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Sorghum and Millets Futures in Asia under Changing Socio-economic and Climate Scenarios

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Abstract

The foremost determinants of agricultural production in much of the developing world are weather conditions and water availability, both of which are susceptible to the vagaries of climate. Any policy interventions that might make a difference to the global food situation in the future, but coupled with the harmful effects of climate change, the full benefits of these reforms may not be passed on to the wider agricultural community. In this report, we analyse the plausible futures of dryland cereals, namely millet and sorghum, under alternative policy and climate scenarios to assess the direction and probable magnitude of the change in supply and world prices of these cereals, particularly in the semi-arid tropics of Asia. We also examine the impact of the policy scenarios on human welfare such as child malnutrition and per capita calorie intake across countries. The human populations of the dryland live in increasing insecurity due to land degradation and desertification. Livelihood of the people in the dryland tropics will be affected by climate change if no measure is taken to check its disastrous implications on dryland farming. Various adaptation strategies are required to manage the possible risks that the agricultural population might face due to the impact of growing population and climate change. Diversification into livestock production is one viable alternative available to cushion the income losses from falling cereal demand. Income plays a major role in removing the constraints for adopting new technologies and enhancing accessibility to them. Changing consumption pattern is significant fallout of the rise in middle income group which prefers livestock products to cereals. Sorghum and millet having traits most suited for dryland farming will satisfy the growing food and feed demand than any other crop, being able to withstand water scarcity and rising temperatures. Indeed, the following analysis shows these cereals to be more resilient to climate change than maize, a substitute for these crops.

Keywords: Dryland cereals; foresight and projections; IMPACT model; Climate change

JEL classification: Q11, Q16

Contents

1 Introduction

Dryland cereals have been the mainstay of food in several countries which have a semi-arid tropical (SAT) climate in Asia, Latin America and Africa. This study as part of HOPE project aims at analysing the total demand, yield, area, production, prices and net trade of dryland cereals viz., sorghum and millet under different socioeconomic and environmental conditions in Asia. These crops are widely grown in harsh agro climatic conditions characterized by high temperatures, unreliable rainfall, land degradation and limited market opportunities. They support food and fodder security for the bulk of the human and livestock population in Asia.

Sorghum is cultivated for food in the developing countries of Asia and Africa whereas in developed countries of America, it is primarily grown for use as feed. In India for example, 12% of total the calorie requirements are met by coarse cereals including sorghum and millet which is about 12% of total calorie requirements (Source: Working Group, Ministry of Agriculture, Government of India. April, 1990). Also, the protein content of sorghum is more than that of rice (Hulse. Laing and Pearson. 1980: United States National Research Council/National Academy of Sciences. 1982. USDA/HNIS. 1984).The export market of sorghum plays an important role in influencing the domestic production in some parts of the world, but the quality of the grain produced in Asia does not provide any export opportunity. The livelihoods of people in SAT economies are dependent on dryland agriculture and crops like sorghum and millet which have proven to have higher tolerance to heat and drought (Blum et al., 1990) compared to rice, wheat and maize, offer a viable alternate. Therefore there is an imperative for finding newer ways of increasing the consumption in other sectors, such as domestic industrial uses.

Sorghum and millet are both primarily grown for food in the semi-arid tropics (SAT). Apart from being the dietary mainstay of the people living in SAT, these crops make significant contribution as livestock feed. Also due to rising income levels, there has been shift in consumption pattern towards high value foods such as milk, eggs, meat and other dairy products triggering high demand for these products hence the derived demand for cereals will increase to a greater extent. Feed for poultry usually constitutes maize, sorghum, broken rice and other grains and cattle feed consists of barley, pearl millet, maize, oats and wheat. Therefore, the derived demand for sorghum in poultry and dairy sector is expected to rise as a result of the increase in livestock consumption. In addition, lately there is a rising demand for industrial uses such as alcohol, starch and other industries. As a matter of fact, it is because of the dwindling food demand that newer ways are sought to increase the consumption of the grain in other industries. In the recent times due to the need for improved quality of potable liquors, grain-based production of alcohol has been suggested as a prospective approach (Dayakar Rao et al., 2003)

The objective of this study is to assess the potential impact of the globalisation by way of income and population growth rates and that of the biophysical changes in the environment on the future of dryland cereals. We consider two socioeconomic scenarios and four climate scenario and compare them with the baseline projections. This will enable us to find out how the negative impact of water scarcity, land degradation and climatic variability can be averted through diversification of agriculture from conventional crops and irrigation practices and forming suitable adaptation strategies to mitigate the dampening effect of climate change on income growth.

The IFPRI IMPACT model has been used for making the baseline projections which includes several commodities and not just the dryland cereals. This gives a realistic picture because of the interactions of the demand and supply of all the crops. The effect of the fall in the prices of the competing crops and the shift in demand to livestock products will have substantial implications for demand and supply of dryland cereals. The effect of trade policies have also been included in the model to reflect the price differential that exist between the country-level prices and the single world price that the IMPACT model calculates. The export and import quantities of the countries are endogenous values just as the world price is calculated based on the global demand and supply. A variable called stock change is introduced to capture any mismatch between net trade and surplus/deficit production. The impact of shocks in the form of drought years, price rise, change in income and population trends and technology improvements are reflected in the quantum of trade in that particular commodity. The water module has also been incorporated in the area and yield functions to address the constraints imposed by stress in moisture levels. Water scarcity on rainfed and irrigated lands are calculated through separate equations. Livestock production helps explicitly calculate the feed demand for feed crops. Demand for livestock products and demand for all food crops are calculated by one equation. The estimates of growth rates that enter the model exogenously are that of income, population, yield and area. These variables are calibrated so as to draw a realistic picture of the actual values.

The first section gives a background to the discussion and rationale behind the scenario output projections. The second section discusses about the historical trends of millet and sorghum in terms of area, production and consumption. The third section talks about the need for scenario projections. The fourth section describes the IMPACT model and its various aspects. The fifth section talks about the key drivers of change and how the scenarios are built. Section six discusses the baseline projections in detail with regard to millet and sorghums' area, production, consumption and net trade. Scenario projections namely the optimistic and pessimistic scenario projections for sorghum and millet are shown in the seventh section. The last section talks about climate change, its key drivers and climate scenario outputs for sorghum and millet separately for irrigated and rainfed lands followed by the conclusion.

2 Historical Trends

2.1 Area and Production Trends of Millet

Asia now has about 35% of the total harvested area of millet in the world compared to the 64% of in 1960. Much of the decline happened in the 1970s. India has 12 times more harvested area of millet than China and the harvested area of millet has declined by 43 % in India in the last fifty years. India has the highest percentage of harvested area of millet at 83% in Asia.

Though the harvested area of millet has declined in India, production has remained stable at about 9.5 million tonnes in the past five decades on average. In China, a marked decline in millet production is observed in the early 1970s, followed by a continued downward trend till 2009 during which the production diminished by 80% compared to the 1960s. The yield in Eastern Asia had climbed steeply between 1980 and 2009, peaking at 2.1 t per hectare in 2005, though area and production have gone down (Appendix A, Appendix B and Appendix C). Overall the world production of millet has increased by 24% from 1960 to its present level at 32 million tonnes in 2009.

2.2 Area and Production Trends of Sorghum

In 2009, sorghum was grown on over 43 million hectares of land globally. Within the sub-continent of Asia, it was grown on over 9 million hectares of land, constituting about 20% of the total harvested land area of sorghum. The total harvested area of sorghum has diminished by 5% in the past fifty years globally. The same trend is observed in Asia due to various socio-economic factors like rapid urbanisation, rising incomes and changing consumer preferences from 58% of total harvested area of sorghum of total cultivated area in the early 1960s to 20% in 2009, which is reflected by the downward trend observed in Southern Asia and South-Eastern Asia (Appendix E). There has been a steep rise in crop yield since 1990 in Eastern Asia but this does not have any impact on the production since the harvested area of sorghum is very small (Appendix G). Southern Asia has the highest sorghum production with the largest harvested area in Asia, in spite of a lower crop yield than that of Eastern Asia (Appendix F).

Asia's contribution to the world production of sorghum has also rapidly gone down from 37% in 1960 to 16% in 2009. The latest global production figures of sorghum stands at 62 million tonnes in 2009 which is about 51% more than the level of production in 1960. This is a consequence of the technological improvements in sorghum breeding.

2.3 Consumption Trends and Dynamics for Millet

Aggregate food demand for any commodity is mainly influenced by its price, that of its substitutes, income, population and consumer preferences. The historical trend of millet demand has more or less been the same globally (Appendix H). The total demand for millet has remained stable close to its average level at 28 million tonnes in the past five decades (Appendix H). In Eastern Asia there has been a major decline in food and feed demand of millet but a substantial jump in feed demand is observed after 1992. Between 1993 and 1994, feed demand has increased by 50% followed by a downward trend (Appendix J). South-Eastern Asia does not show any demand for millet at all. The global demand for millet as feed has almost doubled in 2007-09 compared to the level of feed demand in 1965 (Appendix H). The proportion of feed demand has increased from 7% to 12% out of the total demand for millet between 1960 and 2007 at the global level. There is much scope for improving the feed demand of millet since there is an upward trend in the global feed demand for millet. There also seems to be a stable market for processed foods from millet though it has not yet grown to constitute a major portion of the demand.

2.4 Consumption Trends and Dynamics for Sorghum

Although sorghum is an integral part of the food basket in the semi-arid tropics, globally the aggregate food demand for sorghum has remained stable. However, owing to increasing incomes and the availability of cheaper rice and wheat in many of the main demand centres, the micro-level per capita consumption has been declining. Eastern Asia has shown a declining trend in sorghum demand since 1970 though a major portion of the demand in the Asian region comes from Southern Asia where the demand has been relatively stable (Appendix O). As can be seen from the Appendix L and Appendix M, much of the food demand arises from outside of Asia.

The world feed demand for sorghum shows that a very small percentage of its demand arises out of Asia at around 1% (Appendix L and Appendix N). Though global feed demand for sorghum declined around 1985 following a growing trend, feed demand contributes almost half of the total demand for sorghum globally. Southern Asia shows negligible feed demand for sorghum. There is no utilization of sorghum in any form in South-Eastern Asia and Eastern Asia.

