

1 Analyzing the Long-Run Determinants of Rice Production in 2 Nepal: Evidence from an ARDL Approach (1990–2019). 3 4

5 Abstract

6 Nepal, an agricultural nation in South Asia, is characterized by its distinct topography: 35%
7 mountains, 42% hills, and 23% Terai. This study investigates the key factors influencing
8 Nepal's agricultural food production. Utilizing the Auto Regressive Distributed Lag (ARDL)
9 model, it analyses data spanning 1990 to 2019, focusing on electricity generation, annual
10 mean temperature, foreign exchange rate, and imports of agricultural food products as
11 independent variables. The analysis reveals significant relationships. Electricity generation
12 and the foreign exchange rate exhibit a positive impact on cereal production. Conversely,
13 both cultivated area and annual mean temperature demonstrate a negative impact, posing
14 risks to overall agricultural output in Nepal. These findings highlight critical sensitivities
15 within the agricultural sector. Based on these relationships, the study forecasts agricultural
16 food production up to the year 2060. These projections were developed using four distinct
17 scenarios grounded in potential production growth rates. The long-term outlook underscores
18 the need for strategic planning. A key recommendation emerges: policymakers should
19 prioritize enhancing paddy (rice) production. The study strongly suggests this targeted focus
20 offers substantial benefits. Increasing paddy output is projected to significantly reduce
21 Nepal's trade losses related to agricultural goods. Furthermore, this strategy is identified as a
22 crucial driver for fostering broader national economic development. By concentrating efforts
23 on this vital crop, Nepal can leverage its agricultural sector for greater economic stability and
24 growth amidst its challenging geographic constraints.
25

26 **Keywords:** *Nepal, Agricultural production, Foreign Exchange Rate, ARDL*

27 Introduction

28 The agricultural existence of Nepal depends heavily on rice since it functions as its
29 fundamental food security ingredient for many millions of citizens. The agricultural sector of
30 Nepal encounters difficulties because the nation becomes more dependent on imported
31 agricultural items that negatively impact local rice production. Little research has investigated
32 how agricultural imports affect Nepal's rice production although Joshi et al. (2016), Timsina
33 et al. (2018) and other scholars investigated broader trade liberalization effects in developing
34 countries. The long-term consequences of cheaper imported rice competition for local
35 production and environmental sustainability of farming lands along with farmer incomes
36 demand deeper scientific investigation according to research by Devkota (2020) and Adhikari
37 (2021).

38 Data indicates agricultural imports introduce various impacts on domestic rice production in
39 Nepal by possibly pushing out local farmers yet offering modern farming knowledge to their

40 sector. Analysis of historical trends in production and import statistics alongside
41 governmental policies will evaluate these effects according to the research. The analysis
42 contains vital environmental importance because the dependency shifts in farming methods
43 due to import exposure affect land utilization and water resource handling and agrochemical
44 implementation. The identification of these dynamics enables policymakers to develop
45 agricultural strategies which preserve ecological conservation goals while staying
46 competitive in the trade market and maintaining production self-reliance.

47 Foreign trade performs a transformative function, affecting how domestic economic stability
48 and growth are produced (Smutka et al., 2016). The integration of agriculture into the global
49 economy is becoming more and more important. A point of political and economic
50 convergence, international trade, especially trade in food, connects the economics of several
51 nations (Maslova et al., 2019). Net food-importing developing nations are anticipated to be
52 more negatively impacted by these price changes since food will consume a more even
53 greater portion of their limited income (Aragie et al., 2016). Due to its larger population than
54 any other region, Central and South Asia has a higher demand for food (Hoekstra & Hung,
55 2005). Valdés (2012) found that 35 low-income nations imported food on a net basis. The
56 production of food for the expanding population takes up a significant portion of the earth's
57 land area (Sandström et al., 2014).

58 It is impossible to overstate the value of imports and export to the growth and development of
59 a country's economy because these two factors act as essential stimulants for the economy's
60 overall economic growth (Awe et al., 2018). In the many business and development concepts,
61 new intermediate inputs are of utmost importance (Goldberg et al., 2008). According to these
62 models, business gain from trade by having more access to previously unavailable inputs,
63 which results in a steady increase in profit. By introducing new kinds to their domestic
64 product lines, enterprises, are thus given access to these freshly imported inputs, which
65 results in dynamic advantages from trade.

