Cereal production and food security in South Asia

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Abstract

South Asia is one of the remaining major strongholds of hunger in the world. This is in spite of the fact that countries of the region went through the Green revolution during the second half of the 20th century leading to tripling of cereal production. This study examines the relationship between the production of cereals and food security in the region. Controlling for various economic, demographic, social and climatic factors that drive food security, we study the association between different aspects of food security and cereal production in South Asia during the past 25 years.

We find a beneficial role of production and yield of cereals and the extent of undernourishment. This impact shows for the availability, stability and utilization aspects of food security but not for the access aspect. The positive effect is particularly visible in the case of rice and maize production.

The beneficial effect on food security persists up to three years. Our findings are robust to alternative empirical specifications and techniques. The results explain, in part, the means by which South Asian nations have succeeded in reducing the extent of undernourishment.

Key Words : cereal production, food security, South Asia

JEL Codes : O11, O13, 053, Q18

1. Introduction

The United Nations declared the 2016 to 2025 period Decade of Action on Nutrition. In particular focus in this regard are the countries of Sub-Saharan Africa and South Asia, two regions where a significant proportion of the population still faces hunger.
South Asia alone is home to a third of the world's undernourished (FAO, IFAD, WFP, 2015). In 2014, 281 million inhabitants of the region corresponding to 15% of the population were estimated to be unable to meet their dietary needs. India, the largest and most populous country of the region, accounts for a quarter of all food insecure population in the world.
Serious efforts have been made over the years at both the national and international level to counter this challenge of food insecurity in the region. Measures such as delivery of subsidized cereals through public distribution systems, food stamps, mid-day meals for school children, food for work programmes and provision of nutritional supplements to mothers and children have

helped reduce the proportion of food insecurity in all the eight countries of the region during the previous twenty five years (FAOSTAT, 2016). The Millennium Development Goal (MDG) of reducing poverty by half too was achieved in time (IFPRI, 2016).

An important objective of South Asian governments' food security and anti-poverty policy has been to achieve self-sufficiency in staple grains (mainly rice, wheat and maize). For this purpose, a sizeable chunk of government budgets is spent on price support, subsidies on inputs and agricultural loans, maintenance of stocks of seeds and cereals, and research and development.

Most countries have succeeded in raising cereal yield two or three-fold since the beginning of the Green revolution in the 1960s, and India and Pakistan have become self sufficient in cereal production. What then has been the role of these attempts at food self-sufficiency in achieving food security? Is strong focus on increasing cereal production a significant, even important factor in driving the fall in undernutrition seen in South Asia? Which of the four pillars of food security (availability, access, utilization and stability) as defined by FAO (2009) are more relevant?

In this study, we look for answers to these questions by exploring data on the eight South Asian countries during the 1990 - 2014 period. We take into account different indicators of cereal production as well as its temporal and spatial dimensions. We control for potential endogeneity and include economic, climatic and sociopolitical factors which are considered important determinants of food security.

We find evidence for a beneficial role of the aforementioned focus on improving the production and yield of cereals on South Asia's food security situation. The findings of this study could have useful policy implications in a developing-country context.

The study is organized in the following manner: In the next section, we briefly describe the food security and cereal production situation of South Asian countries. Section 3 introduces the data and model as well as the empirical methodology. Results are presented and discussed in Section 4. Conclusion and policy implications follow.

2. Food security and cereal production in South Asia

2.1. State of food security

The number of undernourished in South Asia has marginally declined since the 1990s (Table 1). While the numbers have fallen in the remaining six countries, the size of food insecure population has grown in Afghanistan and Pakistan. In Afghanistan, the number doubled from 3.8 million in 1990-1992 to 8.6 million in 2014-2016 whereas in Pakistan, it soared from 28.7 million to 41.4 million during the same period.

In Afghanistan, decades of war and internal strife, earthquakes and failed crops have meant that majority of the population lacks access and means to obtain food, whereas population growth rates that are among the highest in the world have exacerbated the problem.

The situation in the region is less gloomy in relative terms. The proportion of undernourished in South Asia's total population has fallen significantly from 23.9% in the early 1990s to 15.7% today (Table 1). While the share has fallen in all the eight countries of the region, the fall is most spectacular in Bangladesh and Nepal: in Bangladesh, the proportion of undernourished halved from 32.8% estimated in 1990-1992 to 16.4% in 2014-2016 while the decrease in Nepal during the same period was even greater from 22.8% to 7.8%. The Maldives are close to eliminating hunger from the country with the share of undernourished down to 5.2% today.