3 Scenario-Based Analysis of Dryland Futures

The idea behind building scenarios and comparing them with the baseline projections is to assess the importance of the drivers and to take necessary steps to ameliorate the adverse effects that may arise from changing climate. The plausible futures are developed under different scenarios so as to closely replicate the potential futures for the crops if any of these scenarios were to materialise. . If there are significant changes from the baseline projections, then the pace and pattern of change is analysed in order to initiate the policy measure to correct the distortions and stimulate the demand for the dryland cereals so that the poor growers will be benefitted. Mostly, a fair idea of the gap between demand and supply and the need for diverting the production into more profitable avenues or creating demand through economic or trade reforms can be perceived. The time period used in the following discussions is between 2000 and 2050 where the projections till 2010 are compared with FAO's historical data as a check to gauge the accuracy of the projections with real world data.

3.1 Key Elements of Scenario Building

The most important exogenous drivers that have a significant effect on the endogenous variables are income, population, yield and area growth rates. The same systems of equations of supply and demand are used for all crop commodities except for sugar and allied products and oilseeds. The key drivers of crop supply are the yield and area growth rate estimates which have a profound impact on the direction of the crop production. On the demand side, the important drivers are income and population growth rate estimates. In this particular report, we consider three socioeconomic scenarios: baseline, optimistic and pessimistic scenarios. The drivers that differ across these scenarios are population and income growth rates. There are three degrees-high, medium and low at which each drivers can be set. Table 1 shows the average per capita GDP growth rates pertaining to each scenario of baseline, optimistic and pessimistic across regions. The GDP growth rates from the Millennium Ecosystem Assessment GDP scenarios are used for building these scenarios. The highest of the rate is used for constructing the optimistic scenario and the lowest for pessimistic scenario. The baseline rates of GDP are taken from the World bank-Economics of Adaptation to Climate Change (EACC) study. As for the population growth rates, United Nations estimates are used which has three variants namely, high, low and medium which are used for the three scenarios of pessimistic, optimistic and baseline respectively (Table 2).

Table 1 Average scenario per capita GDP growth rates (percent per year)

		2010–2050		
Regions	1990–2000	Pessimistic	Baseline	Optimistic
Developed	2.70	0.74	2.17	2.56
Developing	3.90	2.09	3.86	5.00
Low-income developing	4.70	2.60	3.60	4.94
Middle-income developing	3.80	2.21	4.01	5.11
World	2.90	0.86	2.49	3.22

Source: World development indicators for 1990-2000 and author's calculation for 2010-2050

Table 2 GDP and population rates chosen for the scenarios

	Pessimistic	Baseline	Optimistic
GDP, constant 2000 US$	Lowest of the four GDP growth rate scenarios from the Millennium Ecosystem Assessment GDP scenarios (Millennium Ecosystem Assessment 2005) and the rate used in the baseline (next column)	Based on the rates from World Bank (EACC study, Margulis et al., 2010), updated for sub-Saharan Africa and Southern Asian countries	Highest of the four GDP growth rate scenarios from the Millennium Ecosystem Assessment GDP scenarios (Millennium Ecosystem Assessment 2005) and the rate used in the baseline (next column)
Population	UN low variant, 2008 revision	UN medium variant, 2008 revision	UN high variant, 2008 revision

Source: Gerald et al., 2010

The baseline scenario has both population and income drivers set to medium level. Optimistic scenario will have population set to low and income set to high degree levels. This would result in higher per capita income over baseline projections. Pessimistic scenario will have population set to high and income set to low degree levels. This will have lower per capita income than baseline projections over the time period considered. For example in India for 2020, baseline projection of per capita income is $1220 whereas under pessimistic scenario it is $802 and under optimistic scenario it is $1250. In the case of India, the percentage change in per capita GDP under optimistic and pessimistic scenarios, negative or positive as the case may be, is of different magnitudes i.e. +2% in optimistic and -34% in pessimistic scenarios. In contrast, China does not show much of a difference under the two scenarios.

Improved food security, better nutrition status and higher production levels with lower prices are anticipated under the optimistic scenario. If these seem attainable what is the degree of improvement over baseline projections are the secondary questions which are addressed in this report. If the other extreme is observed under pessimistic scenario, what is the extent to which people are affected and in which regions will be brought out. As far as sorghum and millet are concerned, we would like to know the level to which consumption of the crop will go up under tough economic conditions since these are mostly inferior crops (Nagaraj et al., 2012). Consequently the increase in the per capita calorie intake is also assessed following the consumption of these nutrient rich foods. Under optimistic conditions, we would like to know the quantity by which the exports have gone up or imports have come down since the domestic demand falls because of a lower population growth.

Further, when these drivers are changed the implications are percolated across all crops in a particular country. This way the countries that are most vulnerable to poor economic conditions are identified. Feed demand of these crops is based on livestock production which in turn depends on feed prices indicating the derived demand. There are implications not only for the bio-physical changes on crop production but also for socio-economic and technological changes that need to be addressed. Since the final production is an outcome of a complicated structure of the inter-relations among these factors, we choose to assess the outcome resulting from a change in only one factor. Even though the other factors are not changed in the scenario, the effects of these factors are incorporated in the baseline projections of the model. These kinds of experiments are helpful to make a quantitative assessment of the change in the outcomes because of these drivers.

4 The IMPACT Model

The International Model for Policy analysis of Agricultural Commodities and Trade was developed by IFPRI to make long-term global food projections.

4.1 Modeling Methodology of IMPACT

The IMPACT model is designed to examine alternative futures for global food supply, demand, trade, prices, and food security. It provides both fundamental, global baseline projections of agricultural commodity supply, demand, trade, prices and malnutrition outcomes along with cutting-edge research results on quickly evolving topics such as bioenergy, climate change, changing diet/food preferences, and many other themes.

IMPACT covers 30 commodities, which account for virtually all of world food production and consumption, including all cereals, soybeans, roots and tubers, meats, milk, eggs, oils, meals, vegetables, fruits, sugar and sweeteners in a partial equilibrium framework. It is specified as a set of 115 country-level supply and demand equations where each country model is linked to the rest of the world through trade.

The model is written in the General Algebraic Modeling System (GAMS) programming language. The solution of the system of equations is achieved using the Gauss–Seidel algorithm. This procedure minimizes the sum of net trade at the international level at a world market price for a commodity which clears the world commodity market.

The basic IMPACT model is combined with the Water Simulation Model (WSM) in order to estimate the interactions between water supply and demand and food supply, demand, and trade. The scenarios for water are downscaled from and calibrated to Global Circulation Models (GCM) that represents future climates in the different IPCC SRES (Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios). This allows for separate area and yield functions for rainfed and irrigated crops, water allocation among crops, and yield and area reductions from lack of water. Water demand is accounted for from irrigation for agriculture, livestock, domestic/municipal, and industrial sectors. This provides a further supply-side spatial disaggregation of production for irrigated and rain fed crop across 126 water basins. Combining these 126 basins with the 115 geopolitical regions gives 281 “food producing units”.

In addition to trade position estimations, to explore food security effects IMPACT projects the percentage and number of malnourished preschool children (0 to 5 years old) in developing countries as a function of average per capita calorie availability, the share of females with secondary schooling, the ratio of female to male life expectancy at birth, and the percentage of the population with access to safe water (Rosegrant et al., 2008)

4.2 Spatial Coverage of IMPACT

While the primary IMPACT model divided the world into 36 countries and regions, the IMPACT-WATER model uses a finer disaggregation of 281 “food-producing units” – which represent the spatial intersection of 115 economic regions and 126 river basins – out of recognition of the fact that significant climate and hydrologic variations within regions make the use of large spatial units which are inappropriate for water resource assessment and modeling. Of the countries represented within the IMPACT-WATER model, China, India and the United States (which together produce about 60 per cent of the world’s cereals) have the highest level of sub-national disaggregation and are divided into 9, 13 and 14 major river basins respectively, while the other countries or regions considered in IMPACT account for the remaining 90 basins. For the purpose this study we focus on the results of the Asian region which is regionally disaggregated into Southern Asia, Eastern Asia and South-Eastern Asia.

4.3 Crop Model Incorporation

The crop simulation model is incorporated in the IMPACT model as a shifter in the supply functions. The direct effect of the differing climates on the yield and area of various crops are assessed in the process-based simulation model. The system used in the IMPACT modelling suite is the Decision Support System for Agrotechnology transfer (DSSAT, Jones et al. 2003) which brings together programs to model weather/climate, soil dynamics and the crop models themselves (Figure 1).

