69
100	4 949	49
125	5 574	44

Source: FAO, 1975; van Gastel and Hopkins, 1988.

In the absence of quality seed in adequate amount, the investments made on other agricultural inputs such as fertilizers, pesticides both under rainfed and irrigated conditions will not give desired yields. Upon release of a new variety, a breeder will make available a small quantity of seed stock that is very pure and represents the variety. This stock is referred to as parental material and forms the basis of any future maintenance and seed multiplication of the variety (Laverack, 1994). The National Seeds Policy 2002 (India) clearly emphasized that “It has become evident that in order to achieve the food production targets of the future, a major effort will be required to enhance the seed replacement rates of various crops. This would require a major increase in the production of quality seeds……..” seed replacement rate has a strong positive correlation with the productivity and production of crops.

India with nearly 2000 USD million ranks 4th along with Brazil in domestic seed market in the world. The domestic seed market of India had increased from 1500 USD million in 2008 to 2000 USD million (Rs.9400 crores) in 2011, registering an increase of 33.3% in a span of three years. The share of India in commercial seed market is 4.76 percent. According to International Seed Federation (ISF), 2011the domestic seed market value of India may easily reach Rs.15, 000 crores by 2015.

Though modelling and forecasting of phenomena has a long history, its application, especially in the field of agriculture become substantially visible during the latter half of the last century. It got further boost with the introduction of Box – Jenkins methodology. Azhar *et al* (1972) estimated a function relating to wheat production in the Punjab province of Pakistan. They regressed total wheat production on area under the Mexi-Pak wheat, area under local varieties, fertilizer and rainfall in the months of November, December and January, using the data for the 1962-63 to 1971-72 periods. They found that the observed and estimated values of output are very close to each other. The difference between the two values further reduces for irrigated and barani districts. Stationary series (original or transformed) can be modelled using the simple moving averaging, simple exponential smoothing, and Box-Jenkins techniques (Box and Jenkins, 1976). There are two types of averaging techniques: (i) simple averaging, and (ii) moving averaging techniques. With simple averaging technique, the mean of all observations (i.e., yields in current and past years) in a series is used to forecast yield for the next year. Badmus and Ariyo (2011) studied forecasting the cultivated area and production of maize in Nigeria using Autoregressive Integrated Moving Average (ARIMA) model utilizing time series data for the period of 1970-2005. They forecasted the maize production for the year 2020 to be about 9952.72 tons with upper and lower limits 6479.8 and 13425.64 thousand tons respectively. Iqbal *et al*. (2005) estimated ARIMA model and showed that the production of wheat would grow to 29.77 million tones in the year 2022 in Pakistan. The study concluded that the expected growth was low and that the scope for higher area and production laid in adequate government policies regarding wheat cultivation in the country. Sahu amd Mishra (2013) studied forecasting the production, import –export (both in quantity and value) and trade balance of total spices in India and China alongwith world using Autoregressive Integrated Moving Average (ARIMA) model using time series data covering the period of 1961-2009 and forecasted for year 2020. Thus, the production of these two crops in conjunction with study of production behaviour and likely behaviour in future play vital role in augmenting food and nutritional security of SAARC countries. And by virtue of its own importance, study of production behaviour and forecasting of seed is vital. Hence the present study is undertaken.

2. Materials and Methods

For the present study, information on area, production, yield and total seed of rice (paddy) and wheat for seven SAARC countries, excepting Maldives, along with the world are collated from the website of the Food and Agriculture Organisation, (www:fao.org) for the period 1961 to 2010. To examine the nature of each series these have been subjected to get various descriptive statistics. These provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data and simply describe what is or what the data shows. The present study has used minimum, maximum, mean, standard error, median, skewness, kurtosis, simple growth rate, compound growth rate etc. to describe the nature of the series under consideration. With the picturisation of the data through descriptive statistics the task on hand remains to forecast the series for the year to come, so that appropriate corrective measures (if any) could be taken at appropriate level(s). For the purpose the study adopted the Box –Jenkins methodology. Data for the period 1961-2005 has been used for the model building, while data for years 2006-10 are taken for model validation. Models are again compared according to the minimum values of Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Square Error (MSE) and Mean Absolute Percentage Error (MAPPE) and maximum value of Coefficient of determination (R^2).

Autoregressive model: ARIMA models which stands for Autoregressive Integrated Moving Average models. Integrated means the trends has been removed; if the series has no significant trend, the models are known as ARMA models.

The notation AR(*p*) refers to the autoregressive model of order *p*. The AR (*p*) model is written

$$X_t = c + \sum_{i=1}^{P} \alpha_i X_t + \mu_t$$

where $\alpha_{1,} \alpha_2 ....\alpha_p$ are the parameters of the model, *c* is a constant and μ_t is white noise. Sometimes the constant term is omitted for simplicity.

Moving Average model: The notation MA (*q*) refers to the moving average model of order *q*:

$$X_t = \mu + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \varepsilon_t$$

where the θ_1, ..., θ_q are the parameters of the model, μ is the expectation of X_t (often assumed to equal 0), and the ε_t is the error term. Given a set of time series data, one can calculate the mean, variance, autocorrelation function (ACF), and partial autocorrelation function (PACF) of the time series. This calculation enables one to look at the estimated ACF and PACF which gives an idea about the correlation between observations, indicating the sub-group of models to be entertained. This process is done by looking at the cutoffs in the AC and PACF. At the identification stage, one would try to match the estimated ACF and PACF with the theoretical ACF and PACF as a guide for tentative model selection, but the final decision is made once the model is estimated and diagnosed.

3. Results and Discussion

Table 1, Table 2, Table 3, and Table 4 show situation with respect to area, production, yield and total seed in rice in SAARC countries and the world from 1961 to 2010. From Table 1 it is clear that the area of world since 1961 has increased from 115365 thousand hectare to 158377 thousand hectare, registering a growth of almost 0.667% per annum. In SAARC country the average production under rice in India being 94.262MT. In all the SAARC countries area of rice registered a compound growth rate of almost 1 %, well in tune of the whole world (1.005%). The picture in per hectare production of rice is somewhat not encouraging for the SAARC countries. Against the world average productivity of 3.143 t/ha the average productivity of SAARC countries varies between 2.088 t/ha (Bhutan) to 2,809t/ha (Sri Lanka). So for about the growth rate in yield of rice concerned Nepal shows the minimum simple growth rate of 0.82 % during the period against 2.98 % of Bangladesh and 2.73 % for whole world respectively. The difference in the nature of the simple growth rates and compound growth rates is mainly attributed to the lower productivity of rice during the initial years under investigation. The reflection in growth rates of area and productivity is found in production (Table 3) as well as total seed (Table 4) of this countries while comparing with receptivity growth rate of hole world. Thus from descriptive statistics it is clear that under the given constraints in expansion of area, to match with the level of average production scenario of the whole world, the SAARC countries need to gear up in the font of perhectare production of rice. There is further need in breakthrough of the production process to reach the maximum yield at per with highest yielding countries in the world.

Table 1. Area under rice in SAARC countries and world during 1961 to 2010

AREA ('000'ha)	*Afghanistan*	*Bangladesh*	*Bhutan*	*India*	*Nepal*	*Pakistan*	*Sri Lanka*	*World*
Mean	182.89	10148.11	25.50558	40369.63	182.89	1982.555	751.8753	142565.5
Standard Error	3.765	88.772	0.619	419.008	3.765	61.340	20.499	1513.319
Median	180	10223.8	26	41148	180	2012.05	779.4705	144441.6
Kurtosis	-0.745	1.111	-0.182	-1.104	-0.745	-0.539	-0.377	-0.056
Skewness	-0.468	-0.296	0.320	-0.252	-0.468	0.051	-0.204	-0.798
Minimum	121	8483.52	18.5	34694	121	1185.74	431.823	115365.1
Maximum	222	11800	37	45160	222	2962.6	1060.36	158377.7
SGR(%)	-0.097	0.798	0.364	0.133	-0.097	1.933	2.326	0.677
CGR (%)	0.993	1.003	1.003	1.004	0.993	1.015	1.011	1.005

