Impact of Climate Change on Food Crop Productivity, Food Prices and Food Security in South Asia

Jayatilleke S Bandara
Department of Accounting Finance and Economics
Griffith Business School
Griffith University, Nathan Campus
Australia, QLD 4111

And

Yiyong Cai
Marine and Atmospheric Research
Commonwealth Scientific and Industrial Research Organization (CSIRO)
Black Mountain, Canberra
Australia, ACT 2600

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Email: **j.bandaralage@griffith.edu.au**
yiyong.cai@csiro.au

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Introduction

There is a consensus among many researchers of climate change issues on two things. Firstly, global climate change (GCC) is real and it is occurring at a faster rate. Secondly, agriculture (mainly food production) is the most vulnerable sector to climate change. Therefore, the impact on food production, food prices and food security stands out among a wide range of likely negative impacts of human activities-induced climate change. In addition to the upward pressure on food prices caused by increasing demand as a result of the increase in population and income levels, it is obvious that there will be further upward pressure on food prices when food production decreases as a result of GCC as predicted by many empirical studies. For example, food demand is predicted to increase by around 300 percent by the 2080s because of higher population and higher income, and demand for bio-fuel (Cline, 2008, p.28) creating an imbalance between food supply and demand for food even without GCC effects. Climate change will act as a "multiplier" of existing threat to food prices and food security (IASC, 2009) and "world food prices are a useful single indicator of the effects of climate change on agriculture (Quiggin 2007; Nelson, Rosegrant et al. 2009).

Agriculture plays a critical role in economies of developing countries (it dominates around 75 percent) and it is the most vulnerable sector to climate change because farming is so weather-dependent (Nelson, Rosegrant et al. 2009). The recent experience of the global food crisis in 2007 and 2008 demonstrates that populations in developing countries, which are already vulnerable and food insecure, are likely to be the most seriously affected in the world as a result of a food crisis multiplied by GCC. With increasing concern over climate change in recent years, some researchers and international organisations have focused on the strong link between climate change induced productivity drop in agriculture and food security.

According to the IPCC 4th Assessment Report, South Asia is expected to be severely stricken by the GCC mainly because about 70 percent of people in the region live in rural areas dominated by agriculture and they are accounted for about 75 percent of the poor in the region. Although the region's contribution to greenhouse gas emission is low, countries in the region are highly vulnerable to GCC. There is a strong evidence to support the link between productivity in agricultural sectors and weather changes in the region. Extreme weather conditions such as droughts and floods are on the rise in South Asia as well. Even after the global food crisis in 2007-2008, South Asia experienced another episode of rise in food prices in 2009. A recent report on South Asia released by the World Bank (2010, p.28) notes that "domestic food prices have tracked the upsurge in global food prices, exacerbated by droughts". It further notes that erratic monsoon weather conditions in India reduced production of the main crops and it led to higher food prices in 2009. The Indian food price inflation spread to small neighbours such as Bangladesh, Bhutan, Nepal, and Sri Lanka, as well. In the meantime, domestic demand has also increased. The rise in food prices as a result of increasing domestic demand in India was exacerbated by the El Nino weather pattern in 2009. This latest episode of rising food prices in South Asia is an excellent example to demonstrate why South Asia is vulnerable to GCC.

The World Bank (2009) highlights a number of impacts of GCC on food prices in South Asia. Laborde (2011) has also highlighted the impact of climate change on agriculture in South Asia. Among other things the decline in crop yields in the region has been highlighted as a major impact of GCC. Recently a number of attempts have been made to quantify climate change impacts on food production and food prices in individual South Asian countries by using the partial equilibrium approach. However, there is lack of research on the topic using a more integrated approach. A number of economies in South Asia, particularly India, are going through a process of rapid economic growth. The main purpose of this paper is, therefore, to examine the impact of climate change induced productivity changes in food crops focusing on South Asian countries. The next section briefly outlines the modelling framework of this study. Section 3 briefly surveys a large number of quantitative assessments focusing on change in productivity in food crop sectors in the region in order to prepare reasonable and realistic productivity shocks to be introduced to the dynamic model. Section 4 discusses the results of productivity simulations. Section 5 of the paper will provide some concluding remarks.