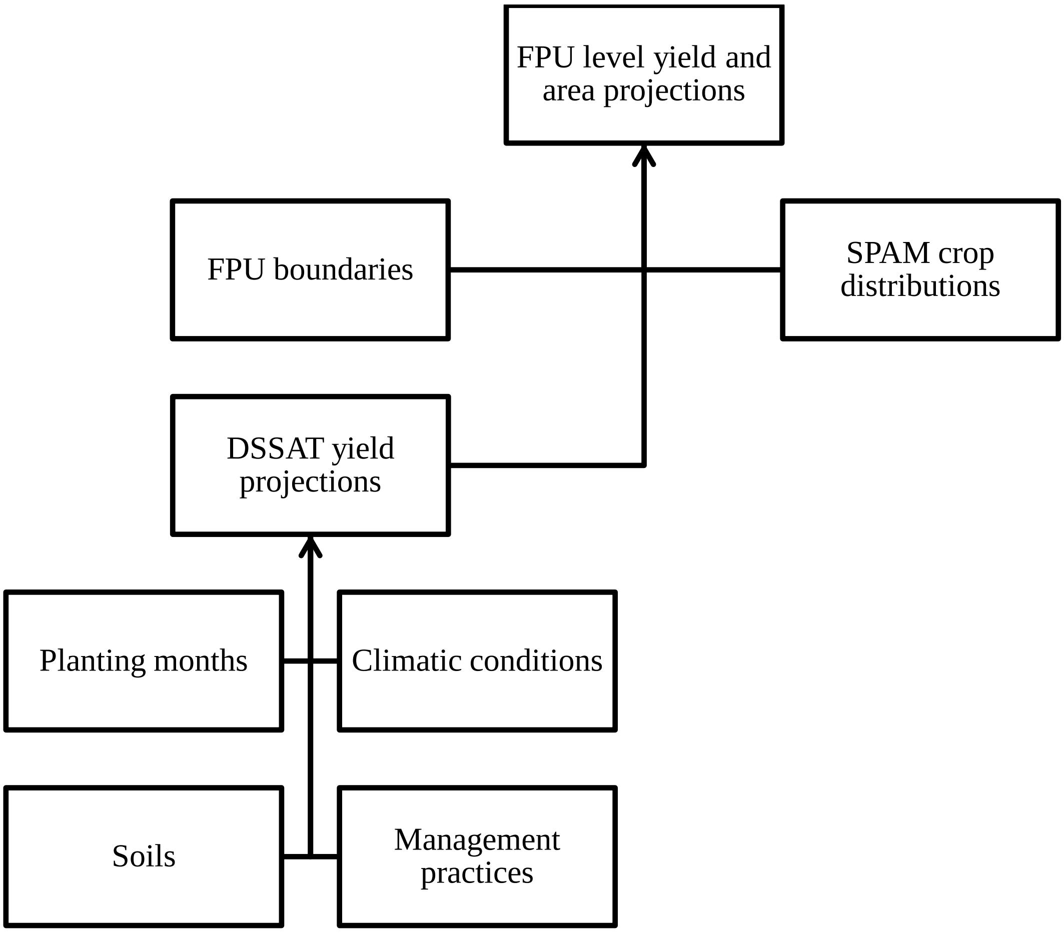

Figure 1: Incorporating climate effects on crops into IMPACT

The supply curve is shifted by several non-price factors like sunshine, temperature, rainfall, soil quality, technological improvements and regulation. Technological improvement is the most important shifter in this model. This is implemented as a multiplicative factor in the yield and area equations as an addition to the annual growth rate: (1+gY) where gY is the intrinsic yield growth rate.

These kinds of simulation models use enormous input data. The climate data are drawn from the FutureClim gridded data sets which are used as input in the weather generators in DSSAT (Jones, Thornton, and Heinke 2010). The monthly averages supplied by FutureClim are used by DSSAT to produce daily weather values. The model computes results for six crops (indica rice, japonica rice, maize, wheat, soybeans and groundnut), two water sources (rainfed and irrigated), 13 climate conditions (baseline + 12 GCM/scenario combinations) and 2 carbon dioxide fertilisation assumptions. The estimation procedure includes three separate planting months, and multiple years' worth of realizations from the random weather generator.

At the end of the crop modelling work, we have gridded maps showing yield estimates for various climatic conditions. Then the yield for the whole food producing unit is computed using an area-weighted average yield. The area allocation by crops is taken from the Spatial Production Allocation Model (You and Wood, 2006). The yield estimates over the years are converted into growth rates for the time interval of interest which enter the supply functions as growth rates.

Equations 1 and 2 are the yield and area functions in IMPACT. The yield portion consists of the overall level coefficient (based on the previous year's level), the output own-price effect, the input factor price effects and the growth rate effects. For irrigated crops, an adjustment is made dependent on the availability of the water for agriculture use and a water stress model. Similarly, area equation depends on prices of competing crops rather than inputs.

Yield:

$$Y_{tni} = \beta_{tni} \times \left(PS_{tni}\right)^{\gamma iin} \times \prod_k \left(PF_{tnk}\right)^{\gamma ikn} \times (1 + gY_{tni} + gYCC_{tni}) - \Delta Y_{tni}\,(WAT_{tni}) \quad (1)$$

Area:

$$A_{tni} = \alpha_{tni} \times (PS_{tni})^{\varepsilon iin} \times \prod_{j \neq i} (PS_{tnj})^{\varepsilon ijn} \times (1 + gA_{tni} + gACC_{tni}) \quad (2)$$

where *t* is the timestep, *n* is the geographic unit, *i* is the crop, and *k* is the factor input; *Y* is the yield for the crop, β and α are yield and area scale factors, *PS* is the output price, *PF*'s are input factor prices, γ's are the output and input elasticities of supply, *gY* is the intrinsic yield growth rate, *gYCC* is the climate change effect on growth rate of yields, Δ *YC* is the yield penalty due to water stress for irrigated systems, and *gACC* is the climate change effect on growth rate for area.

There are some drawbacks in using process-based crop models. It is impossible to obtain even a reasonably close representation of future weather conditions and; move from coarse GCM (General Circulation Model)-level data to plot level information. Critical variables such as solar radiation which determines the plant growth are not usually available for modelling. The response of the crops to CO_2 fertilisation is still an active area of concern since small-scale experiments may not be realised on a large scale. Biotic stresses like pests, diseases and weeds are usually not part of crop modelling. Human response to changes in water availability and, changes in relative prices of the traditional inputs of land, labour and capital in the future are some aspects which cannot be modelled. Finally, the temporal changes in the availability of cultivable land will pose a problem in aggregating high-spatial resolution maps into FPUs.

4.4 Model Calibration, Validation and Interpretation

This report focuses on the impact of two scenarios which are based on two drivers namely income and population. The regional aggregations for which the study is done are Southern Asia, Eastern Asia and South-Eastern Asia[1]. Aggregate-level estimates of elasticities, growth rates and indices used in water module are used to estimate supply equations. Production is calculated separately for rain fed and irrigated lands with different yield rates and water availability levels. Similarly food demand is disaggregated into urban and rural based on proportion of population in the two regions and not based on the respective elasticities, since such data is not available. In Southern Asia, India is the biggest economy of dryland cereals; in Eastern Asia, it is China. The growth rates of income and population across countries are updated every five years from 2000 to 2050. National level figures are suited for the purpose of the study, since it shows the implications on net trade at a national level. The baseline projections are made from 2000 till 2050, where the model is based on the actual values of 2000.

[1]Southern Asia includes Afghanistan, Bangladesh, Bhutan , Iran, India, Nepal, Pakistan And Sri Lanka; South-Eastern Asia includes Indonesia, Malaysia, Myanmar, Philippines, Papua New Guinea, Singapore, Thailand and Vietnam; and Eastern Asia includes China, North Korea, South Korea and Mongolia.

4.5 Model Validation

While creating the plausible futures, the baseline projections are replicated for the year 2000 to reproduce the actual values by adjusting the 'drivers' of area and yield growth. Much of the changes in the net trade positions of the countries are not so large as to change an importer into an exporter but mostly the relative trade positions are maintained. Moreover we would find that the projections over the years smoothens the actual values that are realised so as to provide a composite evaluation of the trend. So the short term fluctuations due to random shocks that are observed in the actual values will not be projected by the model. Some deviations from the actual values for some countries might be observed. We compare the FAO data with the baseline projections for the period between 2000 and 2009 to check if the actual data and the values produced by the model coincide on an average level.

Several crops are included in the study apart from dryland grains and legumes. The cross-price elasticities used in the model show how the shocks in the prices of other commodities impact the demand and supply of the dryland cereals. These values are calibrated so as to reproduce the actual values of the demand and supply of the crops. Rice is the staple food of India and China and if the price of rice goes up, there will be an increase in the quantity of sorghum and millet consumed due to substitution effect.

4.6 Interpretation of results

The reason for considering several scenarios is that the actual path that will be taken by these drivers is clearly uncertain. Though the scenarios are calibrated to get a realistic picture of the plausible futures, some other combinations of socio-economic, technological and policy drivers is equally likely to present itself in the future. Therefore we have stressed only on the two extreme cases although the plausibility of these scenarios may not be certain. Under the given assumptions on the 'drivers' of change in the dryland agriculture embedded in the model, the resulting trajectory represents both the direction and the approximate magnitude of projected changes in selected endogenous variables of policy interest. Percentage changes are chosen for quantifying the degree of change rather than the actual values as they reflect the relative magnitude of the past base values. Similarly, the percentage differences between the indicator values in one scenario and those in another (typically the baseline case) are also useful since it conveys the direction of change and degree to which the alternative assumptions matter in determining the future outcome of the simulated system.

5 Considering Alternative Futures for Dryland Crops

Smallholder agriculture in dryland areas is changing under the influence of biophysical and socio-economic factors. Lack of sufficient water resources, moisture stress, soil degradation, lack of infrastructure and markets, climate change and economic fluctuations are some of the factors that affect the choice made by the smallholder farmers in respect of the crops to be cultivated, land use and investment in new technology. Population pressure induces additional production to be made so as to maintain the same level of wellbeing but the same factor also reduces the land used for agriculture because of increased pressure on land. Climate change will invariably dictate the crops that have to be grown in arid and tropical zones and will also have a major influence on the relative production levels of all the crops.

5.1 Key Drivers of Change

What are the factors which will cause a deviation from the traditional livelihood systems in the dryland tropics? Several key factors like infrastructure facilities, income growth and urbanisation and government trade policies affect the choice of livelihood in the tropics. Of late, access to small-scale irrigation has resulted in cultivation of high value crops like vegetables and livestock production. This is mainly the result of changing consumption patterns in middle-income groups. The effect that these systemic changes will have on dryland agriculture and its implications for poverty reduction and income growth are addressed here. Mostly we are interested in the future of the alternative future for dryland crop-livestock systems because of these changes.

On the demand side, per capita income in each country affects the food consumption behaviour to a large extent. On the supply side, land availability, scarcity of water, climate change and agricultural productivity affect agricultural growth. Prices of crops in different countries are determined by the marketing margins and subsidies provided and taxes imposed by that country. These form a wedge between the country level prices and the single world price for every commodity that the IMPACT model evaluates.

5.2 Plausible Futures and Alternative Scenarios considered

We consider three scenarios-baseline (business-as-usual), optimistic and pessimistic scenarios. The rate at which the per capita income increases or decreases under the optimistic and pessimistic is based on the estimates made by United Nations and World Bank (Table 1). The rate of change of per capita income differs from country to country. Some countries do not experience any change in per capita income under pessimistic circumstances whereas in some countries, per capita income doubles under optimistic scenario. In India per capita income decreases by 63% over baseline projections under pessimistic conditions whereas it increases by 16% over baseline projections in 2050 in the optimistic scenario. In China, per capita income changes almost by equal magnitude under optimistic and pessimistic scenarios. India has a higher population growth rate than China and China has a higher income growth rate than India. Higher income levels will result in adoption of newer technologies by farmers which will in turn increase the yield of the crops.