Table 2. Yield under rice in SAARC countries and world during 1961 to 2010

Yield (t/ha)	*Afghanistan*	*Bangladesh*	*Bhutan*	*India*	*Nepal*	*Pakistan*	*Sri Lanka*	*World*
Mean	2.170	2.479	2.088	2.296	2.192	2.466	2.809	3.143
Standard Error	0.071	0.116	0.059	0.090	0.052	0.077	0.092	0.109
Median	2	2.2064	2	2.202	2.057	2.428	3.0074	3.251
Kurtosis	0.800	-0.618	8.540	-1.419	-0.933	-0.024	-1.278	-1.376
Skewness	1.240	0.793	2.493	0.095	0.379	-0.338	-0.080	-0.072
Minimum	1.518	1.530	1.607	1.294	1.449	1.386	1.770	1.869
Maximum	3.395	4.204	3.998	3.417	2.907	3.581	4.056	4.374
SGR(%)	2.473	2.979	0.847	2.280	0.820	2.446	2.403	2.734
CGR (%)	1.011	1.02	1.002	1.018	1.007	1.014	1.015	1.015

Table 3. Production of rice in SAARC countries and world during 1961 to 2010

Production(mt)	*Afghanistan*	*Bangladesh*	*Bhutan*	*India*	*Nepal*	*Pakistan*	*Sri Lanka*	*World*
Mean	0.392	25.538	0.053	94.262	2.999	5.106	2.180	455.555
Standard Error	0.013	1.388	0.001	4.468	0.117	0.300	0.117	19.733
Median	0.384	22.833	0.053	90.414	2.733	4.878	2.234	466.754
Kurtosis	2.094	-0.193	-0.308	-1.442	-1.325	0.045	-0.384	-1.247
Skewness	1.309	0.892	0.479	0.073	0.409	0.448	0.249	-0.061
Minimum	0.242	13.305	0.037	45.657	1.833	1.643	0.764	215.647
Maximum	0.672	49.355	0.077	148.770	4.524	10.428	4.301	689.043
SGR(%)	2.258	4.941	1.362	2.561	1.855	6.696	7.468	4.319
CGR (%)	1.005	1.025	1.007	1.024	1.017	1.03	1.027	1.023

Table 4. Total seed of rice in SAARC countries and world during 1961 to 2010

Total Seed(mt)	*Afghanistan*	*Bangladesh*	*Bhutan*	*India*	*Nepal*	*Pakistan*	*Sri Lanka*	*World*
Mean	0.019	0.511	0.002	3.837	0.077	0.193	0.088	16.265
Standard Error	0.000	0.004	0.000	0.135	0.001	0.006	0.001	0.206
Median	0.02	0.51	0.00	3.39	0.08	0.19	0.09	16.38
Kurtosis	-0.718	1.043	-0.117	1.511	-1.293	-0.510	0.309	0.927
Skewness	-0.471	0.164	0.369	1.416	-0.172	0.029	0.531	-0.286
Minimum	0.013	0.435	0.001	2.771	0.061	0.114	0.073	12.868
Maximum	0.023	0.590	0.003	6.732	0.094	0.284	0.109	19.872
SGR(%)	-0.097	0.729	0.301	-0.308	0.928	2.030	0.977	0.616
CGR (%)	0.994	1.003	1.002	0.997	1.008	1.014	1.003	1.003

Production scenario of wheat presented in Table 5, Table 6, Table 7 and Table 8 clearly indicates that there has been improvement in area, production, productivity and total seed of wheat in SAARC countries but the fact is that the growth rates are varying over the countries. Though the compound growth rate in almost all the countries are in the tune of worldwide average picture, the simple growth rates are varying. In Bhutan the area scenario of wheat production is declining front where as in Sri Lanka the coverage of wheat is negligible. From tables it is clearly visible that the production of wheat is more in India than other SAARC counties in the world. The average production of wheat in India is 44.63mt with 1.039 % compound growth rates. The production of Pakistan also increased from 3.814 mt to 24.00mt in year 2010 with registering a simple growth rate of almost 10.43%. Afghanistan, Bangladesh, Bhutan and Nepal also registering a growth of 2.01%, 54.54%, -0.204% and 21.49%. India is contributing 12.78% of total of wheat in world.

Table 5. Area under wheat in SAARC countries and world during 1961 to 2010

AW('000'ha)	*Afghanistan*	*Bangladesh*	*Bhutan*	*India*	*Nepal*	*Pakistan*	*World*
Mean	2095.558	414.605	7.173	21972.27	452.20	7131.14	221057
Standard Error	42.319	37.129	0.380	680.599	29.721	174.917	1186.6
Median	2097	499.1925	6.6	23196.55	483.32	7370.55	219928
Kurtosis	-0.370	-1.453	-0.236	-0.709	-1.362	-1.059	-0.390
Skewness	0.053	-0.093	0.616	-0.687	-0.376	-0.403	0.179
Minimum	1570	53.419	3.069	12572	100	4639	204209
Maximum	2897.1	882.224	13	28520	731.13	9131.6	239165
SGR (%)	0.251	11.512	-0.708	2.462	11.524	1.976	0.126
CGR (%)	0.998	1.055	0.997	1.016	1.041	1.022	1

Table 6. Yield of wheat in SAARC countries and world during 1961 to 2010

Yield (t/ha)	*Afghanistan*	*Bangladesh*	*Bhutan*	*India*	*Nepal*	*Pakistan*	*World*
Mean	1.188	1.584	1.106	1.890	1.431	1.695	2.142
Standard Error	0.037	0.083	0.033	0.098	0.051	0.081	0.084
Median	1.187	1.840	1.019	1.893	1.286	1.661	2.255
Kurtosis	1.895	-1.209	0.507	-1.414	-0.264	-1.085	-1.281
Skewness	1.144	-0.599	0.641	-0.137	0.906	0.030	-0.196
Minimum	0.724	0.574	0.639	0.730	0.847	0.760	1.089
Maximum	1.967	2.396	1.766	2.907	2.225	2.716	3.067
SGR(%)	1.573	6.481	0.772	4.748	1.499	4.296	3.591
CGR (%)	1.008	1.029	1.006	1.028	1.013	1.026	1.02

Table 7. Production of wheat in SAARC countries and world during 1961 to 2010

Production(mt)	*Afghanistan*	*Bangladesh*	*Bhutan*	*India*	*Nepal*	*Pakistan*	*World*
Mean	2.504	0.784	0.008	44.633	0.703	12.756	473.844
Standard Error	0.107	0.083	0.001	3.252	0.065	0.855	18.565
Median	2.330	0.896	0.007	44.899	0.645	12.215	502.866
Kurtosis	3.290	-1.191	2.760	-1.371	-1.092	-1.134	-1.086
Skewness	1.721	0.082	1.727	-0.027	0.410	0.155	-0.357
Minimum	1.469	0.033	0.004	9.853	0.126	3.814	222.357
Maximum	5.064	1.908	0.020	80.710	1.572	24.033	686.957
SGR(%)	2.018	54.547	-0.204	12.937	21.490	10.432	3.938
CGR (%)	1.005	1.091	0.002	1.039	1.061	1.035	1.008

Table 8. Total seed of wheat in SAARC countries and world during 1961 to 2010

Total Seed(mt)	*Afghanistan*	*Bangladesh*	*Bhutan*	*India*	*Nepal*	*Pakistan*	*World*
Mean	0.186	0.042	0.001	2.390	0.044	0.731	32.014
Standard Error	0.006	0.004	0.000	0.119	0.003	0.047	0.400
Median	0.178	0.050	0.001	2.581	0.048	0.677	32.934
Kurtosis	3.245	-1.390	-0.227	-0.173	-1.483	-0.700	-0.664
Skewness	1.633	-0.119	0.612	-0.373	-0.245	0.506	-0.835
Minimum	0.133	0.005	0.000	0.778	0.010	0.270	25.250
Maximum	0.319	0.0882	0.0010	4.275	0.0856	1.4924	35.824
SGR(%)	1.169	11.045	-0.735	4.657	12.245	8.940	0.736
CGR (%)	1.007	1.061	0.004	1.021	1.058	1.037	0.995

With the above scenario of production behaviour of rice and wheat, now it is imperative to assess the future behaviour of area, yield, production and total seed of rice and wheat for the food and nutritional security not only for this region but also for other parts of world. As mentioned early, the present study attempt to forecast using ARIMA modelling technique. Among the competitive models, best fitted models have been identified based on the criteria given in the material and methods section. Table 9 to Table 12 depict the best fitted model for area, yield, production and total seed of rice; whereas Table 13 to Table 16 are pertaining to wheat. Though different series has been fitted with different ARIMA models but one thing is clear that none of the series is stationary in nature and first order differencing is required for all the series. Thus starting from (0, 1, 1) ARIMA model to (1, 1, 5) models is found to be suitable in modelling and forecasting the production behaviour and total seed of rice and wheat. The models are validated by comparing the forecasted values with the corresponding actual figures for the period of validation *i.e.* 2006-2010. Table 17 to Table 24 and Figure 1-Figure 8 depict the nature of fitting. The closeness of observed and expected values clearly indicates the goodness of fit of the models. Lastly the fitted models are put under diagnostic check in term of ACF and PACF of residuals. The analyses reveal that the residuals are white noises. Using the above selected and verified models forecasting values are generated for each and every series under consideration. Forecasting values for year 2015 and 2020 are given in Table 17 to Table 24. From the tables it is clear that there would be marginal change in area under rice in all SAARC countries, where as areas under wheat are expected to increase. So far about the yield of rice is concerned it will increase marginally in all the countries and also the world. Automatic reflection of expansion in area and yield is recorded in production scenario also. However, the total seed of rice will remain all most constant except for Pakistan.