Modelling Climate Change and Food Security

In order to project the impacts of climate change on food crop productivity and food prices, we use the Dynamic GTAP (Global Trade Analysis Project) model. Being a general equilibrium global trade model with dynamic elements (Ianchovichina and Walmsley, 2012), the dynamic GTAP is an extension of widely-used GTAP model (Hertel, 1997) in analysing various issues ranging from trade policy and regional economic integration to climate change. The core GTAP model is a global comparative static general equilibrium model which links bilateral trade flows between all countries or regions in the world, and explicitly models the consumption and production for all commodities of each national or regional economy. Similar to any other neoclassical computable general equilibrium (CGE) or applied general equilibrium (AGE) model, producers are assumed to maximize profits and consumers are assumed to maximize utility in GTAP. Product and factor market clearing requires that supply equal demand in each market.

As extension of GTAP, the dynamic GTAP retains all basic features of GTAP and provides an improved treatment of the long-run within the GTAP modelling framework. It is a recursive model, generating a sequence of static equilibria based on the investment theory of adaptive expectations, linked by a number of dynamic features. As highlighted by the pioneer of the dynamic GTAP, the main features of the model include "the treatment of time; the distinction between physical and financial assets, and between domestic and foreign financial assets; and the treatment of capital and asset accumulation, assets and liabilities of firms and households, income from financial assets, and the investment theory of adaptive expectations" (Ianchovichina, 2012, p.5). Recently, the complete dynamic GTAP model (labelled as GDyn) has been documented and published as an edited volume (see for details, Ianchovichina and Walmsley, 2012).

Preliminary Data and Baseline

To simulate the impact of GCC on South Asia, this paper disaggregates the world into 11 regions, which covers South Asian countries such as Bangladesh, India, Nepal, Pakistan, Sri Lanka. Each region's economy is disaggregated into 25 traded goods sectors where 8 produces food crops, namely, rice, wheat, coarse grains, vegetable and fruits, sugar, oilseeds, cotton and fibers, and other crops. In addition, there is a capital goods producing sector. The regional and sector aggregations are provided in Table 2 and Table 3, respectively.

Table 1: Sector Aggregation of Model

Sector Code	Sector Description
Pdr	paddy rice
Wht	wheat
Gro	cereal grains nec
v_f	vegetables, fruit, nuts
Osd	oil seeds
c_b	sugar cane, sugar beet
Pfb	cotton, plant-based fibers
Ocr	crops nec
Ctl	bovine cattle, sheep and goats, horses
Oap	animal products nec
Rmk	raw milk
Wol	wool, silk-worm cocoons
frs	forestry
fsh	fishing
Mine	mining industries
Cmt	bovine cattle, sheep and goat meat products
Omt	meat products
Vol	vegetable oils and fats
Mil	dairy products
Pcr	processed rice
Sgr	sugar
Ofd	food products nec
b_t	beverages and tobacco products
Mnfc	Manufacturing
Serv	Services

Table 2: Regional Aggregation of Model

Region Code	Region Description
Oceania	Oceania
SEAsia	South East Asia
bgd	Bangladesh
ind	India
npl	Nepal
pak	Pakistan
lka	Sri Lanka
xsa	Rest of South Asia
NSAmerica	North and South America
Europe	Europe and former Soviet Union
Africa_MEast	Africa and Middle-East

The model is built upon the dynamic version of the GTAP 8 database. Starting from the year 2007, the dynamic GTAP runs on a three-year step to 2010 and thereon five-year steps through 2030. We use the medium variant of the UN population projections, and assume that the share of labour force in total population is constant. By fine tuning the regional overall total factor productivity we calibrate our baseline to match GDP projections of IMF's World Economic Outlook (WEO) by region. .