66 Under macroeconomic circumstances that support the growth of a successful agricultural
67 industry, ensuring food availability based on import substitution in the context of the
68 globalization of national agri-business industries is feasible (Ozerova et al., 2019). Studies
69 and experience indicate that if we assure the logical placement of production, apply
70 contemporary technology, and train qualified employees, we can improve the
71 competitiveness of local agricultural goods for all of their varieties in the future.

72 A rise in agri-food imports favors low-wage regions more than high-demand ones, despite the
73 fact that closeness to customers has a considerable impact on the geographic distribution of
74 agri-food output (Bagoulla et al., 2010). Also, a rise in the importation of agricultural items
75 that agri-food companies process causes a reallocation of agri-food production away from
76 areas with strong access to agriculture related products and towards places with restricted
77 access. International trade has a huge significance in developing nations like Nepal. And a
78 fundamental concern in many empirical investigations has been the applicability of the
79 export-led growth theory in Nepal (Mishra, 2012).

80 **Methodology**

81 For an empirical investigation, time series data from 1990 to 2019 are analyzed. Total rice
82 production, total cultivated area, annual mean temperature, fertilizer consumption, and
83 precipitation are the major variables used for the study. The data source and measurement
84 unit are mentioned in the table below.

85 The study area of this research is the country, Nepal. which lies between two economically
86 big countries namely China and India. The total area of Nepal is 147181 Sq. KM. and the
87 total population is 29,192,480 among then 48.96% is the population of males and 51.04 is the
88 population of females. The majority of the population belongs to a female. Two third of the
89 total population depends on agricultural income as the primary source of Income. Total
90 export for the financial year of 2021/22 is 118, 851.00 million Nepali rupees and on the other
91 hand, a total amount of 999,342.70 million Nepali rupees has been imported during the year.
92 The country has a total of 1,734,467.20 million rupees of total government outstanding which
93 is 40.70% of the total GDP. So, I am dealing with import, agricultural food production,
94 foreign currency reserve, productivity, and cultivated areas used.

95 Pesaran has greatly popularized the autoregressive distributed lag (ARDL) method, which has
96 many benefits compared to earlier cointegration techniques like EG (Eagle and Geanger
97 1987) and JJ's maximum likelihood-based tests (Johansen and Juseliua 1990) (Ghimire *et al.*,
98 2021). It is easy to determine whether a long-term relationship is close by using the ARDL
99 approach without taking into account the series that is stationary at levels [I (0)] or first
100 difference [I (1)], or a combination of both (Chandio *et al.*, 2018). The ARDL strategy is
101 extremely dependable when there is a small sample size and maintains the strategic distance
102 from the issue of endogeneity and makes a difference to look at the long-term coefficients.
103 ARDL F-stat is utilized to look at the relationship over time between the study variables

104 chosen. We can reject the null hypothesis and infer that the cointegration occurs if the F-
 105 statistic value is significantly larger than the I (1) bound (Chandio *et al.*, 2021b). The lag
 106 order of the ARDL model is selected automatically by Eviews software.

107 **Table 1. Variable definition and sources of data**

Variable Name	Agricultural Import	Electricity Generation	Mean Temperature	Cultivate area	Rural Population	108 Exchange Rate
Abbreviations	<i>RP</i>	<i>PRC</i>	<i>MT</i>	<i>CA</i>	<i>FT</i>	109 <i>EXC</i>
Unit of Measurement	Thousand Metric tons	Millimeters	Celsius degree centigrade	Thousand hectares	Metric Ton	110
Source	(Nepal Rastra Bank, 2022)	(World Bank Nepal, 2022)	(Climate Change Knowledge Portal for Development practitioners and Policy Makers, 2022)	(Nepal Rastra Bank, 2022)	(Nepal Rastra Bank, 2022)	111 (Nepal Rastra Bank, 2022)

113 **Methodological Clarity: Step-by-Step ARDL Approach**

114 Our approach to ARDL clarity becomes more reproducible by explaining the step-by-step
 115 ARDL procedures.

116 Unit root tests on all variables (ADF test) determined their appropriate integration levels to be
 117 either I (1) or I (0).