Table 9. Best ARIMA models fitted to Area under rice

Area ('000ha)	**Models**	**R^2**	**RMSE**	**MAPE**	**MAE**	**MaxAPE**	**MaxAE**	**Normalized BIC**
Afghanistan	ARIMA (1,1,4)	**0.812**	**12.345**	4.795	8.132	27.852	**38.992**	5.582
Bangladesh	ARIMA (0,1,3)	0.717	**325.582**	2.334	**236.197**	8.769	**853.973**	11.968
Bhutan	ARIMA (0,1,5)	0.725	2.414	5.581	**1.42**	32.627	8.493	2.318
India	ARIMA (1,1,5)	**0.834**	**1269.00**	**2.082**	**833.746**	**11.061**	4087.00	14.928
Nepal	ARIMA (0,1,1)	**0.752**	13.388	5.064	**8.56**	29.473	48.174	5.348
Pakistan	ARIMA (0,1,5)	0.936	111.11	**4.086**	83.813	12.432	**368.303**	**9.739**
Sri Lanka	ARIMA (0,1,3)	**0.651**	87.37	8.441	**62.362**	31.472	**207.743**	9.337
World	ARIMA (1,1,5)	**0.953**	**2342.00**	1.169	1679.00	3.268	4900.00	**16.074**

Table 10. Best ARIMA models fitted to yield of rice

Yield (t/ha)	**Models**	**R^2**	**RMSE**	**MAPE**	**MAE**	**MaxAPE**	**MaxAE**	**Normalized BIC**
Afghanistan	ARIMA (0,1,4)	**0.756**	0.25	**7.289**	**0.162**	28.793	0.81	**-2.617**
Bangladesh	ARIMA (1,1,1)	**0.577**	0.281	7.048	0.157	38.153	**1.2**	**-2.222**
Bhutan	ARIMA (1,1,5)	0.647	**0.269**	6.562	0.144	**43.03**	1.028	-1.992
India	ARIMA (0,1,5)	**0.903**	0.2	**6.99**	0.147	27.439	**0.544**	-3.056
Nepal	ARIMA (1,1,2)	0.79	0.173	**6.414**	0.133	**35.968**	0.522	**-3.275**
Pakistan	ARIMA (1,1,1)	0.915	**0.168**	4.895	0.12	16.617	**0.407**	**-2.934**
Sri Lanka	ARIMA (0,1,4)	0.938	0.172	**4.682**	**0.125**	**15.025**	0.364	-2.964
World	ARIMA (1,1,2)	**0.993**	0.062	1.699	**0.049**	5.665	**0.128**	-5.311

Table 11. Best ARIMA models fitted to production of rice

Production rice(mt)	Models	R^2	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalized BIC
Afghanistan	ARIMA (1,1,3)	**0.762**	0.045	8.36	**0.03**	65.729	0.184	**-6.063**
Bangladesh	ARIMA (0,1,5)	**0.98**	**1.474**	4.663	**1.063**	15.93	2.977	1.332
Bhutan	ARIMA (0,1,3)	0.711	0.006	6.602	**0.003**	42.409	**0.018**	**-9.889**
India	ARIMA (1,1,5)	**0.923**	9.072	**7.686**	6.623	30.237	26.875	**4.807**
Nepal	ARIMA (1,1,2)	0.882	**0.3**	7.222	**0.204**	42.05	**0.771**	-1.929
Pakistan	ARIMA (1,1,1)	**0.918**	0.63	7.971	0.423	**24.471**	2.012	**-0.448**
Sri Lanka	ARIMA (0,1,0)	0.895	0.281	10.594	**0.206**	40.931	**0.803**	-2.065
World	ARIMA (1,1,5)	**0.992**	12.8	**2.076**	8.807	**7.311**	33.482	5.734

Table 12. Best ARIMA models fitted to total seed of rice

Seed rice(mt)	Models	R^2	RMSE	MAPE	MAE	Max APE	MaxAE	Normalized BIC
Afghanistan	ARIMA (0,1,2)	**0.748**	0.001	**5.073**	0.001	**29.41**	0.005	-12.871
Bangladesh	ARIMA (0,1,5)	**0.732**	0.016	**2.341**	0.012	**7.973**	0.039	-7.777
Bhutan	ARIMA (1,1,1)	**0.696**	0	**6.495**	0	**32.298**	0.001	-16.469
India	ARIMA (1,1,5)	**0.571**	0.674	**10.896**	0.431	**68.177**	-0.234	3.659
Nepal	ARIMA (0,1,1)	**0.928**	0.003	**2.72**	0.002	**7.841**	0.007	-11.319
Pakistan	ARIMA (1,1,1)	**0.927**	0.011	**3.947**	0.008	**14.952**	0.042	-8.494
Sri Lanka	ARIMA (0,1,3)	**0.195**	0.008	**6.499**	0.006	**19.755**	0.016	-9.437
World	ARIMA (1,1,2)	**0.841**	0.016	**2.242**	0.011	**8.773**	0.043	-5.947

Table 13. Best ARIMA models fitted to Area under wheat

Area ('000ha)	Models	R^2	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalized BIC
Afghanistan	ARIMA (1,1,0)	0.565	203.174	**7.387**	154.866	23.35	**676.486**	10.866
Bangladesh	ARIMA (0,1,5)	**0.953**	**59.341**	12.76	40.092	69.599	156.077	**8.643**
Bhutan	ARIMA (0,1,5)	0.587	1.809	15.341	0.89	178.223	8.198	1.582
India	ARIMA (1,1,2)	**0.969**	867.253	**3.318**	**684.192**	11.887	1913.00	13.928
Nepal	ARIMA (0,1,1)	**0.988**	**23.058**	4.91	16.866	**29.9**	70.542	**6.514**
Pakistan	ARIMA (1,1,5)	0.969	**221.187**	**2.421**	168.341	8.557	**511.993**	11.195
World	ARIMA (1,1,1)	0.621	5275.00	1.855	**4106.00**	4.514	10200.00	**17.618**

Table 14. Best ARIMA models fitted to yield of wheat

Yield (t/ha)	Models	R^2	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalized BIC
Afghanistan	ARIMA (1,1,1)	**0.431**	**0.201**	12.644	0.146	**77.877**	0.564	-2.975
Bangladesh	ARIMA (1,1,5)	**0.924**	**0.161**	7.931	**0.119**	33.534	**0.487**	**-3.414**
Bhutan	ARIMA (1,1,1)	0.621	**0.15**	7.177	**0.079**	64.571	0.611	**-3.483**
India	ARIMA (1,1,3)	**0.978**	0.105	**5.237**	0.082	24.979	0.203	-4.187
Nepal	ARIMA (1,1,0)	0.94	**0.095**	4.872	**0.065**	28.402	0.24	**-4.07**
Pakistan	ARIMA (1,1,4)	0.973	**0.101**	**5.171**	**0.076**	24.971	0.24	-3.957
World	ARIMA (0,1,2)	**0.982**	**0.081**	3.143	0.063	10.775	0.193	-4.539