Quantitative Assessment of Productivity Shocks

It is well-known that countries in the South Asian region will be affected severely due to climate change and the agriculture sector will be the most affected sector. There is a large body of literature on decline in food crop productivity in the region due to climate change. Recently, Knox and Hess (2011) have under taken a systemic review on the projected impact of climate change on food crop productivity focusing on Africa and Asia. Their study provides different estimates on productivity changes in agriculture in the region. As demonstrated in this review, there is no agreement among analysts on the exact percentage of productivity change related to different crops in the region. Table 3 below provides the selected values for the productivity shocks.

Table 3: Productivity Shocks Estimated in Literature

Source	Country	Crop	Productivity change	Comment
Jacoby, et al., (2011)	India	All	17 % decline in overall land productivity across districts	Ricardian estimates using 1.25 C change in temperature over next three decades
Knox and Hess (2011)	Sri Lanka Pakistan Bangladesh India Bhutan Nepal	Rice	Increases by +6.6% Increases by +7.5% Decreases by -5% by 2020s and by -10% by 2080s Decreases upto -27% (main season rice) and -40% by the 2080s An increase in 10% upto 2020s and 2050s and decreases by -4% by the 2080s By – 2% by the 2020s and upto -32% by 2080s	
Knox and Hess (2011)	India Pakistan Bangladesh	Wheat	-60% worst prediction -31% Negative	Projections vary depending on the methodology and the region. Some potential positive effects have also been predicted
Knox and Hess (2011)	South Asia region India	Maize	-10% to -40% increases with time -25% in 2020s and increases upto -60% by 2080s	
	India	Sugarcane	-13% by 2020s and -9% by 2050s	

In this paper, productivity shocks in food crop agriculture in South Asian countries due to climate change over the period of 2007-2030 were selected based on the Knox and Hess (2011) review. When no information was found for a specific region or commodity, we used the value from a neighbouring region or similar crop. For example, few studies were found for cotton, and in these cases we used similar values as for rice. Sugarcane was assumed to have zero response throughout the analysis, given that the few available studies of sugarcane show small net impacts of climate and CO2 changes.

For simplicity, we assume that climate change only affects the land productivity. By doing so, we abstract from modelling potential future impacts of climate change on human health (labor productivity) and social infrastructure (capital productivity). Additionally, estimates were made without consideration of adaptations that may reduce negative or enhance positive outcomes, such as the development of new crop varieties or the significant expansion of irrigation infrastructure in a region. As such, we treat these as pure “land productivity shocks” in the GTAP Model. However, adverse land productivity shocks can engender significant crop price rises, which is a finding of the paper, and these can provide an incentive to invest additional resources in the sector. This form of adaptation is endogenous to the model and is modelled through production functions which vary by crop and region and which allow substitution of labor, capital and purchased inputs for land in response to such climate induced scarcity.

Land productivity shocks that are used in this study are given in Tables 1-8 in Appendix 1. As shown in these tables, except paddy rice in Pakistan and Sri Lanka, other crops sectors in all South Asian countries will be negatively affected by climate change according to some empirical studies. Our shocks are based on these empirical studies.

Summary of Results

Our preliminary results of this study demonstrate that land productivity losses due to future climate change will lead to lower crop food production in South Asian countries and higher domestic food prices. This may lead to a reduction in domestic food consumption and food insecurity in the region. . The adverse impacts of climate change on food production extend to all countries in the region. Tables 4-21 summarize accumulative deviations from baseline for food production, food prices, gross domestic product (GDP) and foreign investment of the South Asian countries that are simulated.