6 Projections and Outlooks for Dryland Crops

The IMPACT model provides the projections of several key elements such as supply, demand and net trade. This model uses the FAO data of 1999-2001 as base values. The output generated is based on several linear and non-linear equations and few regression equations. The food demand equation is based on income and population data of 2000 and thereafter on their growth rates which enter the model exogenously. Similarly the key drivers of production would be the yield and area growth rates. Finally for each year the net trade position for every country is arrived at, under a partial equilibrium model wherein a single world price for every crop equates the global demand and supply of each crop. The baseline projections are used to make comparison with different scenarios. Before the comparisons are made, the baseline projections of the area, yield, demand, supply and net trade of sorghum and millet are discussed.

6.1 Baseline Projections for Millet

The baseline supply projections for India (Appendix T) which is the largest producer of millet in the world show an increasing trend which smoothens out the fluctuations in the actual data for the period between 2000 and 2009. The baseline projections for India show an increasing trend. In 2011, the projection was about 11 million tonnes and it is set to continue even after 2011 but at a decreasing rate relative to the previous decade. The increase in yield of millet per hectare largely offsets the decrease in the area harvested of millet. The yield of millet increases by more than double in 2050 compared to its current levels at 0.818 tonnes/ha (FAO data, 2009) in India. The next largest producer of millet in Asia is China where the production shows a decreasing trend between 2000 and 2006 which then picks up momentum. From the level of 3 million tonnes in 2010, irrigated yield of millet is projected to reach almost 5 million tonnes by 2050, though the area estimates go down during the same period (Table 26). China and India are the main benefactors of diffusion of high yielding and hybrid varieties in Asia as consumers. On a regional level, Eastern Asia has been projected to have the highest yield levels over all other regions throughout the fifty year period between 2000 and 2050 in Asia (Appendix J).

Except for South-Eastern Asia, all regions in Asia register a decrease in the area harvested of millet, nevertheless the distinct upward trend in yield rate in Asia results in the production being pushed upwards (Table 5).

All regions in Asia in conformity with global trend exhibit an increasing trend in demand for millet (Table 6). In Southern Asia, the major portion of the demand arises from India (Table 6). Total demand for millet increases in India at a higher rate than in any other region in Asia. Model projections depict a slight shift within the total demand by 2050 from food consumption to feed consumption in India, though more than 90% of the demand still comes from food requirements (Appendix BB and Appendix CC). This shift is observed because of the high per capita income predictions and change in food preferences of people to livestock products especially poultry.

In Myanmar, which is the major millet economy is South-Eastern Asia, a similar trend is observed in the food and feed demand composition as in India but here the shift is more pronounced. By 2020, the food demand starts decreasing sliding from 1.2 million tonnes in 2020 to 1.1 million tonnes in 2050 and feed demand climbs above the food demand projection climbing from 1.2 million tonnes in 2020 to reach 1.4 million tonnes in 2050 (Tables 7 and 8) . China also exhibits a similar trend. Feed demand constitutes 53% of the total demand for millet in China in 2007 and the model projections estimate a value of 43% for the same period and increasing up to 54% of total demand by 2050.

6.2 Net Trade Projections for Millet

Southern Asia continues to be the largest exporter of millet from 2010 through 2050 (Table 9). South-Eastern Asia turns an exporter after 2020 because of Myanmar beginning to export millet from 2012. In Eastern Asia, North Korea maintains its position of the only exporter of millet in that region throughout the period. China's import requirement reduces by 23% in 2050 to 528,000 tonnes compared to its level in 2010 because of increase in production (Table 9).

Thailand imports more than double the quantity in 2010 by 2050 from 4,000 tonnes in 2010 to 11,000 tonnes in 2050. In Southern Asia, Afghanistan and Nepal import about ten times more millet by 2050 from 11,000 tonnes in 2010 to 110,000 tonnes in 2050. After 2030, Pakistan becomes the second largest importer of millet after China importing 61,000 tonnes in 2030. Overall, the model predicts that the quantities exported will almost triple in 2050 to 2.7 million tonnes in Southern Asia, the major contributor being India. The other notable exporters in Asia will be Myanmar and North Korea with 127,000 tonnes and 21,000 tonnes of export in 2050 (Table 9).

6.3 Baseline Projections for Sorghum

The FAO data showed area harvested of sorghum to follow a declining trend in Southern Asia from 18 million tonnes to 8 million tonnes between 1960 and 2010 (Appendix E); though the baseline projections portray the same trend, they do not show such a steep fall between 2010 and 2050 dropping by about 16% (Table 4). For 2010, the baseline projection of harvested area for India is 9.5 million hectares (Table 4); production remains stagnant between 2000 and 2006 after which the slope of the trend line becomes positive as a result of the rise in yield during that period. Production is estimated to cross 10 million tonnes in 2040 in India (Table 5). The yield projection is about 830 kilograms per hectare in 2010 which increases by 58% by 2050 (Table 28). The next biggest sorghum economy in Asia is China (Table 5). Here also the same trend of declining area and increasing production is observed with growing yield levels. In China, production increases by 35% in 2050 from 2.5 million tonnes in 2010.

Just as India dominates the scene in Southern Asia, China is the main consumer and producer of sorghum in Eastern Asia. In India, demand for sorghum is forecasted to increase over the years till 2050 (Table 6). In the twenty year period between 2010 and 2030 food demand for sorghum is estimated to increase by 15% and then stagnate at around 8.7 million tonnes thereafter in India (Table 7). Feed demand which constitutes a small portion of total demand is expected to increase by more than double (by 236%) in India to reach 397,000 tonnes in 2050 and (by 250%) in Thailand to reach 581,000 tonnes in 2050 from 2010 (Table 8).

6.4 Net Trade Projections for Sorghum

All countries in South-Eastern Asia import sorghum and imports are expected to increase by 60% in 2020 from 96,000 tonnes in 2010 (Table 9); between 2020 and 2040 its imports are estimated to increase by 1.5 times especially driven by Thailand (Table 9). Indian imports fall after 2020 from 459,000 to 307,000 tonnes in 2050. China's import of sorghum increases throughout the projection period; between 2010 and 2050, it increases by 43% from 893,000 tonnes in 2010 to 1.28 million tonnes in 2050. Pakistan's import will climb up to 226 thousand tonnes in 2050 from 84 thousand in 2010. Its total demand for sorghum is expected to increase by almost 92 % to 483,000 tonnes in 2050 from 252,000 tonnes in 2010. Generally Southern Asia's net trade position improves marginally after 2020 with imports declining from 579,000 tonnes to 532,000 tonnes in 2050 (Table 9). As regards the other regions namely Eastern Asia and South-Eastern Asia their import requirement rises almost five times in South-Eastern Asia and 1.4 times in Eastern Asia in 2050 (Table 9).

6.5 Baseline Projections of Malnourished Children

A child is said to be malnourished if her/his weight is more than two standard deviations below the median reference set by the US National Centre for Health Statistics, WHO (WHO, 1997). In the model, the number of malnourished preschool children in developing countries is a function of per capita calorie availability, the ratio of female to male life expectancy at birth, total female enrolment in secondary education as a percentage of the female-age group corresponding to national regulations for secondary education and the percentage of population with access to safe water. These variables were found to be the key determinants of childhood malnutrition in a meta-analysis performed by Smith and Haddad (2000).

Globally the number of malnourished children is expected to go down to 106 million in 2050 from about 150 million children (Table 10). This is a reduction of 30% in the forty year period. India has about 36% of the malnourished children in the world followed by Bangladesh which has about 6% in 2010. Southern Asia, which has about 75% of the malnourished children in the world in 2010, will have about 50% in 2050.

Only after 2020 a considerable drop in the number of malnourished children takes place in India, after 2025 the pace at which malnourishment reduces decelerate leaving about 37 million children to remain malnourished in 2050 (Table 10). Pakistan recovers from malnutrition problem faster than Bangladesh; it will have about 4.6 million malnourished children in 2050 and Bangladesh will have about 6.19 million malnourished in 2050 as well (Table 10). The main reason behind this is that the kilo calorie intake is much higher in Pakistan compared to Bangladesh. This difference increases as the years go by, from 14% in 2020 up to 35% in 2050 i.e. an average Pakistani consumes 35% more kilo calories than an average Bangladeshi citizen per day. Also, the percentage of population with access to safe drinking water reaches 100% in Pakistan in 2015 whereas in Bangladesh it does reach that level even in 2050. By 2040, China will eradicate malnutrition totally from 6 million children in 2010. Indonesia is expected to reduce the number of malnourished chicken from 5.31 million to 2.74 million between 2010 and 2050 (Table 10).

China seems to be much better off in 2050 than any other country in Asia when it comes to malnutrition eradication. South-Eastern Asia reduces its malnourished number by half from 12.2 million in 2010 and Southern Asia by about 25% from 75.6 million in 2010.

6.6 Baseline Price Dynamics

The world price of sorghum is expected to increase between 2010 and 2050; millet prices also rises but after 2041 it moderately reduces. The highest level that millet prices will touch in the next forty years would be $370 per tonne in the early 2040s (Table 12).

In India, producer price of millet reaches $250 per tonne in 2030 and stagnates at that level; producer price of sorghum rises by 21% between 2020 and 2050 from $86 per tonne to $104 per tonne (Table 12).

China, an importer of sorghum and millet is predicted to witness a rise in consumer price of both the cereals; millet follows a steady rise, climbing by 4% from $465 per tonne in 2020 to $487 per tonne in 2050 and sorghum prices rise by about 21% from $168 per tonne in 2020 to $203 per tonne in 2050.