Table 15. Best ARIMA models fitted to production of wheat

Production (mt)	Models	R^2	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalized BIC
Afghanistan	ARIMA (1,1,3)	0.564	**0.519**	14.545	**0.355**	89.944	1.322	**-0.996**
Bangladesh	ARIMA (0,1,4)	**0.956**	**0.129**	18.938	0.084	121.062	**0.366**	-3.618
Bhutan	ARIMA (0,1,1)	0.523	0.003	18.645	**0.001**	354.194	**0.015**	**-11.55**
India	ARIMA (0,1,0)	**0.98**	3.261	7.863	2.603	35.464	9.114	**2.603**
Nepal	ARIMA (1,1,2)	**0.986**	**0.056**	7.247	0.039	42.97	**0.225**	-5.432
Pakistan	ARIMA (1,1,3)	0.981	**0.883**	6.224	**0.667**	30.818	**2.257**	0.307
World	ARIMA (0,1,3)	**0.967**	25.064	4.274	19.287	**10.649**	52.786	7.078

Table 16. Best ARIMA models fitted to total seed of wheat

Seed Wheat(mt)	Models	R2	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalized BIC
Afghanistan	ARIMA (0,1,2)	**0.677**	0.024	8.131	0.016	**28.379**	0.083	-7.283
Bangladesh	ARIMA (1,1,3)	**0.951**	0.006	13.033	0.004	**78.267**	0.016	-9.974
Bhutan	ARIMA (1,1,5)	**0.555**	0	14.527	0.00	**177.314**	0.001	-17.411
India	ARIMA (1,1,1)	**0.853**	0.328	8.577	0.181	**70.148**	1.695	-1.834
Nepal	ARIMA (0,1,1)	**0.972**	0.004	6.993	3.875	**22.274**	0.017	-10.843
Pakistan	ARIMA (1,1,2)	**0.963**	0.067	6.527	0.048	**24.883**	0.16	-5.015
World	ARIMA (0,1,0)	**0.864**	1.097	2.368	0.762	**10.291**	3.396	0.82

Table 17. Model validation and forecasting of area(‘000ha) under rice

Year	Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		Sri Lanka		World	
	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-erved	Pred-icted	Obs-rved	Pred-icted
2006	160	149	10579	10600	26.4	27.4	43810	42970	160	153	2581	2604	910	890	155250	155666
2007	170	181	10575	10697	27.5	25.1	43910	42714	170	176	2515	2538	817	886	154986	155514
2008	190	179	11280	11141	19.4	20.4	43540	42340	190	183	2962.6	2986	1053	955	157655	158203
2009	190	207	11353	11345	23.7	23.0	41850	41557	190	196	2883	2906	977	939	158378	159086
2010	200	180	11800	11734	21.8	22.9	36950	37157	200	193	2365	2388	1060	991	153651	155004
2015		147		12015		22.8		39097		198		2506		1124		159828
2020		141		12347		25.2		39209		191		2623		1230		163728

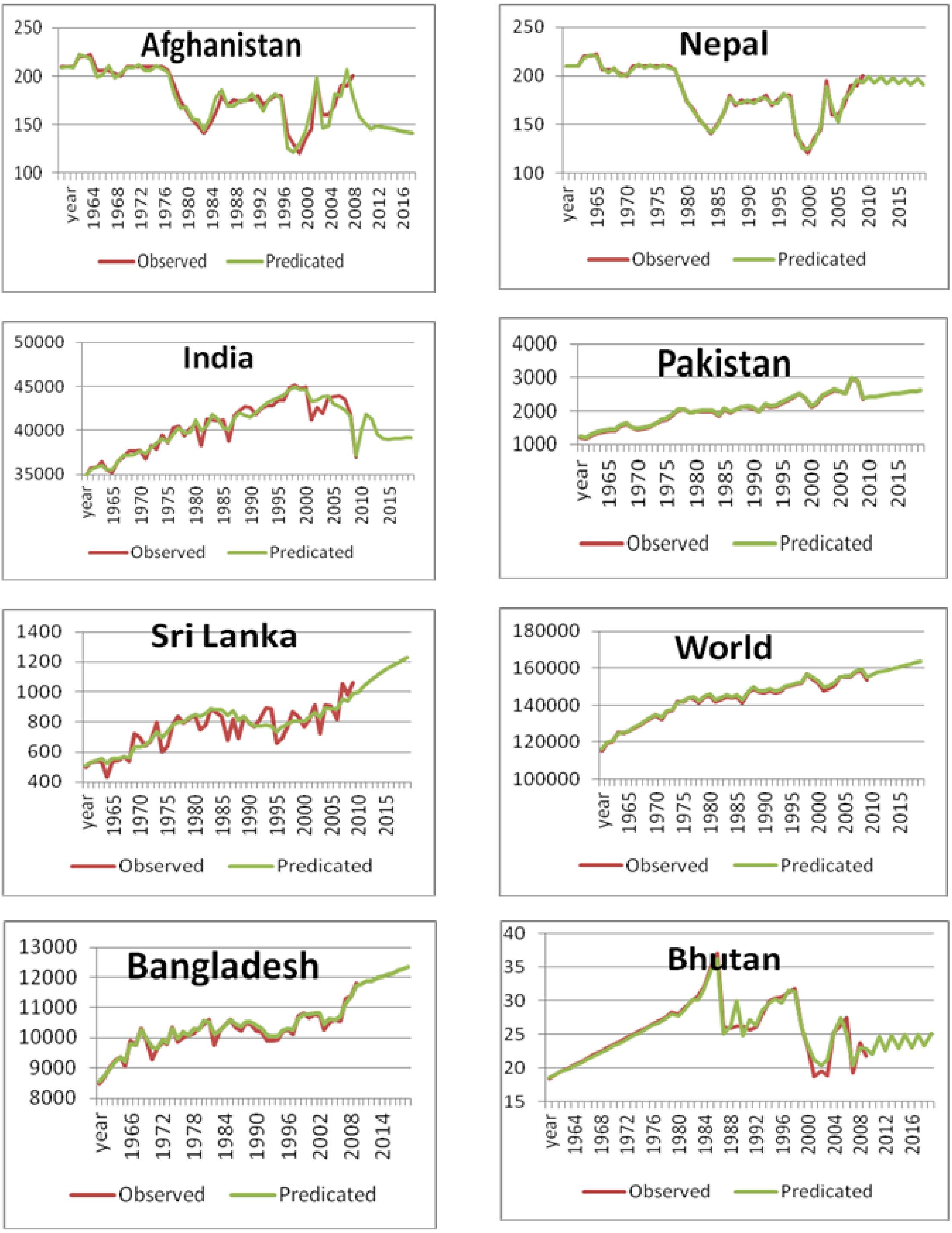

Figure 1. Observed and predicated area (`000ha) of Rice

Table 18. Model validation and forecasting of production(mt) of rice

Year	Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		Sri Lanka		World	
	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted		Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved
2006	0.54	0.55	40.77	41.49	0.07	0.07	139.14	138.39	4.21	4.39	8.16	7.91	3.34	3.33	641	655
2007	0.55	0.56	43.18	43.89	0.07	0.07	144.57	141.88	3.68	4.16	8.35	8.50	3.13	3.28	657	668
2008	0.61	0.62	46.74	47.45	0.08	0.07	148.77	145.55	4.30	4.29	10.43	9.79	3.88	3.61	689	690
2009	0.65	0.66	47.72	48.44	0.07	0.06	133.70	144.17	4.52	4.37	10.32	9.19	3.65	3.74	685	693
2010	0.67	0.68	49.36	50.07	0.06	0.06	120.62	139.62	4.02	4.33	7.24	7.87	4.30	4.03	672	690
2015		0.76		53.63		0.07		148.70		4.52		9.55		4.33		745
2020		0.82		57.20		0.07		157.78		4.78		10.26		4.64		794