The results of our policy simulations show that land productivity losses due to climate change are predicted to reduce food crop production. The low production of food may put pressure on food prices in the region. Overall, persistent adverse impacts of climate change affect food security situation in all South Asian countries. The only exceptions are Pakistan which has increased paddy rice output over the whole simulated period, and Sri Lanka which has higher coarse grain harvest upto 2015. Given higher food prices, while consuming less, on average, consumers will see an increase in their food expenditures. Food markets in South Asian countries balance in response to reduced crop productions largely through increased food imports. Except India, levels of food self-sufficiency in most other countries fall continuously.

Reduced food production will have significant impacts on economies in the region. As of 2030, GDP of all South Asian countries is expected to decrease by -0.8% to -3.4% from the baseline.

Concluding Remarks

The effects of climate change on food production and food prices are complex. In order to capture the link between climate change and food production, a number of modelling frameworks have been developed and extensions have been made. There are a number of quantitative studies that have attempted to quantify the impact of climate change on food production and food prices across different regions. In this study we attempted to quantify the impact of climate change on major countries in the South Asian region by using GTAP dynamic model. Our results also support the view that countries in the South Asian region will be affected severely. Although we have used GTAP dynamic model to examine the effects of climate change in South Asian countries, our results are preliminary and much remains to be done to generate more clear and reliable results. Nevertheless, some important messages emerge from our study. .

Firstly, the preliminary results of our study show that climate change will exert more pressure on already rising food prices. GCC will have quite large negative impacts on food production and prices in the South Asian region in years to come. Secondly, the likely impacts of GCC on food production across countries in the region are significantly high. As some South Asian countries are closer to the equator they will be affected more severely than countries located in higher altitudes. Finally, it is important to implement adaptation measures to mitigate adverse impacts of GCC in the region.

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Table 4: Deviation of Paddy Rice Production from Baseline (Unit = %)

Pdr	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.14	1.09	5.62	9.51	13.69
SEAsia	0.02	0.09	0.15	0.21	0.21
Bgd	-0.17	-0.57	-0.95	-1.27	-1.52
Ind	-0.52	-2.13	-4.32	-5.11	-4.80
Npl	-0.12	-0.26	0.49	0.43	-0.88
Pak	0.56	2.10	3.21	3.08	3.16
Lka	-0.05	-0.02	-0.07	-0.25	-0.41
Xsa	-0.68	-2.29	-3.66	-4.46	-4.85
NSAmerica	0.09	0.47	2.29	4.32	5.14
Europe	0.70	3.51	12.13	20.21	23.04
Africa_MEast	0.10	0.55	2.09	3.25	3.75

Table 5: Deviation of Wheat Production from Baseline (Unit = %)

wht	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.03	0.11	0.44	1.02	1.23
SEAsia	0.01	0.05	0.16	0.36	0.56
Bgd	-1.31	-3.69	-5.32	-6.82	-8.20
Ind	-0.68	-2.11	-3.34	-3.83	-3.48
Npl	-0.29	-1.19	-2.63	-4.48	-6.12
Pak	-0.90	-3.19	-6.72	-10.17	-13.12
Lka	-0.25	-0.82	-1.82	-3.18	-4.10
Xsa	-1.16	-3.70	-7.34	-10.74	-13.60
NSAmerica	0.02	0.02	-0.05	-0.05	0.02
Europe	0.04	0.13	0.24	0.55	0.91
Africa_MEast	0.03	0.08	0.20	0.26	0.41

Table 6: Deviation of Coarse Grain Production from Baseline (Unit = %)

Gro	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.01	0.04	0.15	0.25	0.27
SEAsia	0.01	0.05	0.11	0.15	0.15
Bgd	-0.44	-1.37	-2.97	-5.38	-7.76
Ind	-0.51	-1.65	-2.59	-2.66	-2.19
Npl	-0.30	-1.30	-2.77	-4.52	-6.19
pak	-0.43	-1.69	-3.67	-5.78	-7.35
Lka	0.02	0.18	-0.40	-1.08	-1.41
Xsa	-0.47	-1.58	-2.45	-3.13	-3.60
NSAmerica	0.00	0.00	-0.01	-0.04	-0.05
Europe	0.00	0.02	0.04	0.08	0.13
Africa_MEast	0.00	-0.01	-0.02	-0.06	-0.06