6.7 Summary of Baseline Projections

6.7.1 Millet

Overall the trend in millet area growth is stable (Appendix P). Southern Asia does not exhibit the global trend but a growing trend as regards yield can be observed (Appendix U). So, although the area declines year after year due to shifts in crop area from millet to other competing crops, nevertheless production exhibited an increasing trend. In Southern Asia food demand becomes static, but a growing feed demand for millet can be observed from a low base (Appendix S and Appendix CC). The same trend is observed in Eastern Asia though on a much smaller scale. Except for South-Eastern Asia, all other regions experience a drop in the area under millet but growth in yield levels across all regions in Asia, leads to positive supply trends between 2010 and 2050 in Asia (Appendix T and Appendix U).Southern Asia's feed demand increases at a faster rate than Eastern Asia though its feed demand is at a lower level than that of Eastern Asia (Appendix CC).

Southern Asia exports more than double the quantity of millet in 2050 at 2.7 million tonnes compared to the level in 2010 since India leads in the export of millet in the world with 3 million tonnes in 2050 (Table 9). The imports of millet by Pakistan, Nepal and Afghanistan to the tune of about 0.3 million tonnes (in 2050) of millet in Southern Asia pulls down the export levels in Southern Asia. China has to import millet to satisfy the domestic needs mainly for satisfying feed demand since food demand is predicted to decline (Tables 7, 8 and 9). Due to the low demand of millet in South-Eastern Asia, a significant proportion of the production (about 10%) is exported after 2020 (Table 9).

6.7.2 Sorghum

Globally area and production of sorghum increases over the years (Appendix P and Appendix Q). Eastern Asia has one of the highest yield levels in the world (Appendix X). Southern Asia leads in the production of sorghum in Asia (Appendix W). Southern Asia uses sorghum mainly for food. Eastern Asia uses about half the production of sorghum for feeding livestock and this proportion increases further as we move along the time period. Southern Asia continues to import sorghum till 2050 to narrow the gap between production and demand which is minimal. Though imports by Eastern Asia and South-Eastern Asia are small in magnitude compared to Southern Asia, it forms a bigger proportion of the production than Southern Asia. Sorghum production in Eastern Asia is than that of South East (Appendix W). None of the other regions in Asia show such a high growth in yield trend level as Eastern Asia (Appendix X). Demand for sorghum comes from outside of Asia since the global demand shows a significant positive trend (Appendix Y and Appendix EE).

7 Analysis of Scenario Outcomes

7.1 Optimistic Scenario Projections for Millet

In the optimistic scenario, population and income drivers are set to low and high respectively. This will result in an increasing trend in the per capita income over the years to come. The rates of population and income vary across countries. Better food security projections like increased calorie intake and a drop in the malnourished numbers are expected to come about compared to the baseline projections. The period for which the comparison is made lies between 2000 and 2050. A percentage deviation from baseline projection helps identify the direction and magnitude of the change under each of the two scenarios.

Under optimistic conditions, net trade position of Southern Asia improves whereas that of Eastern Asia and South-Eastern Asia worsens (Table 18). From 2020 onwards, world production and area begins to fall below the baseline projections; global production of millet falls below baseline by 7.4% in 2050; it falls below the baseline by 6.1% in India and in China by 5.1% in 2050. Looking at demand globally, it declines by 2.1% in 2030 and in by 7.4% in 2050 from baseline projections; in India demand falls by 11.6% in 2050 below baseline projections; in China by 3.3% in 2050 (Table 15).

Some countries see a rise in total demand like Afghanistan, Pakistan and Iran in Southern Asia and Philippines, Thailand and Malaysia in South-Eastern Asia. Except for North Korea, Mongolia and Afghanistan, all countries in Asia witness a fall in food demand with India and China having a decline of 12% respectively from baseline projections in 2050 (Table 16).

The positive food demand trend in Myanmar turns negative after 2030 under optimistic scenario (Table 16). Feed demand rises above baseline projections across all countries in Asia (Table 17). In Southern Asia feed demand rises 3.6% above baseline projections in 2050; in Eastern Asia it rises by 4.5%. India continues to export millet under optimistic scenario and its exports are up by 410,000 tonnes in 2050 from 3 million tonnes in baseline projections. China is a net importer of millet under baseline scenario; in 2050 its imports increase by 24,000 tonnes compared to baseline projections because of the rise in feed demand and the fall in production (Table 18).

South-Eastern Asia is a net exporter of millet under baseline projections and its exports go down marginally under optimistic conditions because of the fall in production of millet. Also Myanmar's food demand falls below the baseline much slower than most countries in Asia except for North Korea, Afghanistan and Mongolia and feed demand rises by 2.2% in 2050 from baseline projections under optimistic scenario in South-Eastern Asia which is regionally the lowest increase. So, except for North Korea, Afghanistan and Mongolia millet is an inferior crop in all other Asian countries.

7.2 Pessimistic Scenario Projections for Millet

Production increases above baseline projections in the whole of Asia under pessimistic conditions along with area expansion (Tables 13 and 14). After 2020, globally production improves over and above the baseline under pessimistic scenario (Table 14); it reaches 65 million tonnes about 9.1% above the baseline projections in 2050 (Table 14). In India production increases 7.6% above baseline projections under pessimistic scenario in 2050 and in China by 6.8%. Area expansion takes place at a level of 6.6% globally above baseline projections in 2050. Generally area sown to millet expands under pessimistic scenario 2.5-8% above baseline projections across countries in Asia by 2050 (Table 12).

Global demand for millet goes up under pessimistic scenario after 2020; in India demand shoots up by almost 29% in 2050 above baseline projections (Table 15). Considering food demand alone, India sees the highest demand expansion by 31% in 2050 from baseline projections (Table 16). In China, food demand increases in China by 14% in 2050 from baseline projections. Throughout the time horizon considered, there is a clear and distinct drop in feed demand across all regions in

Asia (Table 16). By 2050, decline in feed demand reaches as high as 12% in some countries but generally ranges between 7-10% from baseline projections.

Though India's export position is retained under pessimistic conditions, it exports about 2.1 million tonnes lower than under baseline projection in 2050 because of increased demand (Table 18). The reduction in import in Eastern Asia is not so high as to change Eastern Asia an exporter (Table 9 and 18).

7.3 Optimistic Scenario Projections for Sorghum

An identical area and production trend is observed across all countries in Asia, where till 2020 the area and production rises above the baseline projections but beyond that period it goes below the baseline projections (Tables 19 and 20), since the difference in per capita GDP over the different scenarios are more pronounced after 2020. As income increases, we can find that there is a tendency for consumers to shift away from the sorghum consumption. Production is driven by demand, so a drop in demand with a rise in income results in less production of the crop.

Demand falls below the baseline projections in a majority of the countries in Asia including India and China (Table 21). Southern Asia being the largest sorghum-growing economy in Asia sees a sharp decline in food demand for sorghum (Table 22). Feed demand rises across all regions up to a maximum of 2.15% which is the case of Pakistan above the baseline projections in 2050(Table 23). Globally this demand is estimated to climb above the baseline by 1.9% in 2040 and by 1.7% in 2050 (Table 23).

The highest percentage of fall in food demand from baseline is seen in South-Eastern Asia wherein by 2050 it falls by 28% followed by Southern Asia and the Eastern Asia with 14% decline respectively (Table 22). So, as we move along the time period, we can observe the rate of decline increasing.

Asia being an importer of sorghum remains the same under optimistic economic conditions except for Southern Asia. India exports 161,000 tonnes in 2030 under optimistic scenario and 900,000 tonnes in 2050 (Table 24). In 2030, China's import reduces by 31,000 tonnes over baseline projections and it imports about 81,000 tonnes less in 2050 (Table 24). In South-Eastern Asia, Papua New Guinea's trade position also improves over the years under optimistic scenario since the domestic food demand falls by almost 28% over baseline projections in 2050 with no feed demand.

7.4 Pessimistic Scenario Projections for Sorghum

When per capita GDP goes down, the consumption of sorghum increases without a proportionate increase in production, worsening the net trade positions in Southern Asia (Table 24). Area and production of sorghum improves from 2040 onwards, until then it lags behind the baseline projections in all regions (Tables 19 and 20). Globally, area sown with sorghum increases by 1.7% above baseline projections; production increases by 2.2% above baseline projections in 2050 (Tables 19 and 20).

Demand for sorghum is higher than that of baseline projections in Southern Asia and Eastern Asia (Table 21). In Southern Asia, it is above the baseline projections by 9% in 2030 and 18.6% in 2050 mostly influenced by the jump in demand in India, Bangladesh and Sri Lanka. In Eastern Asia, North Korea experiences a rise in demand of about 8% over and above the baseline projections under pessimistic scenario in 2050 whereas China does not see such a high increase (Table 21). By contrast, in South-Eastern Asia, the total demand for sorghum falls under both scenarios, under pessimistic this condition is accentuated. Malaysia, Philippines, Thailand and South Korea witness a fall in total demand under pessimistic conditions.

Improved trade positions are found in South-Eastern Asia. This is due to increased production and low demand for sorghum. Imports are lower by about 32,000 tonnes in South-Eastern Asia under pessimistic scenario as against the optimistic scenario where it is 6290 tonnes lower over baseline projections (Table 24). By contrast, Papua New Guinea performs better under optimistic scenario and worse under pessimistic scenario in the South-Eastern Asian region.

As far as feed demand is concerned, under pessimistic conditions, it falls below the baseline projections due to the huge demand arising for food. Asia, in particular, is very fast to change to sorghum consumption unlike the rest of the world.

India’s position is reversed as the highest importer of sorghum in Asia under pessimistic scenario from being the highest exporter under optimistic conditions. China’s imports more than the baseline projections of import but this difference declines as we move along the time horizon i.e. after 2030 (Table 24). Its import stands at 1.3 million tonnes in 2050 (Table 24).

7.5 Malnourishment under Optimistic and Pessimistic Scenarios

There are around 151 million malnourished children in the world in 2010. This number is expected to go down by almost 30% in 2050 i.e., in forty years. Asia has almost 63% of the total malnourished children in the world, out of which India has almost 58% of them. China is projected to completely obliterate malnutrition problem by 2040. The number of malnourished children reduces by 32% in India, 30% in Bangladesh, 39% in Pakistan and 49% in Indonesia from 2010 to 2050. These are the countries that have more than 2 million malnourished children (Table 10). India has about 55 million malnourished children in 2010 and this figure is expected to go down to 31 million in 2050 under optimistic conditions (Table 10). Under the pessimistic scenario, the number of malnourished children decline only to 47.2 million in 2050 from 2010.