118 The determination of cointegration by F-statistic at 10.20 exceeded the I (1) critical value
 119 threshold of 3.99 at 1% level.

120 The program used EViews to select proper lags according to AIC (which found maximum lag
 121 length of two).

122 Endogeneity issues were addressed by using FMOLS and CCR as supplemental methods to
 123 validate the ARDL results which appear in Table 1.

124 **Result and Discussion**

125 Nepal is located in South Asia with facilities of 280 N and 840 E and is arranged in China in
 126 the north and all sides have been covered by India. With 1.89 billion people or one-fourth of
 127 the world's population, south Asia is an area that heavily relies on agriculture for
 128 employment and subsistence (Economics & Library, n.d.-b). Topographically Nepal is
 129 separated into five regions: The Himalayas, High Hills, Mid Hills, Siwalik, and Terai (M.
 130 Paudel, 2013). Rice is consumed by billions of individuals and is the foremost common staple
 131 food of a huge number of individuals on earth, the fact is it feeds more people than any other

132 crop (Wassmann et al., 2009). Rice is the major cereal crop grown in three major zones: terai,
 133 Mid-hills, and high hills of Nepal (Malla et al., 2022).

134 The agricultural sector is known as one of the most vulnerable sectors to climate change
 135 because the overall growth of this sector mainly depends upon climate and climate conditions
 136 (Sinnarong et al., 2019). Climate change plays a very significant role in the overall product
 137 development of the agricultural sector in Nepal. For the nation's development, the
 138 Agribusiness sector plays a very important role in providing job opportunities and for the
 139 country's economic advancement (Lee et al., 2019). Due to its importance different NGOs,
 140 INGO, and government policymakers are actively involved in the development of the
 141 agricultural sector in Nepal.

142 The productivity and sustainability of rice production are undermined by biotic and abiotic
 143 stresses, and the impact of these stresses can be exasperated by dramatic global temperature
 144 changes (Ayinde et al., 2013).

145 **Bound Test**

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	10.20192	10%	1.99	2.94
K	6	5%	2.27	3.28
		2.50%	2.55	3.61
		1%	2.88	3.99
Dependent Variable: LNCERALPROD				
Method: Fully Modified Least Squares (FMOLS)				
Date: 01/16/23 Time: 17:46				
Sample (adjusted): 1991 2019				
Included observations: 29 after adjustments				
Cointegrating equation deterministic: C				
Long-run covariance estimate (Prewhitening with lags = 2 from AIC maxlags = 2, Bartlett kernel, Newey-West fixed bandwidth = 3.0000)				

146

147 Import of Agricultural food products, the major variable of concern, has a positive impact on
 148 the production of agricultural food production. It indicates that the current level of import of
 149 food products has not harmed the production of food crops in Nepal. A negligible value of
 150 the coefficient indicates that the influence of the import of food products is weaker. It means
 151 a one percent increase in agricultural import affects cereal production by only 0.01 percent.

152 Electricity generation has a positive impact on cereal production which indicates that along
 153 with an increase in electricity generation the use of electricity for cereal production-based
 154 agricultural activity might have increased. Furthermore, it might have helped to reduce
 155 energy costs used for agricultural production motivating increasing cereal production.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNAGRIIMPORT	0.017698	0.001902	9.306651	0.000
LNMEANTEMP	-0.64803	0.028433	-22.7912	0.000
LNRURALPOP	-0.84164	0.030908	-27.23	0.000
LNCULAREA	-0.04989	0.015631	-3.19149	0.0042
LNELEGEN	0.363801	0.005261	69.14613	0.000
LNEXCHANGE	0.066836	0.007154	9.342451	0.000
C	21.93865	0.480591	45.64933	0.000
R-squared	0.923418	Mean dependent var		8.872656
Adjusted R-squared	0.902533	S.D. dependent var		0.204948
S.E. of regression	0.063984	Sum squared resid		0.090067
Long-run variance	8.87E-06			