Table7: Deviation of Vegetable and Fruit Production from Baseline (Unit = %)

v_f	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.10	0.29	0.49	0.78	0.96
SEAsia	0.02	0.05	0.10	0.14	0.18
Bgd	-0.59	-1.77	-2.75	-3.65	-4.22
Ind	-0.62	-1.94	-3.40	-4.60	-5.02
Npl	-0.41	-1.71	-3.35	-5.49	-7.73
pak	-0.47	-1.65	-2.87	-3.76	-4.36
Lka	-0.51	-1.40	-2.39	-3.46	-4.24
Xsa	-0.87	-2.67	-4.20	-5.38	-6.17
NSAmerica	0.04	0.10	0.20	0.42	0.63
Europe	0.02	0.08	0.27	0.58	0.87
Africa_MEast	0.03	0.07	0.14	0.19	0.21

Table 8: Deviation of Oil Seeds Production from Baseline (Unit = %)

Osd	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.09	0.32	0.94	1.90	2.56
SEAsia	0.07	0.27	0.73	1.19	1.37
Bgd	-1.03	-2.94	-3.84	-4.77	-5.86
Ind	-0.95	-3.23	-5.55	-6.91	-7.25
Npl	-0.68	-2.09	-2.93	-4.25	-5.90
pak	-1.37	-3.99	-6.65	-8.93	-10.87
Lka	-0.47	-0.89	-1.98	-3.88	-5.78
Xsa	-1.34	-4.29	-6.50	-8.13	-9.38
NSAmerica	0.07	0.26	0.76	1.56	2.27
Europe	0.06	0.28	0.91	1.91	2.69
Africa_MEast	0.05	0.15	0.41	0.78	1.10

Table 9: Deviation of Sugar Production from Baseline (Unit = %)

c_b	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.02	0.11	0.25	0.29	0.25
SEAsia	0.03	0.17	0.51	0.59	0.43
bgd	-0.25	-0.54	-0.36	-0.88	-1.67
ind	-0.46	-1.93	-3.77	-3.62	-2.66
npl	-0.34	-1.29	-2.48	-4.03	-5.69
pak	-0.18	-0.82	-1.54	-1.99	-2.20
lka	-0.39	-0.68	-1.70	-4.05	-6.61
xsa	-0.47	-1.80	-3.53	-4.95	-6.13
NSAmerica	0.02	0.13	0.32	0.34	0.26
Europe	0.02	0.12	0.40	0.66	0.67
Africa_MEast	0.03	0.17	0.50	0.50	0.31

Table 10: Deviation of Cotton and Fibre Production from Baseline (Unit = %)

pfb	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.31	1.07	3.05	5.27	5.57
SEAsia	0.21	0.71	2.00	3.89	5.55
bgd	-0.58	-2.37	-4.02	-5.97	-7.94
ind	-0.71	-2.30	-4.78	-6.29	-7.01
npl	-0.14	-0.99	-3.47	-6.41	-9.21
pak	-0.57	-2.58	-4.25	-5.11	-5.23
lka	0.70	2.99	6.21	8.39	9.71
xsa	-0.88	-3.06	-4.29	-4.69	-5.16
NSAmerica	0.38	1.37	2.67	3.94	4.82
Europe	0.43	1.80	4.05	6.93	8.97
Africa_MEast	0.18	0.66	0.86	1.04	1.35

Table 11: Deviation of Other Crops Production from Baseline (Unit = %)

ocr	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.12	0.50	2.08	4.36	5.95
SEAsia	0.09	0.36	1.17	2.40	3.67
bgd	-0.54	-1.56	-2.57	-3.36	-3.76
ind	-0.61	-2.19	-5.40	-7.29	-7.87
npl	-0.33	-1.23	-3.03	-4.96	-7.02
pak	-0.72	-2.27	-3.75	-5.30	-6.68
lka	-1.21	-3.20	-4.83	-6.52	-8.03
xsa	-0.95	-2.91	-4.82	-6.30	-7.30
NSAmerica	0.06	0.24	0.96	2.02	2.92
Europe	0.08	0.38	1.53	3.43	5.40
Africa_MEast	0.23	0.77	2.15	3.66	5.02