Table 1. Undernourishment Trends in South Asia

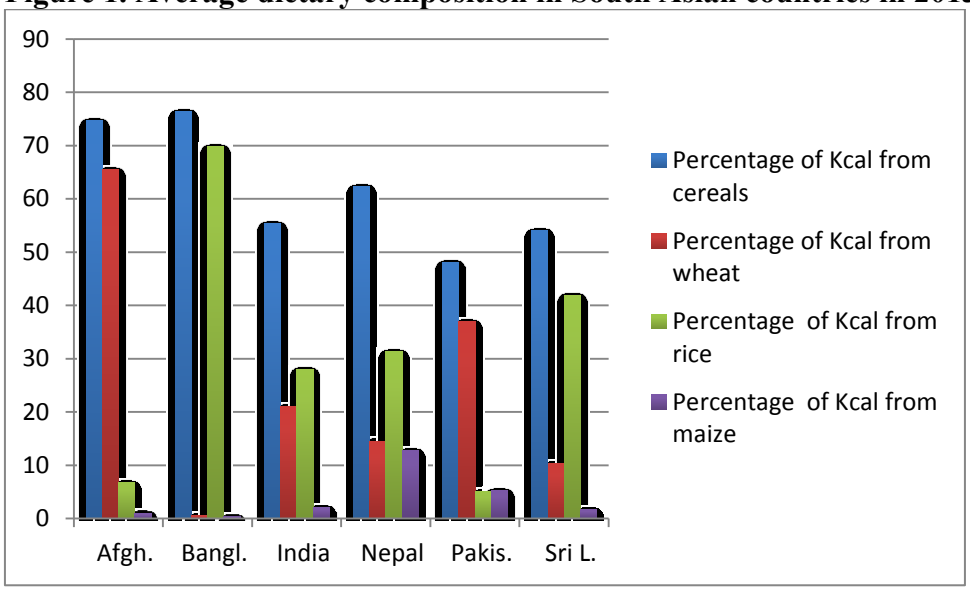
	Number of Undernourished		Undernourishment Prevalence	
	1990-1992	2014-2016	1990-1992	2014-2016
South Asia	**291,2**	**281,4**	**23,90%**	**15,70%**
Afghanistan	3,8	8,6	29,50%	26,80%
Bangladesh	36	26,3	32,80%	16,40%
India	210,1	194,6	23,70%	15,20%
Maldives	< 0,1	< 0,1	12,20%	5,20%
Nepal	4,2	2,2	22,80%	7,80%
Pakistan	28,7	41,4	25,10%	22%
Sri Lanka	5,4	4,7	30,60%	22%

FAOSTAT, 2016

India, which accounts for 69% of the region's undernourished, has seen a 36% drop in the number of undernourished in the past quarter of a century despite a 48% increase in population (FAOSTAT, 2016). This notwithstanding, one Indian in seven (194 million or 15.2%) still remain food insecure and close to half of the children under five years of age are stunted.

In South Asia, average per capita calorie consumption is low by world standards ranging from 2090 kilocalorie a day in Afghanistan to 2673 in Nepal. Cereals account for half to three-quarters of average caloric intake in the countries of the region (Figure 1). Bhutan, Maldives, Nepal and Sri Lanka mainly rely on rice for their caloric intake while wheat is the chief source of calories in Afghanistan and Pakistan. The population of India's northern and western states likewise depends on wheat while rice is the staple food in the southern and eastern states.

Figure 1. Average dietary composition in South Asian countries in 2013 (share of cereals)



FAOSTAT, 2016

Given the high dependence on cereals for covering caloric requirements in South Asia seen in Figure 1, national food security policies have mainly focused on improving availability and

access to affordable staple foods. These policy interventions targeted the pricing and supply mechanisms as well as direct financial support programmes.
All the countries of the region maintain public distribution systems that make available cereals at below-market prices. For this purpose, cereals are procured at announced support prices within the country or imported in case of insufficient domestic production. These systems assume an indispensible role in food importing countries such as Afghanistan and Bangladesh during global price spikes like those seen in 2007-2008[1].
Bangladesh, India and Pakistan maintain large-scale Public grain reserves to counter such contingencies. India's Targeted Public Distribution System (TPDS) aims at improving the food security situation of 800 million poor by providing ten kilo of subsidized food grains per family every month. However, these distribution systems involve large subsidies and struggle to target the poor; their reach is partial and losses are high in the presence of poor storage and delivery mechanisms. In addition to distribution programmes, several schemes aim at improving food security by providing the poor access to food through initiatives such as Mid-day Meal Programme and Work for food schemes later transformed into the National Rural Employment Guarantee Scheme (India), Food Support Programme (Pakistan) and Samurdhi food stamp programme (Sri Lanka). International development agencies and non-governmental organizations also run food support programmes in areas hit by natural calamities, conflict and poverty.

2.2. State of cereal production

In 2014, South Asia produced more than 400 million tons of cereals, or about 15% of the global production (FAO, 2016). The region's part in the world production is far below its share of the world population.
The Green Revolution during the 1960s and later led to sharp increases in the region's cereal output. South Asia's cereal grew threefold from 1961 to 2014 (Table 2). In comparison, cereal yield of Africa and Least Developed Countries (LDCs) as a whole almost doubled during the period. Today, South Asia produces about twice as much per hectare (30028 hg/ha) as Africa does (16131 hg/ha). Annex 1 compares cereal yield for various regions across the world.
Bangladesh by far leads the way with a yield of 46 184 hg per hectare, almost thrice the level in 1961. In spite of this, the country must still import large quantity of cereals, mainly wheat. In contrast, India and Pakistan, despite their low yields of 29841 hg per hectare and 27503 hg per hectare respectively, have managed to become self sufficient in cereal production. The two countries achieved the highest growth in cereal yield in the region of 215% and 221% respectively.