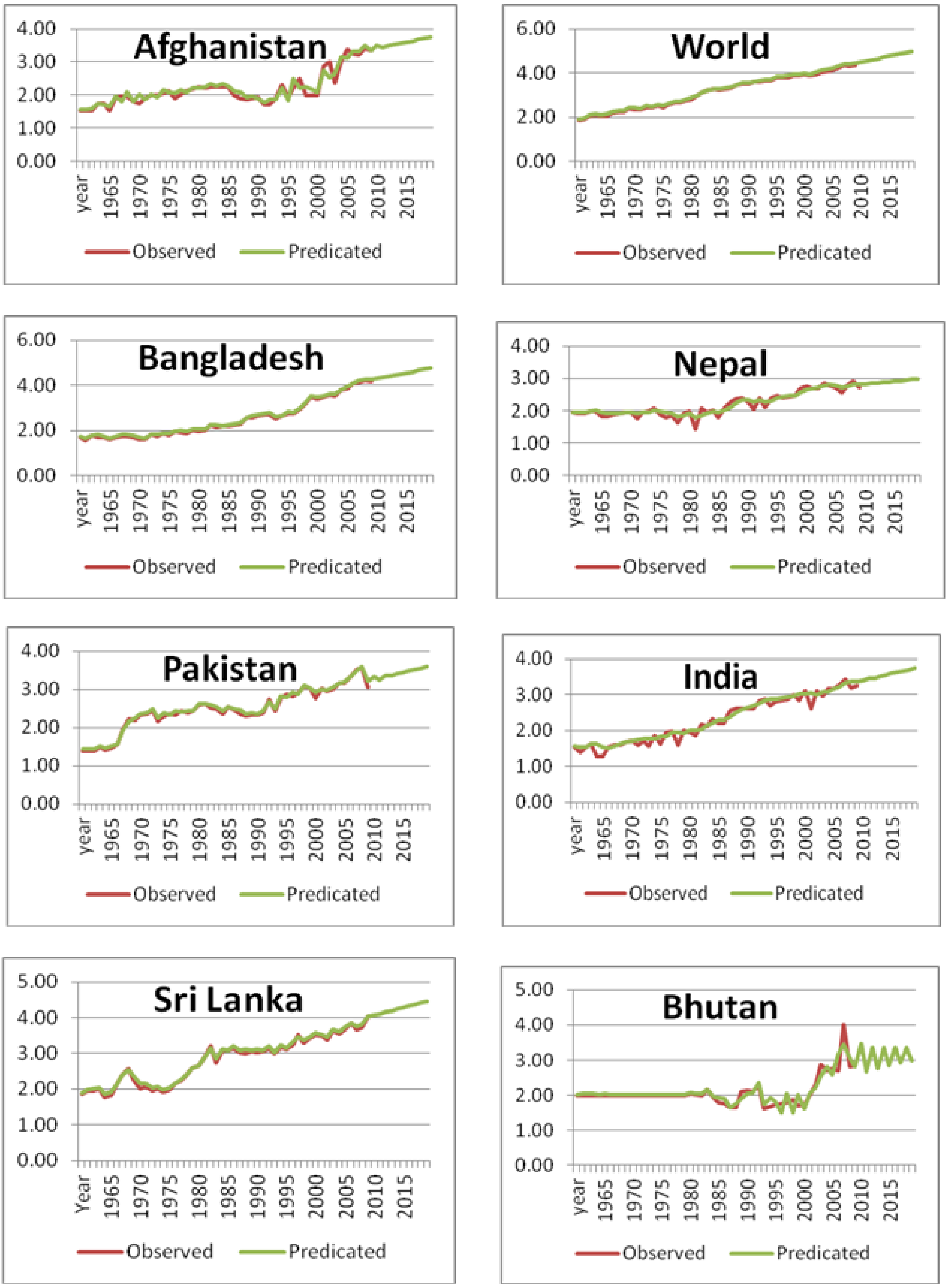

Figure 2. Observed and predicated yield (t/ha) of Rice

Table 19. Model validation and forecasting of yield(t/ha) of rice

Year	Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		Sri Lanka		World	
	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted
2006	3.4	3.1	3.85	3.94	2.75	2.78	3.18	3.09	2.72	2.80	3.16	3.21	2.85	2.92	3.67	3.75
2007	3.2	3.3	4.08	4.09	2.70	2.84	3.29	3.20	2.56	2.71	3.32	3.34	2.83	2.94	3.83	3.83
2008	3.2	3.3	4.14	4.23	4.00	3.55	3.42	3.27	2.78	2.76	3.52	3.46	3.07	3.02	3.68	3.77
2009	3.4	3.5	4.20	4.24	2.80	3.12	3.19	3.41	2.91	2.82	3.58	3.56	3.06	3.09	3.74	3.80
2010	3.4	3.3	4.18	4.24	2.83	2.99	3.26	3.46	2.72	2.82	3.06	3.26	3.01	3.08	4.06	4.02
2015		3.6		4.48		3.09		3.66		2.89		3.43		3.28		4.13
2020		3.8		4.74		3.19		3.85		3.00		3.65		3.48		4.35

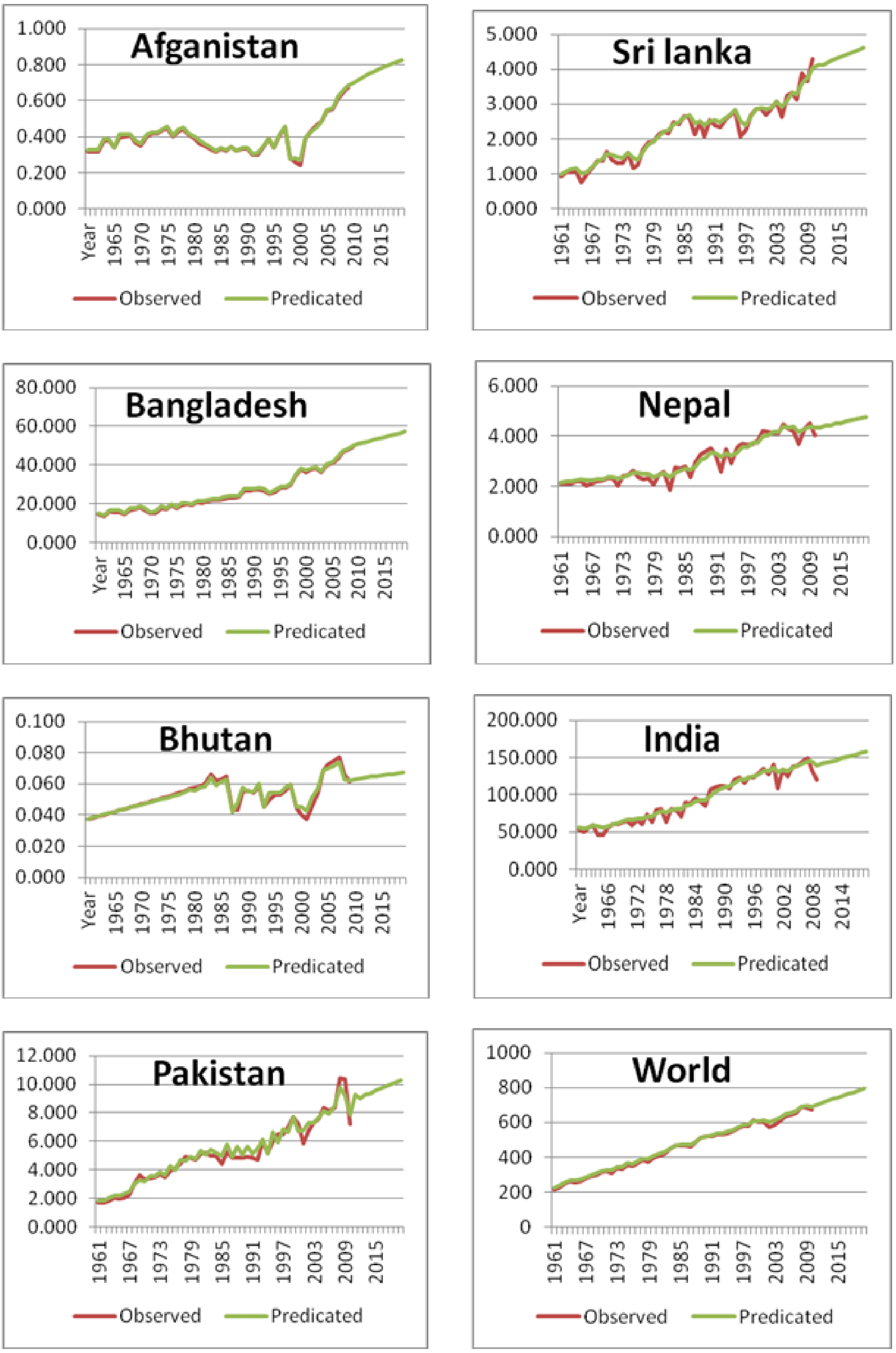

Figure 3. Observed and predicated production (MT) of Rice

Table 20. Model validation and forecasting of total seed(mt) of rice

Year	Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		Sri Lanka		World	
	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted
2006	0.018	0.018	0.529	0.537	0.0022	0.0021	3.29	3.27	0.088	0.089	0.241	0.248	0.094	0.095	16.25	16.32
2007	0.020	0.020	0.564	0.560	0.0015	0.0016	3.27	3.25	0.088	0.089	0.284	0.282	0.084	0.091	16.34	16.26
2008	0.020	0.020	0.568	0.568	0.0019	0.0018	3.14	3.15	0.088	0.089	0.277	0.253	0.109	0.095	16.93	16.92
2009	0.021	0.021	0.590	0.583	0.0017	0.0018	2.77	2.89	0.088	0.089	0.227	0.234	0.101	0.100	16.72	16.99
2010	0.021	0.021	0.590	0.586	0.0017	0.0016	2.77	2.89	0.088	0.089	0.227	0.247	0.109	0.100	16.75	17.04
2015		0.021		0.583		0.0018		2.91		0.092		0.273		0.107		17.40
2020		0.021		0.589		0.0018		2.86		0.095		0.286		0.109		18.00