Table 12: Deviation of Paddy Rice Prices from Baseline (Unit = %)

pdr	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.12	0.71	1.78	1.21	0.78
SEAsia	0.05	0.21	0.43	0.57	0.58
bgd	1.00	2.93	4.19	5.03	5.48
Ind	2.42	6.98	8.31	8.91	8.37
npl	0.66	2.18	3.47	3.78	3.45
pak	-0.13	-0.24	-0.37	-1.27	-2.15
Lka	0.04	0.05	-0.08	-0.19	-0.19
Xsa	2.09	6.81	9.58	11.29	12.37
NSAmerica	0.08	0.39	1.23	1.66	1.52
Europe	0.21	0.92	1.32	0.74	0.38
Africa_MEast	0.06	0.34	1.13	1.73	1.82

Table 13: Deviation of Wheat Prices from Baseline (Unit = %)

Wht	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.05	0.19	0.40	0.46	0.38
SEAsia	0.03	0.13	0.29	0.43	0.49
Bgd	0.48	1.47	2.53	3.61	4.57
Ind	0.99	3.29	3.86	3.31	2.48
Npl	1.42	5.27	9.31	13.27	17.43
Pak	0.89	2.57	3.49	4.14	4.71
Lka	0.07	0.25	0.61	1.00	1.20
Xsa	1.20	3.43	3.72	3.70	3.93
NSAmerica	0.06	0.21	0.48	0.75	0.90
Europe	0.05	0.17	0.35	0.48	0.48
Africa_MEast	0.04	0.15	0.33	0.57	0.68

Table14: Deviation of Coarse Grain Prices from Baseline (Unit = %)

Gro	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.05	0.18	0.35	0.40	0.35
SEAsia	0.05	0.18	0.42	0.59	0.65
bgd	2.40	7.12	8.79	9.91	11.32
ind	2.57	7.61	8.26	6.77	4.99
npl	2.27	9.21	18.49	30.33	43.32
pak	2.27	8.66	14.06	17.99	22.67
lka	1.54	4.32	5.68	6.12	5.86
xsa	2.95	10.42	14.79	16.70	17.44
NSAmerica	0.05	0.19	0.45	0.67	0.75
Europe	0.04	0.16	0.35	0.47	0.46
Africa_MEast	0.04	0.15	0.29	0.50	0.59

Table15: Deviation of Vegetable and Fruit Prices from Baseline (Unit = %)

v_f	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.07	0.25	0.41	0.42	0.36
SEAsia	0.04	0.17	0.37	0.49	0.52
bgd	1.38	4.11	6.08	7.46	8.43
ind	2.01	5.80	7.04	7.50	7.51
npl	1.33	4.44	7.01	9.31	11.62
pak	1.32	4.21	6.58	8.23	9.10
lka	1.10	2.88	4.26	5.24	5.68
xsa	1.43	4.41	6.00	6.77	7.15
NSAmerica	0.07	0.26	0.59	0.87	0.95
Europe	0.05	0.17	0.37	0.49	0.47
Africa_MEast	0.04	0.18	0.37	0.62	0.70

Table16: Deviation of Oil Seeds Prices from Baseline (Unit = %)

osd	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.09	0.33	0.68	0.79	0.71
SEAsia	0.08	0.35	0.86	1.27	1.41
bgd	0.72	2.22	3.63	4.61	5.14
ind	1.53	4.40	5.44	6.48	6.89
npl	1.08	3.38	5.23	7.18	9.35
pak	0.86	2.50	4.57	6.87	9.02
lka	1.11	3.77	6.02	7.69	8.15
xsa	1.10	3.07	4.63	5.99	7.12
NSAmerica	0.07	0.31	0.77	1.20	1.36
Europe	0.05	0.18	0.38	0.49	0.44
Africa_MEast	0.04	0.18	0.44	0.80	0.98