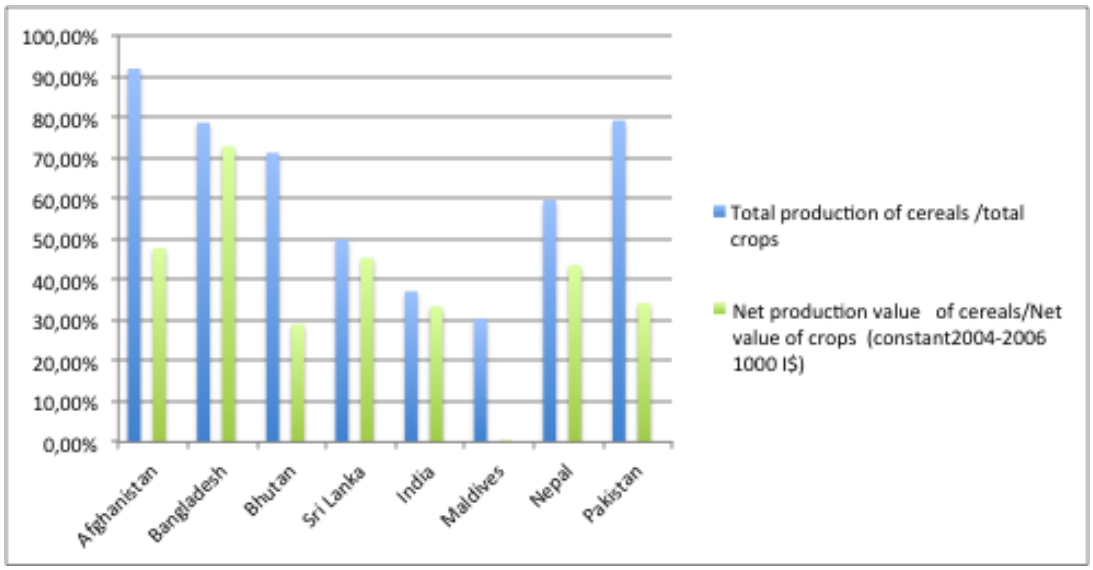
[1] Between January 2007 and April 2008, the price of coarse rice in Bangladesh and wheat in Afghanistan nearly doubled (World Bank, 2010).

Table 2. Evolution of cereal yield per Hectare in South Asia (1961 - 2014)

	1961	1970	1980	1990	2000	2014	Evolution (%) 1961-2014
Afghanistan	11151	11151	13490	12006	8063	20175	80,93%
Bangladesh	16811	16662	20058	24906	33844	46184	174,72%
Bhutan	14408	14367	14250	10350	14379	31300	117,24%
India	9473	11348	13500	18912	22942	29841	215,01%
Maldives	8883	8922	8500	10000	14855	24051	170,75%
Nepal	18466	17825	16871	19201	21363	27479	48,81%
Pakistan	8564	12297	16131	17664	24079	27503	221,15%
Sri Lanka	17654	21547	25011	29650	33382	38019	115,36%
South Asia	10118	11835	14170	18935	23488	30028	196,78%
Africa	8102	9075	11309	11805	12699	16131	99,10%
Least developed countries	10725	11176	13253	13788	16008	20009	86,56%

Source : FAOSTAT

Figure 2. Cereal production in South Asian countries (share of total crops)



Source : FAOSTAT

The importance of cereal production varies widely among the countries of the region (Figure 2). In four out of eight countries, cereals represent more than 70% of the total crop produce reaching as high as 91% in Afghanistan. In India, Maldives and Sri Lanka in contrast, cereals account for less than half of the crop production. Barring Bangladesh, cereals amount to less than half the value of agricultural production in all the countries of South Asia. This owes to significant production of high value crops such as cotton, sugarcane and spices. South Asia produced 428 tons of sugarcane in 2014 (FAOSTAT, 2016). The production of rice and wheat, in comparison, was 225 million tons and 129 million tons respectively (Table 3). India, Pakistan and Bangladesh

are among the world's largest producers of rice while India and Pakistan are among top rice exporters. India exported close to 24 million tons of cereals in 2013 while Pakistan exported about 5 million tons.

Table 3. Evolution of rice, wheat and maize production in South Asia

	Rice			Wheat			Maize		
	1991	2000	2014	1991	2000	2014	1991	2000	2014
Afghanistan	333000	260000	537000	1 650 000	1 469 000	5370259	480000	115000	316000
Bangladesh	26777904	37627500	52231000	890 000	840000	1303300	3350	10 000	1525000
Bhutan	55157	44300	76621	5000	4350	5172	40 000	48 500	74370
India	111151408	127464896	157200000	55134496	76368896	94483000	8961700	12043200	23670000
Nepal	3222540	4216465	5047047	835970	1183530	1883147	1204710	1414850	2283222
Pakistan	4864650	7203900	7005000	14565000	21078600	25979000	1203100	1643200	4695000
Sri Lanka	2389000	2859900	3381000				34050	31050	241144
South Asia	148793659	179676961	225477668	72 190 466	100 944 376	129023878	11886910	15247300	32804736

Source : FAOSTAT

The strong performance in cereal production and yield discussed above has resulted from a long-held policy of South Asian governments of striving for self sufficiency in grains as a means to achieving food security (Pingali, 2004). Research and development at government research centers focused on producing new high-yield varieties better suited to South Asia's soils and climate. Subsidies were provided on agricultural inputs including seeds, fertilizers, machinery, irrigation water, electricity for tubewells etc.