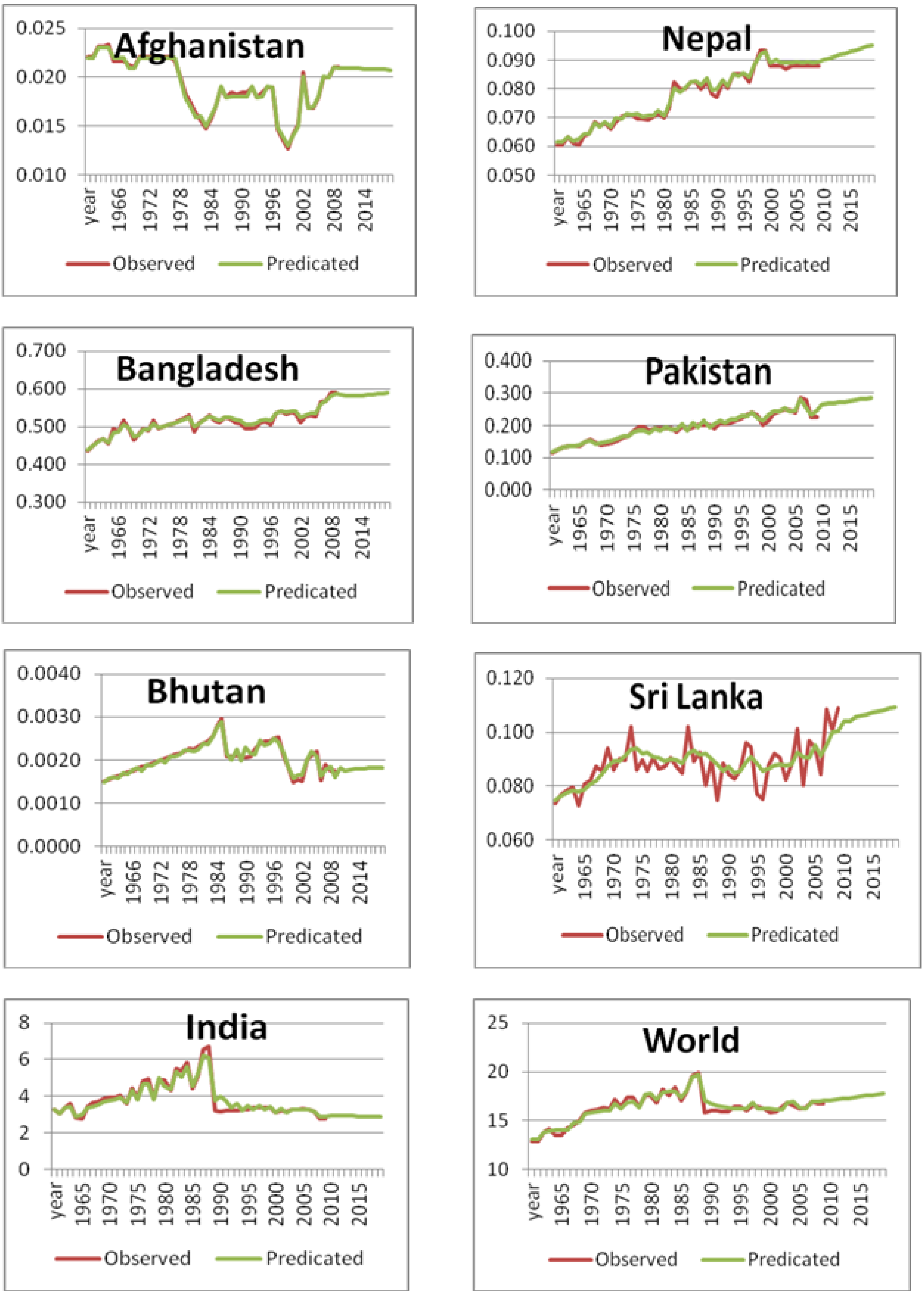

Figure 4. Observed and predicated total seed (MT) of Rice

Table 21. Model validation and forecasting of area('000ha) under wheat

Year(area Wheat)	Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		World	
	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted
2006	2444	2364	479	473	6.75	5.5	26484	26823	672	689	8448	8539	211836	208796
2007	2466	2437	399	392	6.87	5.5	27995	28338	703	720	8578	8659	216705	220335
2008	2139	2267	388	394	3.30	5.5	28039	28490	706	717	8550	8670	222789	222717
2009	2575	2444	395	401	3.12	5.5	27750	27917	695	712	9046	9039	224845	221291
2010	2504	2497	376	378	3.2	5.4	28520	28771	731	742	9132	9224	216775	217285
2015		2521		410		5.1		30439		808		9678		219566
2020		2544		442		4.8		32060		874		10133		220711