Under optimistic conditions, malnutrition reduces by varying degrees across the different regions. Comparing with the baseline projections of 2050, countries which succeed in bringing down these malnourished numbers in the range of 20% and 30% are Bangladesh (20%), Vietnam (20%), Pakistan (24%) and Malaysia (24%) (Table 10). More than 50% reduction in malnutrition number over baseline happens in Myanmar (58%), Papua New Guinea (57%) and North Korea (59%) in 2050. Afghanistan and Mongolia do not have malnourished children by 2050 under optimistic scenario.

Under pessimistic scenario, malnutrition numbers increase in the neighbourhood of 30% over baseline projections in Indonesia, Papua New Guinea, Philippines, Thailand and Vietnam in 2050. Malaysia and Iran witness a surge of more than 45% in their malnutrition numbers in 2050 (Table 10). China is the worst affected and it sees a 141% rise over baseline projections in 2030. Otherwise most other countries experience between 19% and 33% of rise in their malnutrition figures over the baseline figures of 2050 (Table 10). Globally malnutrition is observed to rise under pessimistic and fall under optimistic but the magnitude of the scenario impact is more under pessimistic conditions.

7.6 Food Security under Optimistic and Pessimistic Scenarios

Typically, we find that per capita calories intake improving under optimistic scenario and declining under pessimistic scenario. In India from 2020, per capita calorie intake increases above baseline projection under high income scenario and in Iran it increases by 2030 (Table 11). South-Eastern Asia sees a higher calorie intake in 2050 by almost 32 % from baseline projections followed by Eastern Asia with 27% higher food intake. Countries with low per capita income like Afghanistan, North Korea, Bangladesh, Nepal, Mongolia and Pakistan benefit the most from higher income levels. In 2050, optimistic calorie intake over baseline projections are up by 75% in Afghanistan, 67% in Nepal, 90% in North Korea, 32% in Bangladesh and 133% in Mongolia (Table 11). In most of the countries, the drop in calorie intake under pessimistic scenario does not take place by the same magnitude as the jump in calorie intake under optimistic scenario. China, Vietnam, India, Thailand and South Korea are the countries which are worst affected under pessimistic scenario since the calorie intake diminishes between 8% and 18% when the rise under optimistic scenario is just between 3% and 10%. Regionally, it is Eastern Asia which is worst affected under pessimistic scenario where during the period between 2010 and 2050, the per capita calorie intake is lower by 2% in 2010, increasing along the time horizon to 28% in 2050 (Table 11).

7.7 Summary of Key Findings from Alternative Policy Scenarios

7.7.1 Millet

We find that both sorghum and millet are affected the same way under the two policy scenarios. Since millet is an inferior crop in Southern Asia, its demand goes down as income increases. However this decline is smaller than the quantity of increase in demand when income goes down. The need to satisfy the growing demand for feed uses need not be overemphasized under optimistic conditions. This is due to the increase in demand for livestock products following income increases. In contrast with this scenario, we also find countries importing millet following a jump in demand under lower income levels.

7.7.2 Sorghum

We find that demand for sorghum falls under optimistic conditions and rises under pessimistic conditions just like the case of millet. Feed demand which is a small proportion though responds otherwise and its demand rises under optimistic scenario across all regions. Southern Asia becomes an exporter of sorghum under optimistic scenario. Lower food demand consequently leads to surplus production being exported under optimistic scenario, pushing income levels even higher.

8 Climate Change

Climatic conditions dictate the sustainability and therefore the future of dryland crops. Agricultural production depends on the temperatures and precipitation conditions. Any changes in the prevailing conditions require instant adaption to these changes. Farmers will experience a combination of beneficial effects and adverse effects. The resource poor farmers that typify the SAT might not be able to cope under high risk scenarios. These production fluctuations will reflect in the price levels. This translates into difficulties for national government policy-makers and international trade authorities to facilitate smooth flow of agricultural commodities to satisfy the consumption requirements of the different regions, particularly food aid shipments. The magnitude of the changes in food production and price levels cannot be assessed with accuracy since the pathway of these climatic changes are not easily predictable. To this effect, we develop four different climate scenarios which help in combining the biophysical changes with the socioeconomic modeling. These scenarios represent wetter and hotter climatic conditions than the present conditions by varying degrees. We compare these scenarios with a baseline scenario which assumes the present climatic conditions into the future. The fall in production and yield realisations will provide an idea of the technology investments (like drought tolerant, flood resistant and disease resistant varieties) that need to be made in order to maintain the required production levels.

8.1 Climate Change Drivers

The principal driver of the climate change scenarios are the GreenHouse Gas (GHG) emission levels. The consequences of more concentrations of GHG in the atmosphere will have adverse effects on the climate, but we do not know the range within which these changes will cause fluctuations across all the regions. So we consider two scenarios of GHG emissions- A1B and B1 for each of the two climate scenarios. The Table below shows the changes in temperature and rainfall under the four scenarios between 2000 and 2050. The changes in temperature and precipitation under MIROC are higher than under CSIRO. The CSIRO A1B and B1 scenarios represent a dry and relatively cool future; the MIROC A1B and B1 scenarios represent a wet and warmer future. Each crop is “grown” first with 2000 climate and then with 2050 climate, with identical location-specific inputs. Irrigated crops are assumed to receive as much water as needed so irrigated crop yield effects are driven by temperature only. Yield effects for rainfed crops combine both temperature and precipitation effects. The MIROC-A1B scenario has the greatest increase in precipitation; it tends to result in higher rainfed yields than the CSIRO-A1B scenario in the tropical regions. But it also has higher temperatures, which tend to reduce rainfed yields and irrigated yields.

Table 3 Climate and emission scenarios' global average changes between 2000 and 2050

Climate Scenarios	**GHG Emission Scenarios**	**Precipitation change (%)**	**Precipitation (Mm)**	**Minimum temperature**	**Maximum temperature**
CSIRO	B1	0	0.1	1.2	1
CSIRO	A1B	0.7	4.8	1.6	1.4
MIROC	B1	3.6	25.7	2.4	2.3
MIROC	A1B	4.7	33.8	3	2.8

8.2 Baseline Projections under Rainfed and Irrigated Environments

We observe the patterns of trend of the area, production and yield of the projections, so that an analysis of the deviation from baseline can be made under the four climate scenarios. The period for which this analysis is made is from 2000 to 2050. Moreover, we observe the projections for sorghum grown under irrigated and rainfed conditions separately. Because of the drought tolerant characteristic of the crop, they are mostly grown under rainfed conditions. Therefore we focus more on the projections for production from rainfed lands.

8.2.1 Projections of Area, Yield and Production of Millet

Millet is grown largely under rainfed conditions. By 2050, in Asia, millet yield ranges between 0.28 to 2.24 tonnes per hectare under rainfed conditions (Table 28) and between 1.16 to 5.25 tons per hectare from irrigated area (Table 27). By 2050, Bangladesh, Bhutan, Sri Lanka and North Korea indicate higher yield levels than

China which had the highest yield in 2010 (Table 28). Nevertheless, India has the highest harvested area and production of millet (Table 25 and 26). A contrasting trend is observed within India, wherein the rainfed area cultivated with millet decreases by 27% over time but the irrigated area increases, though by a small magnitude of 3% between 2010 and 2050 (Table 25 and 26). In India rainfed area under millet reduces from 9.8 million hectares to 7.1 million hectare in 2050, which is the greatest largest in Asia (Table 26). Globally there is an increase in the area of millet as opposed to the case in Asia. Yield grows at the rate of 1% per annum under rainfed conditions in India and in China. In India, production increases by 15% in 2050 from 8.4 million tonnes in 2010 (Table 30) whereas in China production increase marginally to reach 982,000 tonnes in 2050 under rainfed conditions. This is entirely due to the yield growth since area decreases in both the countries (Table 26 and 30).

8.2.2 Projections of Area, Yield and Production of Sorghum

The average irrigated yield of sorghum is about 2.8 tonnes per hectare in the world in 2010. This figure increases by 65% in 2050 (Table 27). In rainfed areas, this figure is about 1.2 tonnes per hectare (Table 28), increasing 59% between 2010 and 2050. Generally sorghum yield is found to be higher when grown on irrigated land. Only 8% of the sorghum harvested area is irrigated. China has the one of the highest yields in the world. It has lower yields under rainfed conditions but India has more or less the same yield level under rainfed and irrigated conditions. South-Eastern Asia, Korea and Sri Lanka grow sorghum only under rainfed conditions (Table 29). India has the largest area of sorghum in the world, most of which is rainfed. In India, rainfed yield grows at the rate of 1% per year. In contrast, projections of rainfed area cultivated with sorghum decreases from 8.6 million hectares in 2010 to 6.8 million hectares in 2050 (Table 26). So in spite of a declining area trend, yield growth results in production expanding by 24% between 2010 and 2050 (Table 30). In China, the yield growth in rainfed area does not increase as much as the yield in irrigated area. Yield under rainfed condition grow in varying magnitudes and in 2050, it exceeds 3 tonnes per hectare in Bangladesh, Papua New Guinea, Thailand and China. India is projected to have a yield of 1.3 tonnes per hectare in 2050 from 0.83 tonnes per hectare in 2010 (Table 28). All these projections are under the assumption of no change in climate conditions i.e. the climate that prevailed in the late 20th century is presumed to continue into the 21st century also.

Production shows an increasing trend, but at a decreasing rate. Production from irrigated land forms a small part of the total production (about 13%). In 2050, production from rainfed lands is expected to go up by 90% from its level of 52 million tons in 2010 globally (Table 30). China and India increase their production by 8% and 24% respectively. India is estimated to produce 8.9 million tons of sorghum in 2050, followed by China which is projected to produce 1.3 million tons, both under rainfed conditions.

