**Empirical Analysis of Indian Rainfall and Rice Productivity**

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***Abstract***

*This paper presents an empirical analysis of the rice production in connection with rainfall for India. Four main parameters (area of sowing, nonmonsoon rainfall, monsoon rainfall & technological advancement) have been used for this empirical analysis. In the first model, simple relationship is developed using production & area with zero intercept. This model did not give any significant result (R2 = 0.368). In above model when we added a constant, model results varied significantly, and result improved (R2 = 0.845). Similarly, three more models along with rainfall have been evaluated. Empirical analysis clearly shows the improvement by adding rainfall as a constraint of equations. With these results, author also advocate for such empirical analysis on regional basis.*

***Keywords:*** *India, rice, rainfall, empirical, model*

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**INTRODUCTION**

Rice is the most consuming cereal of India. Rice is the most consuming cereal in East India (West Bengal, Orissa), North Eastern states (Assam, Arunachal Pradesh, Mizoram, Nagaland, Manipur, Tripura), and South Indian States (Tamil Nadu, Andhra Pradesh, Kerala, Karnataka). Average consumption of rice is varying from 23.4 to 151.8 Kg/per capita for urban area which is slightly higher than the average variation of 20.4–162 Kg/per capita for rural area [1–3]. Average rice consumption from the year 2000–2014 is shown in Figure 1.

*Fig. 1: Rice Consumption of India [2, 4].*

For a country with greater spatial variation of climate, such as India, the average rainfall varies significantly over time and space (Figure 2). From the above mentioned point of view, this paper is developed in three sections namely: Average rainfall, empirical model formulation & analysis of empirical models.

**Rainfall**

Rain is the main source of water in India and Fig. *2* explains the spatial variability of rainfall in India. It varies in the order of 400 on the lower side up to the order of 3500 mm on higher side.

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*Fig. 2: Annual Average Rainfall (mm) [Data Source: IMD & MoWR, Created using ARC-GIS) [5].*

**Model Formulation**

Production of rice is directly dependent upon the area of cultivation, same year monsoon rainfall, previous year nonmonsoon rainfall (NMR) & advancement of technology [4]. Average monsoon rainfall (MR) during 1960–2011 was used to develop four different empirical models (Eqs. 1–4). Total rainfall of India was estimated to be 1178 mm (during 1960–2011) with standard deviation of 107 mm.

 (1)

 (2)

 (3)

 (4)

 (5)

Where,

P = Production of rice (in million tons)

A = Area used for rice production (in million hectare)

NMR = Presowing nonmonsoon rainfall (mm)

MR = Monsoon rainfall (mm)

a, b, c, d, e, f, g, h, i, j, k, l & m are empirical constants and found with the optimization using SPSS22 software. SPSS Statistics is a software package applied for statistical analysis. Long produced by SPSS Inc., it was acquired by IBM in 2009.

**RESULTS AND DISCUSSIONS**

It is observed that there is a falling trend of annual average rainfall for India (Fig. *3*). An average 3.78% of decrement was noticed during 1961–2011. Average monthly rainfall data of India is changed into two parts—MR and NMR. Series was constructed for presowing rainfall (NMR), which is responsible for available moisture contents, rainfall during crop period (MR) & area of sowing. By applying above mentioned models, the results obtained are tabulated in Table 1.

*Fig. 3: Average Annual Rainfall (mm) during 1960–2011.*

***Table 1:*** *Model and Results.*

|  |  |  |
| --- | --- | --- |
| **Model No** | **Empirical Constants** | **R2** |
| 1 | a = 1.581 | 0.368 |
| 2 | b = 1.581, c = -194.54 | 0.845 |
| 3 | d = 3.71, e = -0.127, f = -0.056 | 0.595 |
| 4 | g = 6.432, h = -0.048, i = 0.011, j = -192.13 | 0.860 |
| 5 | k = 0.698, l = 0.107, m = 0.140 | 0.865 |

Extent of linearity of Figure 4 is the indicant of better empirical model for rice production prediction. Analysis of these outcomes from Table 1 shows that Model 5 is overall the best model among the five assumed in the paper. In depth analysis also suggest that Model 4 is better than Model 5 for higher production level performance. Model 2 also has better performance where additional parameters signify the technical advancement & facilities available in the area.

*Fig. 4: Observed vs. Predicted Models.*

**CONCLUSIONS**

1. Performance of empirical rice production is getting better after inclusion of rainfall parameters (R2 = 0.368 to R2 = 0.595).
2. Additional parameter also improves the performance but rate is slightly lower (R2 = 0.845 to R2 = 0.860).
3. Model 5 (Area exponential model) has the best performance over the period and hypothesis of analysis.
4. Rainfall has significant effect on the production of rice so that regional analysis should be carried out to find dependability of rice production on rainfall. This will also help for better agricultural planning (irrigational demand estimation) to cope up with change in rainfall conditions.

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