Table17: Deviation of Sugar Prices from Baseline (Unit = %)

c_b	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.06	0.23	0.45	0.48	0.42
SEAsia	0.06	0.26	0.63	0.76	0.71
Bgd	1.38	4.40	6.41	7.53	8.24
Ind	2.38	7.10	8.68	8.94	7.42
Npl	1.30	4.83	8.75	12.97	17.12
Pak	1.67	5.39	8.24	10.03	10.94
Lka	1.09	3.20	4.64	5.54	5.90
Xsa	1.63	5.15	6.39	6.99	7.31
NSAmerica	0.06	0.25	0.59	0.82	0.87
Europe	0.04	0.15	0.33	0.42	0.40
Africa_MEast	0.04	0.17	0.44	0.63	0.61

Table 18: Deviation of Cotton and Fibre Prices from Baseline (Unit = %)

Pfb	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.16	0.67	1.42	1.48	1.16
SEAsia	0.09	0.35	0.83	1.13	1.11
bgd	1.17	4.14	7.45	10.58	12.95
ind	1.76	6.26	6.96	7.87	8.88
npl	1.54	6.43	9.08	10.90	12.78
pak	1.44	4.50	7.41	9.70	11.21
lka	0.08	0.30	0.65	1.01	1.18
xsa	1.41	4.67	7.24	8.87	9.54
NSAmerica	0.17	0.77	1.49	1.87	1.96
Europe	0.13	0.62	1.24	1.57	1.43
Africa_MEast	0.05	0.24	0.42	0.64	0.78

Table19: Deviation of Other Crops Prices from Baseline (Unit = %)

ocr	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.09	0.37	0.85	0.92	0.78
SEAsia	0.09	0.36	0.96	1.52	1.77
Bgd	1.45	4.40	6.23	7.42	8.20
Ind	1.77	5.27	5.32	6.01	6.69
Npl	1.39	4.65	6.20	7.50	8.95
Pak	1.31	4.21	7.27	9.58	11.36
Lka	0.74	2.13	3.83	5.42	6.63
Xsa	1.39	4.28	5.82	6.79	7.48
NSAmerica	0.08	0.32	0.90	1.41	1.58
Europe	0.05	0.18	0.43	0.57	0.54
Africa_MEast	0.08	0.34	0.93	1.53	1.74

Table 20: Deviation of GDP from Baseline (Unit = %)

	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.00	0.01	0.01	0.00	-0.01
SEAsia	0.00	0.01	0.02	0.03	0.04
bgd	-0.08	-0.41	-0.94	-1.50	-1.82
ind	-0.11	-0.58	-0.86	-0.82	-0.82
npl	-0.13	-0.75	-1.92	-3.45	-4.91
pak	-0.11	-0.63	-1.30	-1.64	-1.72
lka	-0.08	-0.29	-0.62	-0.98	-1.21
xsa	-0.20	-0.86	-1.36	-1.65	-1.81
NSAmerica	0.00	0.01	0.02	0.02	0.03
Europe	0.00	0.01	0.01	0.00	-0.02
Africa_MEast	0.00	0.01	0.01	0.00	0.01

Table21: Deviation of Foreign Investment from Baseline (Unit = %)