156
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 158 production of agricultural food production. It indicates that current level of import of food
 159 products have not much harmed for the production of food crops in Nepal. Negligible value
 160 of the coefficient indicates that the influence of import of food product is weaker. It means one
 161 percent increase in agricultural import affects cereal production by only 0.01
 162 percent. Electricity generation has a positive impact on cereal production which indicates that
 163 along with an increase in electricity generation the use of electricity for cereal production-
 164 based agricultural activity might have increased. Furthermore, it might have helped to reduce
 165 energy costs used for agricultural production motivating increasing cereal production.

166 The annual mean temperature has hurted agricultural food products in Nepal which indicates
 167 that increasing temperature affects the production capacity of agricultural food products
 168 resulting in to decrease the production. The cultivated area has a negative impact on the
 169 agricultural food products in Nepal. It indicates that the cultivated area will not increase the
 170 production of agricultural food production in the long run. The production area has almost
 171 remained constant during the study period. So, other factors such as fertilizer used, and
 172 irrigation might have impacted the production side of agricultural food production in Nepal.
 173 In the long run there seems the possibility of the application of the law of diminishing returns
 174 due to limited area of production which might cause decline in production. The
 175 exchange rate has a positive impact on agricultural food production in Nepal. It indicates that
 176 increment in the exchange rate will motivate the agricultural producer to produce more and
 177 sale of agricultural food products abroad. It men's an increment in the exchange rate will
 178 generate more income from exporting agricultural food products in foreign country

179 **Conclusion**

180 This study conclusively demonstrates that Nepal's agricultural food production, particularly
181 rice, is shaped by a complex interplay of factors. While agricultural imports exhibit a
182 statistically positive impact, its effect is minimal (a 1% increase in imports leads to only a
183 0.01% increase in cereal production), suggesting current import levels do not significantly
184 displace domestic production but offer limited direct benefit. Crucially, the research identifies
185 electricity generation and a favorable foreign exchange rate as significant positive drivers of
186 cereal output, likely by reducing energy costs and incentivizing exports. Conversely, rising
187 annual mean temperatures exert a substantial negative impact, highlighting the severe
188 vulnerability of Nepal's agriculture to climate change. Furthermore, cultivated area negatively
189 affects long-term production, signaling the onset of diminishing returns due to limited arable
190 land expansion potential and inefficiencies in land use. These findings underscore the sector's
191 sensitivity to environmental change, infrastructure limitations, and economic policies.
192 Forecasts extending to 2060, developed under various growth scenarios, emphasize the
193 urgent need for strategic interventions to ensure future food security and economic stability in
194 the face of these challenges. Prioritize and aggressively invest in climate-resilient paddy
195 (rice) production as the foundational strategy for Nepal's agricultural future.

196 The study's conclusive evidence shows rising annual mean temperatures exert a substantial
197 and significant *negative* impact on agricultural food production (coefficient: -0.648,
198 $p=0.000$). Given rice's fundamental role in national food security and the economy, and the
199 projected exacerbation of climate change impacts, focusing *specifically* on enhancing rice's
200 resilience to heat stress is paramount. This requires immediate, large-scale investment in
201 developing, disseminating, and supporting the adoption of heat-tolerant rice
202 varieties specifically bred for Nepal's diverse agro-ecological zones (Terai, Mid-Hills, High-
203 Hills). Concurrently, significant resources must be directed towards scaling up climate-
204 adaptive water management infrastructure and practices, such as efficient irrigation systems
205 (e.g., drip, sprinkler), rainwater harvesting, and watershed management, to mitigate the
206 combined stress of rising temperatures and potential water scarcity. This targeted focus on
207 climate-proofing the staple rice crop is the essential first step to safeguarding food security,
208 protecting farmer livelihoods from climate shocks, and ensuring the long-term sustainability
209 of Nepal's agricultural sector, upon which the majority of its population depends. Without
210 this foundational resilience, gains from other positive factors like improved electricity access
211 or favorable exchange rates will be severely undermined by climate vulnerability.

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