Besides, small farmers were provided cash benefits and subsidized credit. Efforts were made to improve access to agricultural credit and to reduce its cost (FAO, 2014). Programmes for agricultural insurance in case of natural and climatic disasters were established and expanded. Another measure designed to improve production and protect farmers from sharp market price fluctuations has been the minimum support price of cereals fixed every year by the government.

Thanks to these policy measures, South Asia has over the years managed to enhance its production of cereals as well as its yield and productivity.

3. Model, data and methodology

3.1. Model and data

We empirically examine the relationship between food security and cereal production in South Asia. Food security is considered to exist when all individuals at all times have physical and economic access to sufficient safe and nutritious food to meet their dietary needs. We take the prevalence of undernourishment in each country as the main indicator of food security.

Furthermore, the four aspects of food security namely availability, access, stability and utilization as defined by FAO (2009) are considered.

Availability measures the supply of sufficient quantity of nutritious food to all individuals. Access indicates the physical and economic capacity of all individuals to acquire sufficient quantity of nutritious food. Stability refers to consistent supply of nutritious food through management of price shocks arising from local or international economic or weather fluctuations. Finally, utilization reflects the biological capacity of individuals to absorb nutritious food. This ability could be proxied by health and sanitation indicators.

These four dimensions of food security are examined by employing the following indicators: Dietary energy supply as a percentage of average dietary energy requirement (availability), domestic food price index (access) and variability of net per capita food production (stability).

Given the lack of a clear-cut indicator for the utilization aspect, we employ two alternate variables as proxy for individuals' food absorption capacity, namely the percentage of population using improved sanitation facilities and the mortality rate of under five children. The former points to the overall sanitary environment in which people live in the country whereas the latter reflects the prevalence of life-threatening diseases.

In addition to cereal production, we also check the association of food security with per capita cereal production and the yield of cereal crops as well as with the production of South Asia's three main cereals (rice, wheat and maize). In the same vein, we assess the role of the diversity of nutritious food available to the consumers in driving food security by including the share of dietary energy derived from cereals, roots and tubers as an explanatory variable. In other studies, diversity of food supply has been shown to be linked with food security (see for instance Arimond and Ruel, 2004 ; Dillon and al., 2015 ; Fanzo and al., 2013 ; Hoddinott and Yohannes, 2002 ; Kumar and al., 2015 ; Ruel, 2002).

In addition, we control for a number of economic, demographic, political and natural factors that are considered important drivers of food security. Economic development is considered key to decreasing hunger in developing countries (FAO, IFAD, WFP, 2015 ; FAO, 2015; Fontan-Sers and Mughal, 2017). Rising economic tide lifts the levels of food consumption and hence alleviate food insecurity as long as growth is not poverty-neutral. South Asia is one of the world's fastest growing regions with average growth estimated to exceed 7% in 2016 (IFPRI, 2016). GDP per capita is taken as the indicator of economic development.

Another important factor is population growth. South Asia added equivalent of two United States of America in the past quarter of a century as the region's population grew from 1.16 billion in 1991 to 1.74 billion in 2015 (data from World Bank 2016). Rapid increase in population can impede efforts to reduce hunger in the presence of limited resources and economic opportunities.

Including inflation in the model is also important. Rising prices hit the poor proportionally more and could hurt their food purchasing power. Asian Development Bank (2013) report that an increase of 1% in food price lead to 0,4% increase in the prevalence of undernourishment.

Government plays a crucial role in formulating and implementing food security policies. We include government spending as a share of GDP to proxy government's involvement in fighting hunger.

Climatic shocks such as cyclones, floods or failure of seasonal rains could jeopardize availability or access to food. South Asia is one of the world regions most hit by climate-related catastrophes. Floods are a recurrent phenomenon all over the region particularly during the monsoon season lasting from June to September, while occasional droughts have devastated parts of Afghanistan, Pakistan, India and Bangladesh. We include a binary variable to account for food shortage, crop failure and famine to gauge the influence of such disasters on food security.

Yet another important factor is the role of terrorism. Conflict and violence hurts economic activity, destroys lives and assets and could thereby aggravate hunger. South Asia has long

suffered from ethnic, religious, communal and political terrorist activity. Over 67,000 people are reported to have been killed in terrorist attacks in the region since 1990 (National Consortium for the Study of Terrorism and Responses to Terrorism, 2016). Terrorism related casualties per million population is taken as an indicator of terrorism in South Asia. Finally, we include a dummy variable for the 2007-2008 food crisis.

Our parsimonious baseline model can be given as:
Undernutrition_prevalence i,t = f (lncereals i,t, lngdppc i,t, popgrowth i,t, inflation i,t, gfce i,t, climatologicaldisaster i,t, terrorkilledmillion i,t, foodcrisis) (1)

where 'i' represents the corresponding country of South Asia and 't' the year of the observation. Table 4 gives the definitions and sources of the variables included in the study while the summary statistics of these variables are given in Table 5.