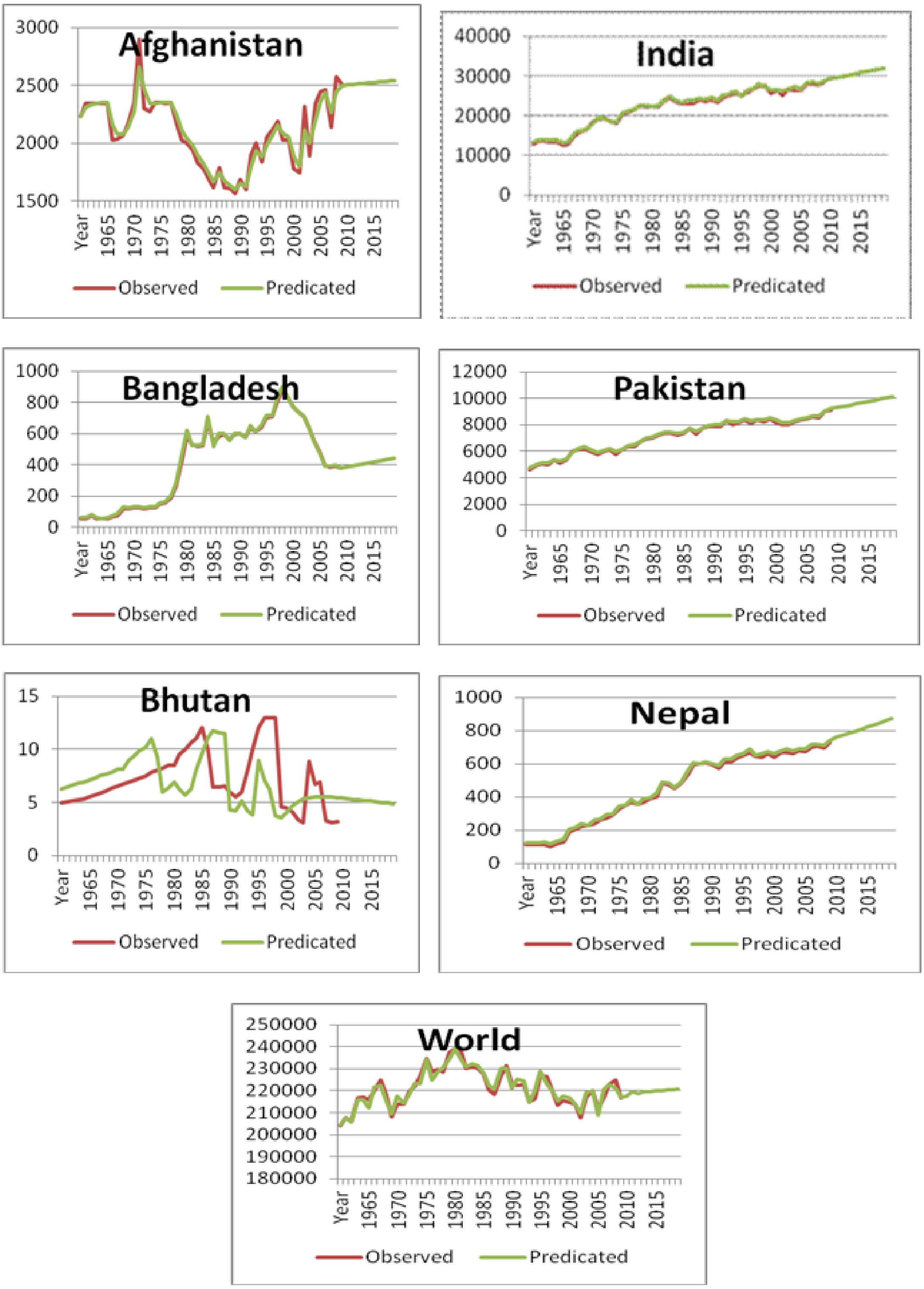

Figure 5. Observed and predicated area ('000ha) of Wheat

Table 22. Model validation and forecasting of production(mt) of wheat

Year(Prod. Wheat)	Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		world	
	Obs-rved	**Pred-icted**	**Obs-rved**	**Pred-icted**	**Obs-rved**	**Pred-icted**	**Obs-rved**	**Pred-icted**	**Obs-rved**	**Pred-icted**	**Obs-rved**	**Pred-icted**	**Obs-rved**	**Pred-icted**
2006	3.36	4.22	0.74	0.71	0.009	0.007	69	71	1.39	1.46	21.28	21.62	603	619
2007	4.48	3.07	0.74	0.79	0.009	0.008	76	75	1.52	1.58	23.29	22.05	613	629
2008	2.62	4.14	0.84	0.93	0.006	0.007	79	79	1.57	1.54	20.96	22.54	683	657
2009	5.06	3.49	0.85	0.90	0.004	0.006	81	82	1.34	1.45	24.03	22.76	687	661
2010	4.53	5.74	0.90	0.95	0.005	0.005	81	83	1.56	1.68	23.31	23.33	651	654
2015		4.68		1.21		0.009		90		1.67		25.29		727
2020		5.37		1.41		0.009		97		1.80		27.34		777

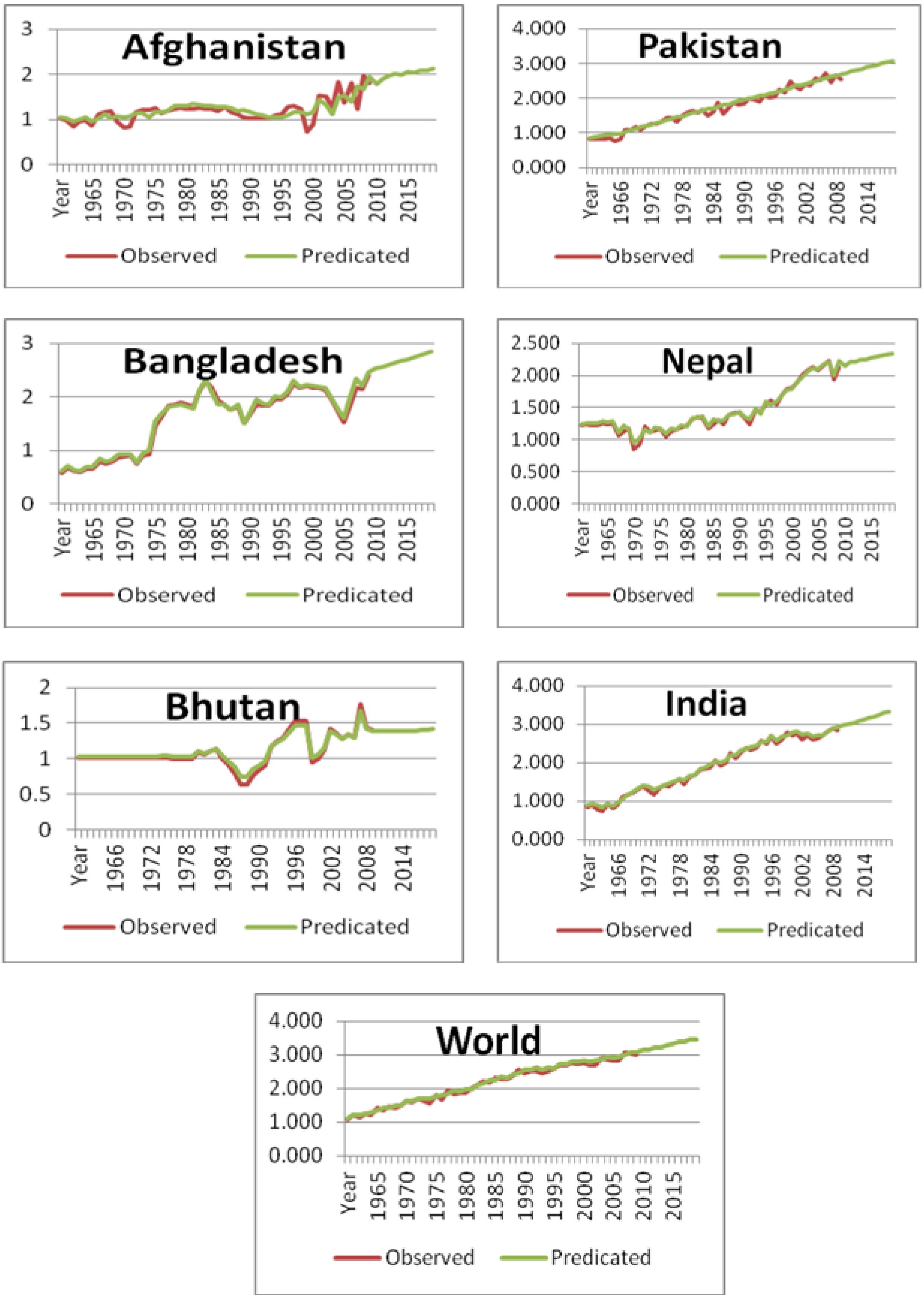

Figure 6. Observed and predicated yield (t/ha) of Wheat

Table 23. Model validation and forecasting of yield(t/ha) of wheat

Year	Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		World	
	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted
2006	1.376	1.526	1.534	1.607	1.35	1.34	2.62	2.71	2.075	2.090	2.519	2.545	2.846	2.915
2007	1.818	1.384	1.847	1.992	1.29	1.30	2.71	2.71	2.156	2.186	2.716	2.572	2.827	2.952
2008	1.226	1.750	2.175	2.338	1.77	1.67	2.80	2.82	2.225	2.206	2.451	2.634	3.067	3.000
2009	1.967	1.666	2.152	2.208	1.44	1.42	2.91	2.90	1.934	1.993	2.657	2.639	3.055	3.090
2010	1.810	1.938	2.396	2.451	1.41	1.39	2.83	2.92	2.129	2.219	2.553	2.696	3.005	3.071
2015		1.996		2.666		1.39		3.12		2.250		2.884		3.296
2020		2.126		2.845		1.41		3.33		2.347		3.079		3.465