8.3 Description of Climate Scenarios

We consider two scenarios- MIROC and CSIRO. To each climate scenario, there are two GHG (Green House Gas) emission scenarios being applied. These climate scenarios do not reflect the regional variability and the accurate seasonal patterns. CSIRO-B1 scenario simulates temperature changes without any change in precipitation. Going by precipitation changes alone, this is the worst case scenario since it has the lowest precipitation levels. Considering temperature increases also, MIROC-A1B is the one with the largest temperature jump. We do not have a scenario with decreasing precipitation changes. MIROC scenario simulates higher average precipitation levels globally. The GHG emission levels are indicative of the CO_2 concentrations in the farmers' field. A1B emission scenario has a growth of 1.51% in average annual precipitation level between 2000 and 2050 and B1 has an increase of 1.65% for the same criteria.

Under MIROC- A1B scenario, annual minimum temperature increases by 3^{0}C on an average globally and maximum temperature by 2.8^{0}C, which constitutes the highest increase in temperature among the four scenarios. Under CSIRO-B1, minimum temperature increases by 1.2^{0}C and maximum temperature by 1^{0}C which represents the lowest change in temperature among the scenarios. Sorghum and millet being drought tolerant crops, the extent to which they will be affected by these changes are not expected to be high.

The positive effect of climate change will be reflected by an increase in yield and production and the negative effect by a fall in yield and production. The change is calculated from the baseline results discussed above. Baseline results do not incorporate any change in temperature or rainfall. The changes may not be identical across all regions within Asia, so the analysis that follows will discuss the regional differences that exist in the regions' response to climate change.

8.3.1 Climate Scenario Projections for Millet

MIROC scenario represents a wetter and warmer climate than CSIRO climate scenario. The focus is on rainfed yield here mainly because of the fact that coarse cereals are mostly grown under rainfed conditions. So, more precipitation and higher temperature favour high productivity of millet globally (Table 43). Under MIROC scenario, MIROC-A1B proves to be suitable for millet cultivation since the yield increases above the yield figure by as much as 13% in 2050 (Table 34). In 2030, global rainfed yield of millet is about 8% higher under MIROC-A1B than under the baseline projection (1.3 million tonnes) (Table 28), as opposed to just about 1% higher under MIROC-B1 scenario (Table 34). Again, under MIROC-A1B, the yield increases vary from region to region. We know that yield levels are higher in Eastern Asia than in Southern Asia (Table 28). In the same way, under MIROC-A1B Eastern Asia has advantage over Southern Asia wherein China has double the yield increase as that of India under rainfed conditions over the projection period (Table 34). Iran, Sri Lanka and Pakistan see fall in rainfed yields over the years under MIROC-A1B scenario (Table 34). Interestingly, unlike MIROC-A1B, MIROC-B1 increases the rainfed yield of Pakistan and Sri Lanka over the years and they turn out to be the highest country–level increase under MIROC-B1 (Table 34).

CSIRO- scenario does not help increase the yield levels of India and China, the two big producers of millet in the world. Under CSIRO-A1B, there is a marginal increase in rainfed yields of millet in China, whereas under CSIRO-B1, it drops close to 1% in 2050 compared to the baseline yield projections for China over the years. None of the CSIRO scenarios improves the yield levels of India and fortunately the yield decrease is marginal hitting a maximum of 1% in 2050 (Table 34).

Except for India and China, all other Asian countries witness varying levels of increases in rainfed yields. Particularly notable are Iran , Sri Lanka and Pakistan, where yields increase about 2% over baseline in 2030 and about 4% in 2050 (Table 34) under CSIRO scenario.

When it comes to area changes under climate scenarios, CSIRO scenario does not have much impact; though the deviation is invariably negative (Table 32). Again our focus is on rainfed areas. MIROC-A1B affects the area cultivated with millet differently at the global level and in Asia. At the global level, MIROC-A1B tends to decrease the area under millet, by close to 13% in 2050 (Table 32) whereas in South and Eastern Asia, it significantly increase the area under millet cultivation. India is found to increase its area under millet by 4% in 2020 and then by 11% in 2050 (Table 32) under MIROC-A1B compared to the baseline projections. China is projected to increase its area under millet by more than 10% from 2030 onwards, reaching 17% over and above the baseline projections in 2050 (Table 32).

MIROC-B1 impacts area under millet cultivation in different ways across different parts of the world (Table 32). Globally it marginally increases the yield level over the years to come (Table 32). It decreases the area under millet in China and in India by less than 1% (Table 32). Iran and South Korea are relatively affected more than other countries in Asia.

Production improves in Asia under all climate scenarios except for CSIRO-B1 (Table 36), though the decrease is only marginal (Table 36). MIROC scenarios have positive impact in production in India and China. Under MIROC-B1, India sees an increase in production by a few percent points, but under MIROC-A1B, but sees much larger increases of 20% in 2040 and 25% in 2050 over the baseline projections in the respective years. China realises an increase of 28% in 2030 and 53% in 2050 over baseline production figures (Table 36) under MIROC-A1B.

8.3.2 Climate Scenario Projections for Sorghum

The pattern of yield changes of sorghum under the four climate scenarios is similar to that of millet yield changes. Generally Asia is better off under MIROC climate scenario than under CSIRO scenario (Table 40). In Southern Asia, yield increases as high as 11% in 2050 under MIROC-A1B over the baseline scenario (Table 40). In Eastern Asia, China and North Korea see a surge in sorghum yields by about 13% in 2030 and about 24% in 2050 under MIRCO-AIB compared to the baseline projections (Table 40). South Korea also experiences significant yield increase at around 12% in 2050 under MIROC-A1B over the baseline scenario projections (Table 40). Sri Lanka, Thailand, Pakistan and Papua New Guinea witness a drop in yield level over baseline scenario under MIROC-A1B.

Except for Thailand, yield levels under MIROC-B1 increase at around 3% in 2040 and 2050 in Eastern Asia and at around 6% in Southern Asia over baseline scenario. India is the only Asian country whose yields are negatively impacted by

CSIR0 climate scenario. South-Eastern Asia and Eastern Asia witness a rise of 2% and 1% respectively in sorghum yields under CSIRO-A1B and even lesser under CSIRO-B1 scenario.

Area under sorghum expands under CSIR0 scenario marginally across all countries except for South Korea (Table 38). MIROC-B1 scenario affects area under sorghum marginally through the globe. MIROC-A1B impacts China and India positively, raising sorghum yields by 8% and 12% in India and China respectively.

Production is not as much affected by CSIRO-scenarios as MIROC. It marginally reduces in India but it increases elsewhere leaving production at more or less the same level as baseline (Table 42). Thailand is the only Asian country whose production falls in MIROC-B1 scenario (Table 42) by almost 5% in 2040 through 2050, relative to baseline. MIROC-A1B provides promising results for Asia particularly for Southern Asia and Eastern Asia. Production in China rises over and above baseline projections under MIRCO-AIB scenario in 2030 by 21% and in 2050 by 39%. North Korea and South Korea also witness their production soar above baseline by 28% and 13% respectively in 2050. India and Pakistan find their sorghum production increase by the same magnitude at about 13% in 2030 and 21% in 2050 (Table 42). MIROC-A1B pulls down the production level in South-Eastern Asia by about 8% in 2050.

8.3.3 Changes in price level under Climate Scenarios

Under baseline projection millet prices rise by 12% from $324/tonne in 2010 to $364/tonne in 2050 (Table 43). Climate change causes millet prices to rise even further across the entire time horizon. The price rise is highest under MIROC-A1B wherein prices rise by 5% in 2030 over baseline projections and by 9% in 2050 (Table 43). In all other scenario, about a 3% hike is expected in 2030 and 5% in 2050 from $365/tonne and $364/tonne respectively. This is in contrast to the high production levels under the scenario.

Even without climate change, sorghum prices rise by 32% from $115/tonne in 2010 to $152/tonne in 2050. In 2050, MIROC-A1B causes sorghum prices to rise by 7% over and above the baseline.

8.3.4 Comparative analysis with maize under climate change

Climate change affects the yield levels of different crops differently due to the nature of the crop. Since climate change is already unfolding as predicted, several adaptation strategies are sought to mitigate its effects on the well-being and livelihood of the people across the globe. Of the coarse cereals grown in the world, maize is currently cultivated on the largest area. It enters the food chain directly and indirectly as feed for livestock. It is therefore worthwhile comparing the effects of potential changes in yields in maize vis-à-vis sorghum and millet, which are close substitutes, in order to draw up effective and well-targeted mitigation strategies. Comparing the yield changes of maize, millet and sorghum under the different climate scenarios, we find that millet and sorghum are less affected than maize. Maize yields deviates negatively from baseline by as much as 15% under MIRIOC-A1B, 6% under MIROC-B1 and by around 1% under CSIRO scenario (Table 45). Under CSIRO scenario, millet and sorghum yields are lesser by 0.3% over baseline scenario, which is on the lower limit. Likewise under MIROC-BI scenario the changes are upwards by about 1% for millet and sorghum compared to the baseline.

The most optimistic results are shown by MIROC-A1B, where yield of sorghum and millet increase in Southern Asia by 13% and 15% respectively in 2050. Therefore, millet and sorghum are much more adaptable under climate change compare to maize.

Area expansion under MIROC-A1B scenario in the case of maize is quite significant in 2050 at around 15% (Table 44) globally but due to yield decline, production consequently drops by 10% under MIROC-A1B and 7% under MIROC-B1 in 2050 (Table 48). Globally we find millet and sorghum production going up and maize output climbing down under all scenarios except for MIROC-A1B (Table 46).

9 Conclusions and Policy Implications

The future of dryland agriculture will depend on changes in supply and demand patterns for dryland commodities, which in turn depends on technological improvements, price fluctuations, income levels and government interventions. Historical trends suggest that area cultivated with dryland crops has been declining because of the rise in income levels and shift in choice of crops. However, the productivity gains have resulted in increasing the supply levels. Government trade policies also play a key role in shifting the demand to other crops through price level changes and increasing the availability of substitute crops by removing the import restrictions. Understanding the influence of the different factors of bio-physical and socio-economic nature that affect crops one at a time is important to make systematic assessment of the future of dryland cropping systems. Thus the impact of alternative policies on the future of dryland agriculture and the livelihoods that depend on them can be made under varied combinations of the key 'drivers'. The scenarios considered here help understand the implications of the socio-economic policies on the demand of dryland crops and hence on the production decisions taken to satisfy them. In case of a slump in the demand of dryland crops, the intervention of the government to improve the demand situation would make a significant difference to the future of dryland commodities and livelihoods that depend on them. Food security and alleviation of malnutrition being the main concern of developing economies in the light of growing low-income populations, the emphasis on dryland agriculture would go a long way in securing the wellbeing of the people.