Table 4. Variable definitions and sources

Variables	Definition	Source
undernutrition	Prevalence of undernourishment (%) (3-year average)	World Bank World Development Indicators database
lncereals	Production of cereals in log	FAOSTAT
PerCapitaCerealProd	Production of cereals per capita	FAOSTAT
lncerealyield	Yield of cereals in log	FAOSTAT
ln rice	Production of rice in log	FAOSTAT
ln wheat	Production of wheat in log	FAOSTAT
ln maize	Production of maize in log	FAOSTAT
Foodsupplydiversity	Share of dietary energy derived from cereals, roots and tubes	FAOSTAT
Average Dietary Energy Supply Adequacy	Dietary Energy Supply as a percentage of Average Dietary Energy Requirement	FAOSTAT
Food Price Index	Domestic food price index	FAOSTAT
Per capita food production variability.	Variability of net per capita food production in constant 2004-2006 international $	FAOSTAT
Improved sanitation facilities (% of population with access)	percentage of the population using improved sanitation facilities	FAOSTAT

Mortality	Mortality rate, under-5 (per 1,000 live births)	United Nations Population Division. World Population Prospects, Census reports and other statistical publications from national statistical offices, Eurostat: Demographic Statistics
lngdppc	GDP per capita in log	World Bank national accounts data
popgrowth	Growth in total population	United Nations Population Division. World Population Prospects, Census reports and other statistical publications from national statistical offices, Eurostat: Demographic Statistics
inflation	Inflation, consumer prices (annual %)	International Monetary Fund, International Financial Statistics and data files.
gfce	Public spending to GDP ratio	World Bank World Development Indicators database
climatologicaldisaster	dummy variable taking the value of 1 for the year of Climatological disaster (drought, earthquake, flood, extreme temperature event) associated with food shortage, crop failure or famine	Emergency Events Database (EM-DAT)
terrorkilledmillion	terrorism related casualties per million population	Global Terrorism Database
Food crisis	Dummy variable taking 1 for 2007-2008 and zero otherwise	

Table 5. Summary statistics

VARIABLES	N	mean	sd	min	max
undernutrition	175	22.79	8.989	5.200	46.70
lncereals	168	14.44	4.716	1.386	19.50
percapitacerealprod	168	205.8	97.66	0.0180	346.5
lncerealyield	192	7.716	0.357	6.692	8.391
lnrice	168	15.13	2.418	10.53	18.89
lnwheat	144	14.44	2.919	8.341	18.37
lnmaize	191	11.89	3.742	0.693	16.98
foodsupplydiversity	140	64.14	13.24	41	85
Average Dietary Energy Supply Adequacy	175	106.7	7.900	89	131
Food Price Index	104	6.280	2.025	2.660	9.500
Per capita food production variability.	184	6.274	6.395	0.900	35.10
Improved sanitation facilities (% of population with access)	192	46.34	24.66	6.200	98
mortality	200	74.54	41.205	8.6	174.2
lngdppc	171	6.593	0.757	5.454	8.561
popgrowth	198	1.961	1.321	-1.766	9.414
inflation	186	7.281	4.928	-18.109	30.555
gfce	164	11.642	4.583	4.136	22.931
terrorkilledmillion	200	6.9943	19.9956	0	170.611

3.2. Methodology

The estimation proceeds as follows. In the first step, we alternately study the relationship between undernourishment prevalence on the one hand and the three indicators pertaining to the production of cereals on the other. The three indicators account for the quantity of cereals produced, per capita production and yield per hectare.

We also examine undernourishment's association with the production of rice, wheat and maize in South Asia. These estimations are carried out using Fixed-effects panel estimator[2].

Next, we test the robustness of our estimates. First, we check if food supply diversity influences food security in any way. Second, we take into account the two outliers in our dataset. The Maldives are the smallest country of the region with negligible cereal production. The country is the most prosperous among South Asian countries and is close to eliminating hunger. At the other extreme, India corresponds to 75% of the region's population and even greater share of its output. We estimate the model by alternating excluding the two countries. Third, we carry out the estimations on the one, two, three, four and five-year lagged values of cereal production instead of the level variable used in the baseline model.

We also estimate the baseline model using alternative econometric techniques in consideration of potential endogeneity and serial autocorrelation issues. Arellano and Bond, System GMM and Dynamic Panel Data (DPD) estimators are used for this purpose. In the third step, we consider cereal production's association with the four aspects of food security, namely availability, access, stability and utilization.

[2] The Haussman Specification test invariably maintains a P-value of 0.00.

4. Findings

Table 6 shows results of various production-related specifications. The association of undernourishment prevalence with cereal production, per capita production and yield, all the three indicators is found to be statistically significant and strong (Columns 1 - 3). The sign of the three coefficients is negative suggesting the existence of a negative relationship between food insecurity and cereal production. A 1% increase in cereal production is association with an 11% decrease in the proportion of undernourished in the population, while the drop in the latter is even stronger in case of a 1% increase in yield (21%).

Crop-wise estimates show a likewise strong result for rice production (Column 4). However, the coefficient for wheat production is insignificant with a p-value of 0.17 (Column 5), possibly owing to the fact that wheat is the primary staple in only two countries of the region.

Among the control variables, population growth rate and government consumption expenditure as share of GDP are found to be the strongest factors driving food security. High population growth, all things considered, intuitively leads to high incidence of under- and mal-nutrition. Higher public spending, in contrast, leads to lower proportion of undernourished population.

The coefficients of other explanatory variables are mostly insignificant.

Alternative estimates reported in Table 7 show the robustness of these findings. The negative relationship between undernourishment and cereal production seen above remains even after excluding the two outliers, the Maldives and India. Likewise, the association persists when one, two and three-year lags of cereal production are employed (Columns 4 to 6).