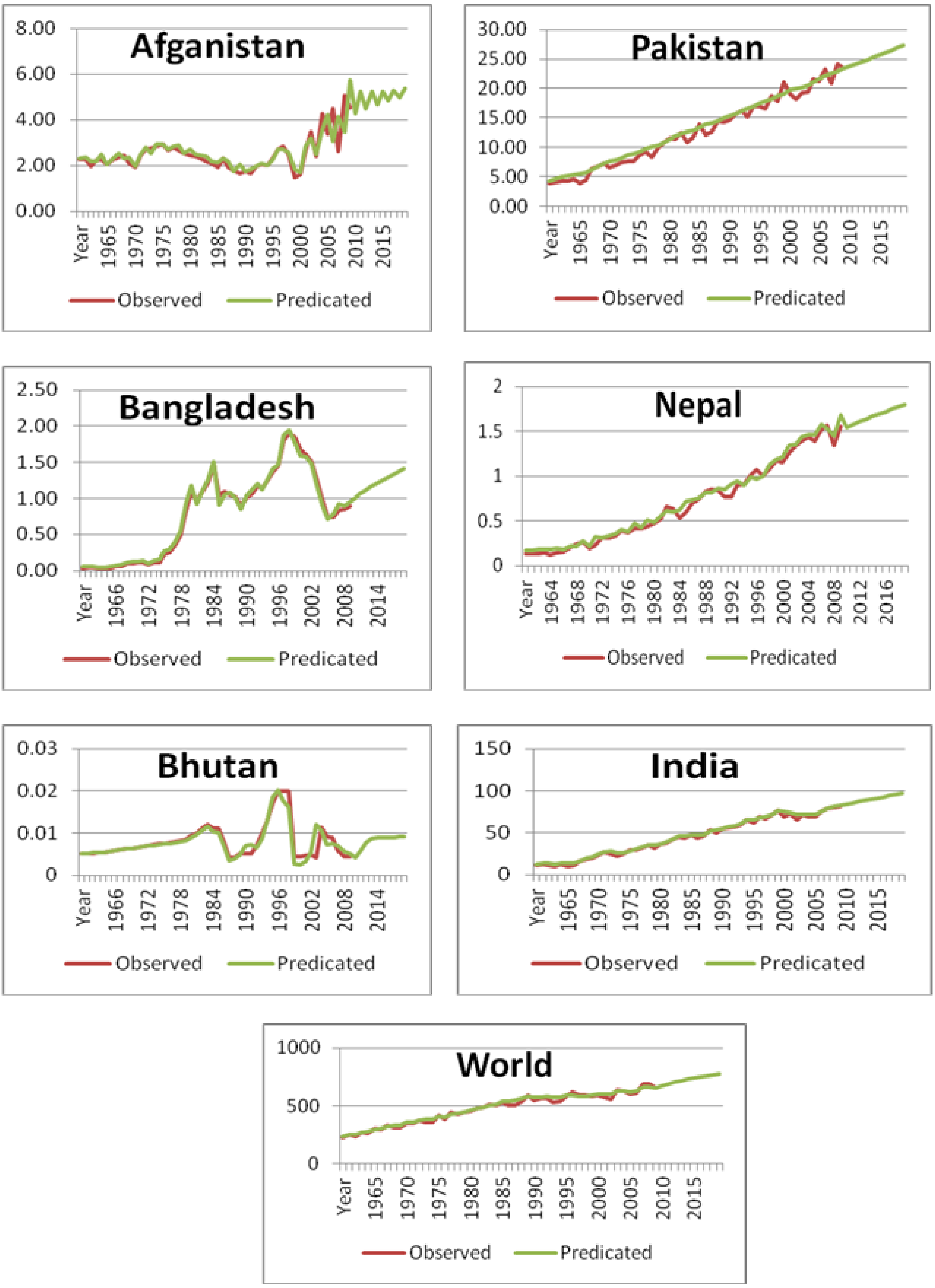

Figure 7. Observed and predicated Production (mt) of Wheat

Table 24. Model validation and forecasting of total seed(mt) of wheat

Year	Afghanistan		Bangladesh		Bhutan		India		Nepal		Pakistan		World	
	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted	Obs-rved	Pred-icted
2006	0.210	0.233	0.040	0.037	0.001	0.0003	2.80	2.80	0.07	0.07	1.22	1.26	32.9	33.5
2007	0.303	0.277	0.039	0.037	0.000	0.0003	2.80	2.85	0.09	0.08	1.29	1.27	34.1	34.4
2008	0.256	0.293	0.039	0.038	0.000	0.0003	2.78	2.84	0.07	0.08	1.25	1.34	34.9	35.3
2009	0.319	0.302	0.038	0.037	0.000	0.0003	2.85	2.88	0.07	0.07	1.49	1.43	34.7	35.3
2010	0.313	0.296	0.038	0.038	0.000	0.0003	2.85	2.90	0.07	0.07	1.45	1.51	34.4	34.4
2015		0.320		0.043		0.0003		3.10		0.08		1.65		36.1
2020		0.329		0.047		0.0003		3.30		0.09		1.77		37.3

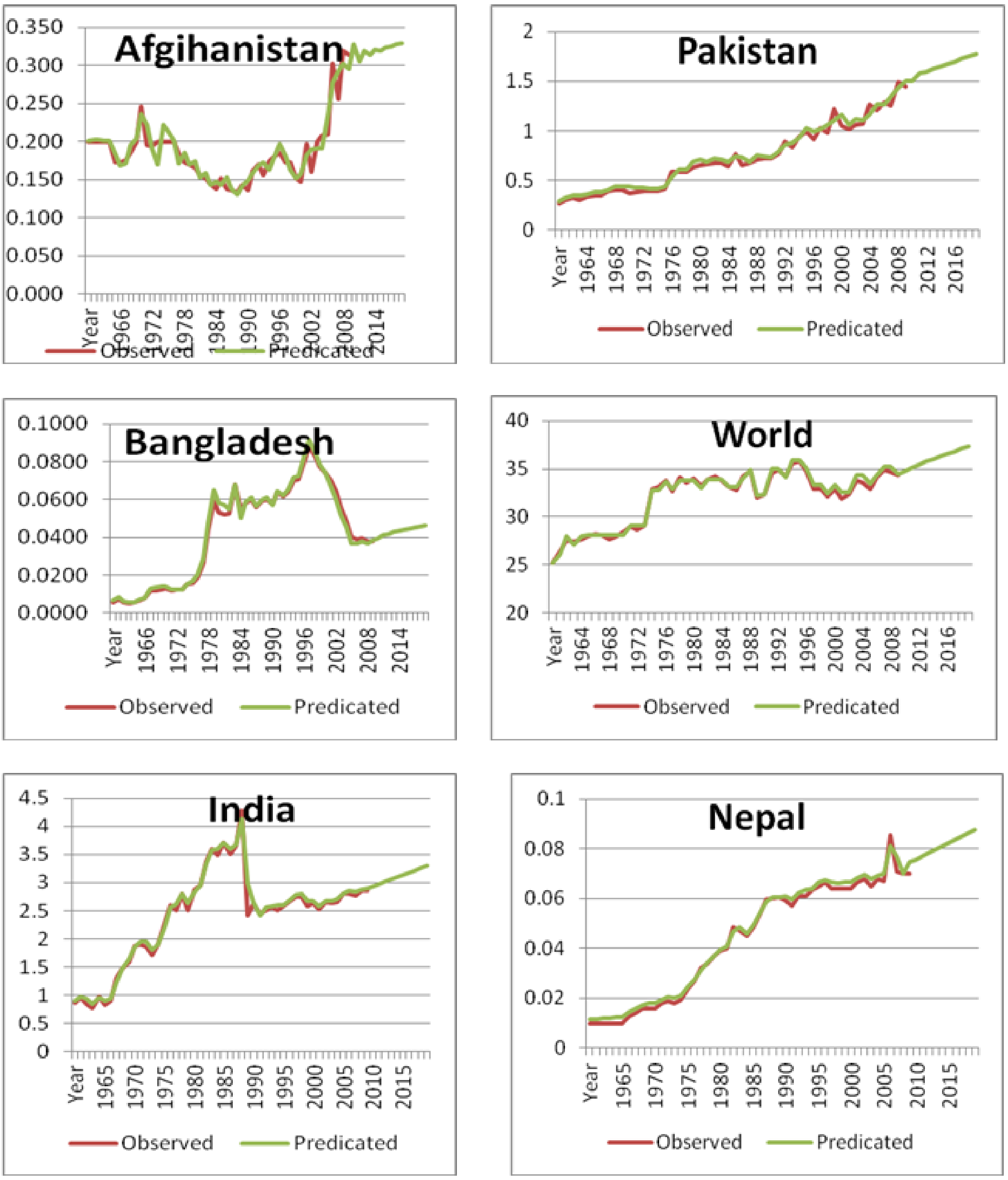

Figure 8. Observed and predicated total seed (mt) of Wheat

In contrast to the projected stagnant area under wheat in Afghanistan, all other SAARC countries would have increased areas under wheat in the years to follow. Except for Bhutan, the yield of wheat in other SAARC countries and also for the world is forecasted to increase. India will be having 3.3 metric tons of wheat per hectare against to 2.21 metric tons at present. Similarly the world average yield will increase to 3.47 t/ha against the present around 3 t/ha. Total seed of wheat will also increase to 37.3 million ton during the year 2020 against the present 34.4 million ton.

Now the question is whether the forecasted areas, productions, yields and total seeds would be sufficient to meet the challenge of food and nutritional security in this region or not? Given the resource crunch situation, particularly the land and water, there is no option but to increase the productivity of these two major crops. Even if the productivity could reach near by the respective present highest productivity of the world then there would be a quantum jump in the production vis-à-vis food security. In this direction good quality of seed, accessible by the farmer and available to the farmer can play vital role.

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