	Y2010	Y2015	Y2020	Y2025	Y2030
Oceania	0.02	0.04	0.00	-0.06	-0.13
SEAsia	0.01	0.07	0.16	0.23	0.34
bgd	-0.40	-1.71	-3.65	-5.41	-6.11
ind	-0.55	-2.80	-7.79	-5.67	-3.59
npl	-0.32	-1.50	-3.50	-5.76	-7.55
pak	-0.39	-1.86	-3.53	-4.07	-3.77
lka	-0.21	-0.61	-1.29	-1.94	-2.37
xsa	-0.31	-0.99	-1.57	-1.90	-2.02
NSAmerica	0.02	0.08	0.14	0.18	0.19
Europe	0.01	0.04	0.02	-0.02	-0.06
Africa_MEast	0.02	0.10	0.05	0.00	0.05

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Appendix 1

Table 1: Land Productivity Shocks to Paddy Rice (Unit = %)

pdr	Y2007	Y2010	Y2015	Y2020	Y2025	Y2030	Total
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEAsia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bgd	0.00	-0.67	-1.11	-1.11	-1.11	-1.11	-5.00
ind	0.00	-1.80	-2.98	-2.98	-2.98	-2.98	-13.00
npl	0.00	-0.26	-0.44	-0.44	-0.44	-0.44	-2.00
pak	0.00	0.89	1.48	1.48	1.48	1.48	7.00
lka	0.00	0.13	0.22	0.22	0.22	0.22	1.00
xsa	0.00	-1.80	-2.98	-2.98	-2.98	-2.98	-13.00
NSAmerica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Africa_MEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 2: Land Productivity Shocks to Wheat (Unit = %)

wht	Y2007	Y2010	Y2015	Y2020	Y2025	Y2030	Total
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEAsia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bgd	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
ind	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
npl	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
pak	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
lka	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
xsa	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
NSAmerica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Africa_MEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3: Land Productivity Shocks to Coarse Grain (Unit = %)

gro	Y2007	Y2010	Y2015	Y2020	Y2025	Y2030	Total
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEAsia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bgd	0.00	-2.40	-3.97	-3.97	-3.97	-3.97	-17.00
ind	0.00	-2.40	-3.97	-3.97	-3.97	-3.97	-17.00
npl	0.00	-2.40	-3.97	-3.97	-3.97	-3.97	-17.00
pak	0.00	-2.40	-3.97	-3.97	-3.97	-3.97	-17.00
lka	0.00	-2.40	-3.97	-3.97	-3.97	-3.97	-17.00
xsa	0.00	-2.40	-3.97	-3.97	-3.97	-3.97	-17.00
NSAmerica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Africa_MEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4: Land Productivity Shocks to Vegetable and Fruit (Unit = %)

v_f	Y2007	Y2010	Y2015	Y2020	Y2025	Y2030	Total
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEAsia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bgd	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
ind	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
npl	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
pak	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
lka	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
xsa	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
NSAmerica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Africa_MEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5: Land Productivity Shocks to Oil Seeds (Unit = %)

osd	Y2007	Y2010	Y2015	Y2020	Y2025	Y2030	Total
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEAsia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bgd	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
ind	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
npl	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
pak	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
lka	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
xsa	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
NSAmerica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Africa_MEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6: Land Productivity Shocks to Sugar (Unit = %)

c_b	Y2007	Y2010	Y2015	Y2020	Y2025	Y2030	Total
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEAsia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bgd	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
ind	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
npl	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
pak	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
lka	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
xsa	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
NSAmerica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Africa_MEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table7: Land Productivity Shocks to Cotton and Fibre (Unit = %)

pfb	Y2007	Y2010	Y2015	Y2020	Y2025	Y2030	Total
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEAsia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bgd	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
ind	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
npl	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
pak	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
lka	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
xsa	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
NSAmerica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Africa_MEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table8: Land Productivity Shocks to Other Crops (Unit = %)

ocr	Y2007	Y2010	Y2015	Y2020	Y2025	Y2030	Total
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEAsia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bgd	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
ind	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
npl	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
pak	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
lka	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
xsa	0.00	-1.36	-2.26	-2.26	-2.26	-2.26	-10.00
NSAmerica	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Africa_MEast	0.00	0.00	0.00	0.00	0.00	0.00	0.00