The significance of the association dissipates beyond three lags (Columns 7 and 8).

The estimations of dynamic panel models (results not shown) corroborate our main finding of a significant salutary effect of cereal production on food security in South Asia.

The above findings notwithstanding, the share of cereals in South Asia's average caloric intake does not appear to influence the proportion of undernourished population in the region (Column 1). South Asia's poor derive a very high share of their calorie requirements from cereal grains. Improved availability of staples seems to help them significantly whereas access to other sources of calorie does not appear to change the state of hunger. Food security in South Asia therefore responds more to the production of cereals than to their share in daily nutritional intake. This insignificant relationship between undernutrition and production diversity corroborates the findings of Sibhatu and al. (2015) in the context of Ethiopia and Kenya.

The results presented so far are also borne out in the estimates of multiple dimensions of food security reported in Table 8. Cereal production significantly and beneficially influences the availability, access and utilization aspects of food security. The adequacy of dietary energy supply substantially increases (Column 1), the variability of per capita food production falls (Column 3), and health indicators improve (Columns 4 and 5).

The first finding again highlights the strong link between higher grain production and better nutritional situation in South Asia. The financial access dimension represented by the Food Price Index variable does not significantly correlate with cereal production (Column 2). Thanks to strong cereal price subsidy policies and other safety nets in force across the region, shortfall in domestic grain production does not significantly increase local food prices.

All in all, the evidence of a beneficial effect of cereal production in South Asia on the region's food security situation seems to be substantial.

Table 6. Food security and cereal production - Production indicators

VARIABLES	(1) undernutrition	(2) undernutrition	(3) undernutrition	(4) undernutrition	(5) undernutrition	(6) undernutrition
lncereals	-11.73***					
	(2.857)					
percapitacerealprod		-0.0697***				
		(0.0126)				
lncerealyield			-21.53***			
			(3.746)			
lnrice				-9.313***		
				(2.261)		
lnwheat					-2.588	
					(1.869)	
lnmaize						-2.159***
						(0.212)
lngdppc	-1.116	-2.735	1.918	-3.407*	-3.305**	-2.001
	(2.104)	(1.795)	(2.223)	(1.915)	(1.306)	(1.327)
popgrowth	4.150***	5.566***	2.136***	3.044***	3.770***	2.716***
	(1.136)	(0.950)	(0.722)	(0.735)	(0.798)	(0.560)
inflation	-0.0839	-0.0602	-0.0994	-0.0642	-0.0162	0.0465
	(0.0666)	(0.0618)	(0.0616)	(0.0657)	(0.0448)	(0.0497)
gfce	-1.508***	-1.242***	-0.835***	-0.557***	-1.150***	-0.696***
	(0.257)	(0.241)	(0.194)	(0.206)	(0.158)	(0.156)
climatologicaldisaster	0.425	0.169	0.153	-0.0339	0.389	0.303
	(0.584)	(0.556)	(0.545)	(0.600)	(0.437)	(0.444)
terrorkilledmillion	0.0124	0.00354	-0.0131	-0.0362*	-0.00888	-0.0234
	(0.0230)	(0.0217)	(0.0183)	(0.0202)	(0.0141)	(0.0150)
foodcrisis	0.478	0.541	0.872	1.141	0.306	0.902
	(0.920)	(0.867)	(0.867)	(0.941)	(0.620)	(0.709)
Constant	231.1***	56.88***	184.8***	196.4***	88.54***	65.71***
	(44.68)	(12.35)	(21.91)	(31.78)	(28.98)	(7.931)
Observations	106	106	126	121	78	126
R-squared	0.741	0.770	0.673	0.637	0.807	0.780
Number of id	6	6	7	6	4	7

Note:Columns 1 to 6 show estimations with logs of cereal production, per capita cereal production, cereal yield, rice production, wheat production and maize production respectively.
Bangladesh is excluded in estimation with wheat production (Column 5) due to its negligible role in daily diet.

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7. Food security and cereal production - Alternative estimates

VARIABLES	(1) undernutrition	(2) undernutrition	(3) undernutrition	(4) undernutrition	(5) undernutrition	(6) undernutrition	(7) undernutrition	(8) undernutrition
foodsupplydiversity	-0.432							
	(0.360)							
lncereals		-12.96***	-7.634*					
		(3.103)	(4.268)					
L.lncereals				-7.156**				
				(2.881)				
L2.lncereals					-9.061***			
					(2.792)			
L3.lncereals						-5.787*		
						(3.386)		
L4.lncereals							-1.797	
							(3.044)	
L5.lncereals								0.561
								(0.976)
lngdppc	-10.35***	-0.916	-9.043	-3.283	-3.240	-4.212*	-5.053**	-5.019**
	(3.206)	(2.161)	(5.992)	(2.183)	(2.155)	(2.259)	(2.243)	(2.164)
popgrowth	3.817***	3.830***	2.891*	4.612***	4.135***	4.716***	5.444***	6.043***
	(0.909)	(1.176)	(1.583)	(1.298)	(1.272)	(1.435)	(1.481)	(1.161)
inflation	-0.0150	-0.0822	-0.0699	0.00418	0.0404	0.0576	0.0303	0.00759
	(0.0759)	(0.0680)	(0.0833)	(0.0730)	(0.0751)	(0.0777)	(0.0764)	(0.0705)
gfce	-0.413	-1.477***	-1.266***	-1.434***	-1.758***	-1.684***	-1.755***	-1.622***
	(0.279)	(0.262)	(0.332)	(0.290)	(0.300)	(0.320)	(0.326)	(0.309)
climatological disaster	0.346	0.312	0.633	0.652	0.703	0.921	1.234*	0.978
	(0.710)	(0.605)	(0.706)	(0.635)	(0.622)	(0.644)	(0.641)	(0.618)
terrorkilledmillion	-0.0283	0.0130	0.0237	0.00957	0.0145	0.0227	0.0136	0.00426
	(0.0325)	(0.0232)	(0.0268)	(0.0246)	(0.0239)	(0.0252)	(0.0242)	(0.0222)
foodcrisis	0.307	0.470	0.160	0.277	0.140	-0.0538	0.0784	0.306
	(1.130)	(0.930)	(1.202)	(0.987)	(0.959)	(0.991)	(0.942)	(0.880)
Constant	115.3***	258.2***	206.0***	165.9***	200.5***	150.0***	88.77*	47.68**
	(38.71)	(50.13)	(50.11)	(46.37)	(45.91)	(55.18)	(50.40)	(21.33)
Observations	111	101	83	102	98	94	90	86
R-squared	0.505	0.746	0.738	0.703	0.716	0.693	0.692	0.688
Number of id	7	5	5	6	6	6	6	6

Note:

Column 1 shows estimation including food supply diversity.

Columns 2 and 3 show estimations excluding Maldives and India respectively.
Columns 4 to 8 show estimations with one, two, three, four and five lags of the log of cereal production respectively.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Alternative estimates reported in Table 7 show the robustness of these findings. The negative relationship between undernourishment and cereal production seen above remains even after excluding the two outliers, the Maldives and India. Likewise, the association persists when one, two and three-year lags of cereal production are employed (Columns 4 to 6).
The significance of the association dissipates beyond three lags (Columns 7 and 8).
The estimations of dynamic panel models (results not shown) corroborate our main finding of a significant salutary effect of cereal production on food security in South Asia.

The above findings notwithstanding, the share of cereals in South Asia's average caloric intake does not appear to influence the proportion of undernourished population in the region (Column 1). South Asia's poor derive a very high share of their calorie requirements from cereal grains. Improved availability of staples seems to help them significantly whereas access to other sources of calorie does not appear to change the state of hunger. Food security in South Asia therefore responds more to the production of cereals than to their share in daily nutritional intake. This insignificant relationship between undernutrition and production diversity corroborates the findings of Sibhatu and al. (2015) in the context of Ethiopia and Kenya.

The results presented so far are also borne out in the estimates of multiple dimensions of food security reported in Table 8. Cereal production significantly and beneficially influences the availability, access and utilization aspects of food security. The adequacy of dietary energy supply substantially increases (Column 1), the variability of per capita food production falls (Column 3), and health indicators improve (Columns 4 and 5).
The first finding again highlights the strong link between higher grain production and better nutritional situation in South Asia. The financial access dimension represented by the Food Price Index variable does not significantly correlate with cereal production (Column 2). Thanks to strong cereal price subsidy policies and

other safety nets in force across the region, shortfall in domestic grain production does not significantly increase local food prices.

All in all, the evidence of a beneficial effect of cereal production in South Asia on the region's food security situation seems to be substantial.

Table 8. Food security and cereal production - Dimensions of food security

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Average Dietary Energy Supply Adequacy	Food Price Index	Per capita food production variability.	Improved sanitation facilities (% of population with access)	mortality
lncereals	9.068***	-0.197	-11.39***	12.52***	-27.81***
	(2.627)	(0.274)	(2.647)	(3.302)	(6.352)
lngdppc	-2.713	0.444	12.38***	24.14***	-72.62***
	(1.935)	(0.298)	(1.841)	(2.296)	(4.417)
popgrowth	-4.495***	-0.321**	0.852	-1.026	2.863**
	(1.045)	(0.150)	(0.563)	(0.702)	(1.351)
inflation	0.104*		-0.194**	-0.0967	0.384**
	(0.0613)		(0.0756)	(0.0943)	(0.181)
gfce	1.891***	0.136***	0.136	0.0463	-1.873***
	(0.237)	(0.0324)	(0.267)	(0.333)	(0.641)
climatologicaldisaster	-0.876	-0.00633	-0.731	0.105	1.609
	(0.537)	(0.0650)	(0.760)	(0.948)	(1.823)
terrorkilledmillion	-0.0406*	0.00973	-0.0270	-0.0371	0.143*
	(0.0211)	(0.00666)	(0.0323)	(0.0403)	(0.0776)
foodcrisis	-0.604	-0.0408	2.750**	1.300	-3.830
	(0.846)	(0.0825)	(1.146)	(1.430)	(2.751)
Constant	-37.26	5.460	105.9***	-313.9***	1,002***
	(41.08)	(3.885)	(35.57)	(44.37)	(85.36)
Observations	106	75	129	129	129
R-squared	0.696	0.420	0.421	0.780	0.887
Number of id	6	6	7	7	7

Notes:

Columns 1 to 5 show estimations with Average Dietary Energy Supply Adequacy, Food Price Index, Per capita food production variability, Improved sanitation facilities and mortality as dependent variables respectively.

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Conclusion

South Asia is one of the final bastions of hunger. Despite strong economic growth that brought millions out of poverty, many in the region still lack sufficient food to satisfy dietary energy requirements. One of the objectives of South Asian countries' food policies over the decades has been to attain self-sufficiency in cereal production. Thanks to strong agricultural performance since the green revolution, production of wheat, rice and other cereal crops has doubled or tripled across the region. Nonetheless, the production of most of the countries in the region has still fallen short of the needs of a rapidly rising population leaving the countries exposed to global price shocks. The need for self-sufficiency in staple grains was deeply felt during the food price hike of 2007-2008 (Pingali, 2015).

In this study, we examine the role cereal production has played in driving South Asia's food security situation during the 1991 to 2014 period. We found that higher production and better yield are associated with lower proportion of undernourished population. This is particularly the case with rice, the main source of calories for much of South Asia's population.

In rural areas, farmers retain part of their cereal production for home consumption. Similarly, landless labourers working in the fields are in part paid in grains. Increased cereal production is helpful even in urban areas due to subsidized sale of domestic food production.

Our findings therefore suggest a beneficial effect of policies aimed at enhancing cereal production.

Consequently, efforts should be stepped up to improve crop yields which still lag the levels achieved in the developed countries. These include focusing on developing drought-resistant crop varieties, providing farmers better quality seeds, information and technology, managing water distribution more efficiently and reducing post-harvest grain losses.

Climate change is a looming challenge in this context as South Asia is one of the regions hardest hit by changing climate. The frequency of floods, droughts and extreme temperatures is increasing and farmers already are having to change their sowing habits to minimize crop loss (Ahmad et al., 2013).

Finally, fighting hunger in the region should not be at the cost of neglecting malnutrition. Large number of South Asians are deficient in proteins and micronutrient deficiency too is rife among children and women. Work on enhancing dietary quality and diversity should therefore go hand in hand with measures to increase quantity.

References

AHMAD M., IQBAL M. and KHAN M. A. (2013) Climate Change, Agriculture and Food Security in Pakistan: Adaptation Options and Strategies, Pakistan Institute of Development Economics, International Development Research Centre, 8p.

ARIMOND M. and RUEL M.T. (2004) Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys, *Journal of Nutrition*, Vol 134, no 10, 2579–2585.

ASIAN DEVELOPMENT BANK (2013) Food security in Asia and the Pacific. 131 p.

DILLON A., McGEE K. and OSENI G. (2015) Agricultural production, dietary diversity and climate variability, *The Journal of Development Studies,* Vol.51, n°8.

FANZO J., HUNTER D., BORELLI T., MATTEI F.. (2013) Diversifying Food and Diets : Using Agricultural Diversity to improve Nutrition and Health, Routledge, London, 401 p.
FAO, IFAD, WFP (2015) The State of food insecurity in the world, Meeting the 2015 International Hunger targets : taking stock of uneven progress, Rome, 62 p.
FAO (2016) FAO Cereal Supply and Demand Brief. Monthly Report of the FAO.
FAO (2015) The State of Food Security and Agriculture. Social protection and agriculture : breaking the cycle of rural poverty, Rome, 151 p.
FAO (2014) Trends, emerging issues and policy alignments since the 2007/2008 food security crisis, Food and Agriculture policy decisions, 136 p.
FAO (2009) Declaration of the World Summit on Food Security, WSFS 2009/2, 16 November, 2009.
FONTAN SERS C. and MUGHAL M. (2017) From Maputo to Malabo: Public Agricultural Spending and Food Security in Africa, unpublished manuscript.

HODDINOTT J., YOHANNES Y. (2002) Dietary Diversity as a Food Security Indicator, Food Consumption and Nutrition Division, Paper n°136, IFPRI, 2p.
IFPRI (2016) The 2016 Global Food Security Report, 154 p.
KUMAR N., HARRIS J. and RAWAT R. (2015) If they grow it, will they eat and grow ? Evidence from Zambia on agricultural diversity and child undernutrition, *The Journal of Development Studies*, Vol.51, n°8.
NATIONAL CONSORTIUM FOR THE STUDY OF TERRORISM AND RESPONSES OF TERRORISM (START) (2016) Global Terrorism Database.
PINGALI P. (2004) Agricultural diversification in Asia : opportunities and constraints, in Proceedings on *the FAO Rice Conference* « Rice is life », FAO, 20p.
PINGALI P. (2015) Agricultural Policy and Nutrition outcomes- getting beyond the preoccupation with staple grains, *Food Security*, 7, 583-591.
RUEL M.T. (2002) Is dietary diversity an indicator of food security or dietary quality. A review of measurement issues and research needs, IFPRI, FNCD Discussion Paper n°140.
SHEKAR M. (2015) Nutrition and agriculture: bridging the gap, Investing in Health, News and Views in Healthy Development, World Bank.
SIBHATU K.T., KRISHNA V.V., QUAIM M. (2015) Production diversity and dietary diversity in smallholder farm households, PNAS, Vol 112, n°34, 6p
WORLD BANK (2010) Food price increases in South Asia: national responses and regional dimensions. Discussion Paper 46, World Bank, Washington, DC.