The use of the IMPACT model in this study has been to identify the key trend in the historical and future growth of dryland agriculture and the important drivers that underlie each of the plausible futures. This has expanded the range of analysis and the critical linkages between economic growth, agricultural productivity, trade and market policies and the consumption of these crops as food and feed has been examined. However it is important to note that there are some limitations inherent in the model. Since IMPACT is a partial equilibrium model, there is no feedback effect from or to other sectors of the economy; agriculture is the only sector that is considered in the economy. Production level of crops is not calculated from equating marginal cost and revenue but from yield levels and land area under cultivation. Imposition of taxes and subsidies are at the national level which does not represent the actual structure of taxes and subsidies. Due to lack data on rural and urban income elasicities, consumption is calculated based on an average figure for elasticity and then divide into rural and urban consumption based on the respective populations.

The results from our analysis has shown that dryland commodities will continue to play a key role in the food security of the growing population in developing countries directly as food and in livestock production to meet the demand of milk and other products. The usage of sorghum and millet as feed crops seem to continue in the future as it has in the historical trends. With maize performing worse under both

CSIRO and MIROC climate scenarios, sorghum and millets can provide a credible alternate to meet the anticipated growing demand in livestock and related products.

There is a wide variation that is observed in the response of area, production and demand of dryland crops under the different scenarios. Some of the changes have been consistent with our expectations mostly driven by market price response and substitution effects.

The expected substitution effect is predicted to happen toward higher 'quality' foods and also an induced demand for these crops in other usages as feed. Productivity growth has resulted in securing the wellbeing of the people and also in improving the competitiveness of the other crops. The consumer prices seem to come down as a result of production exceeding demand under optimistic scenario. Investment in market infrastructure will go a long way in reducing the marketing costs and reduce the consumer prices further. Trade protectionism will only aggravate the problems of price increase when import prices are much less than the domestic production costs.

We cannot conclude that that reduced consumption of dryland cereals will result in reduced calorie intake since only a small portion of the nutrition requirements are met from these two crops in Asia. The income driver does influence the consumption patterns of the crops under different scenarios. We find that dryland crops are utilized in some way or the other as either food or feed under entirely opposing scenarios. Therefore we can rest assured that even if food demand goes down drastically, we can find other avenues by which the crop can be usefully consumed with the help of the government policies and technological investment in industrial infrastructure.

Under climate change, for both sorghum and millet, a warmer and wetter climate is represented by MIROC proves to be favourable for increased output. Compared to maize, a substitute for millet and sorghum, the latters' yield is affected by just about 0.3% under CSIRO on the downside which is lesser relative to the yield decline of maize.

MIRCO-A1B shows opposing results for maize on one hand and sorghum and millet on the other. Maize yields fall by as much as 22% in 2050 over baseline scenario globally while sorghum and millet yield rises by 5 % and 13% respectively in 2050. Under any of the climate scenarios millet and sorghum proves to be more resilient than maize, in fact even performing better under certain scenarios.

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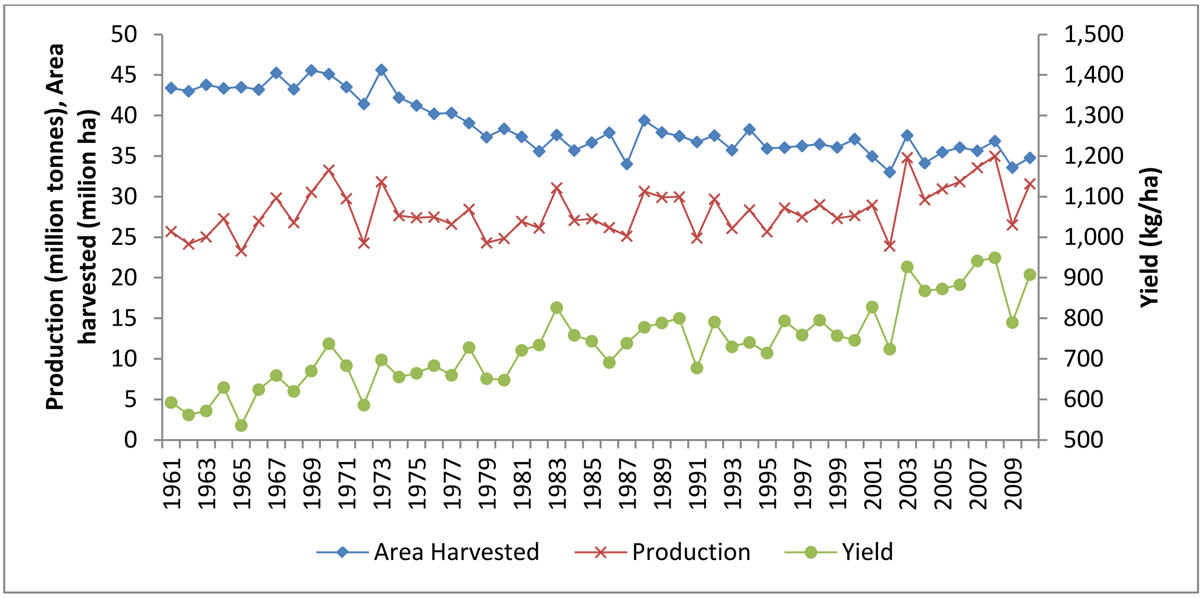
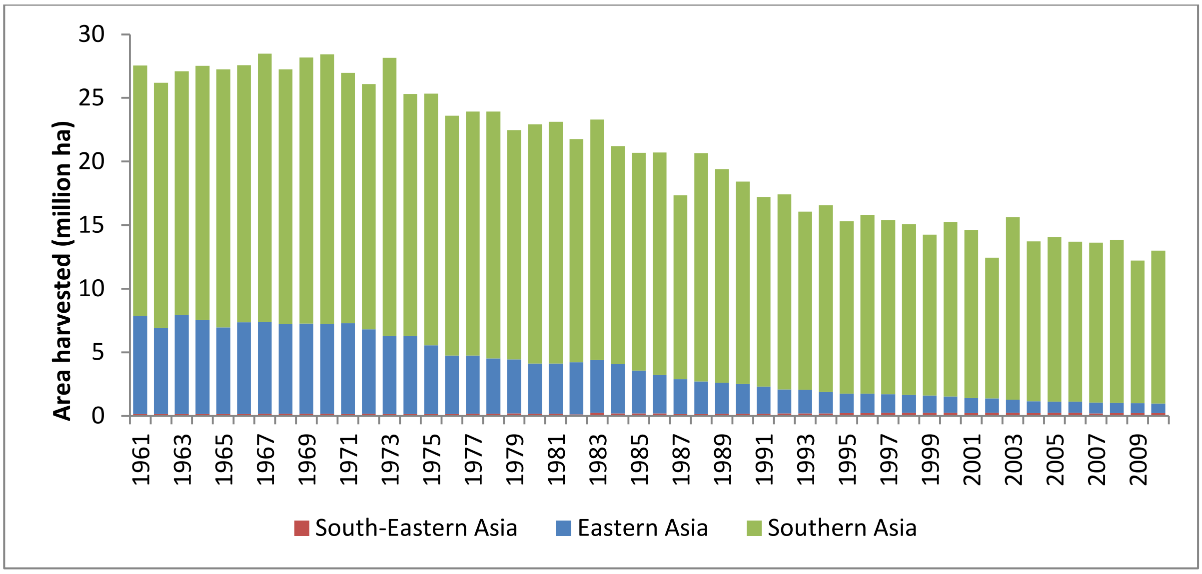
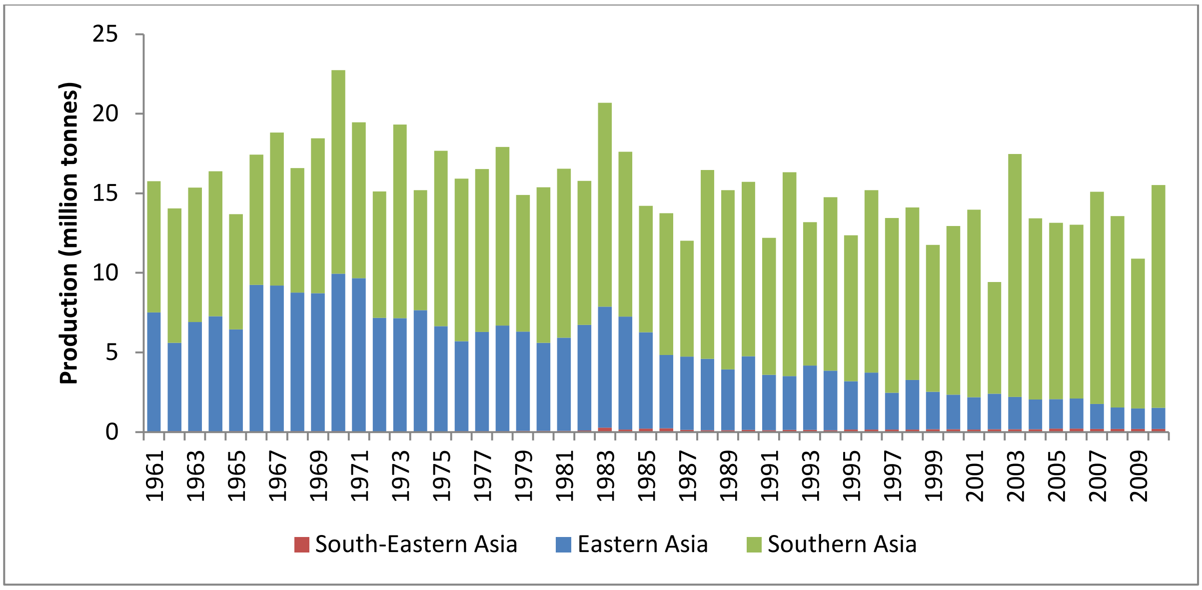
Appendixes



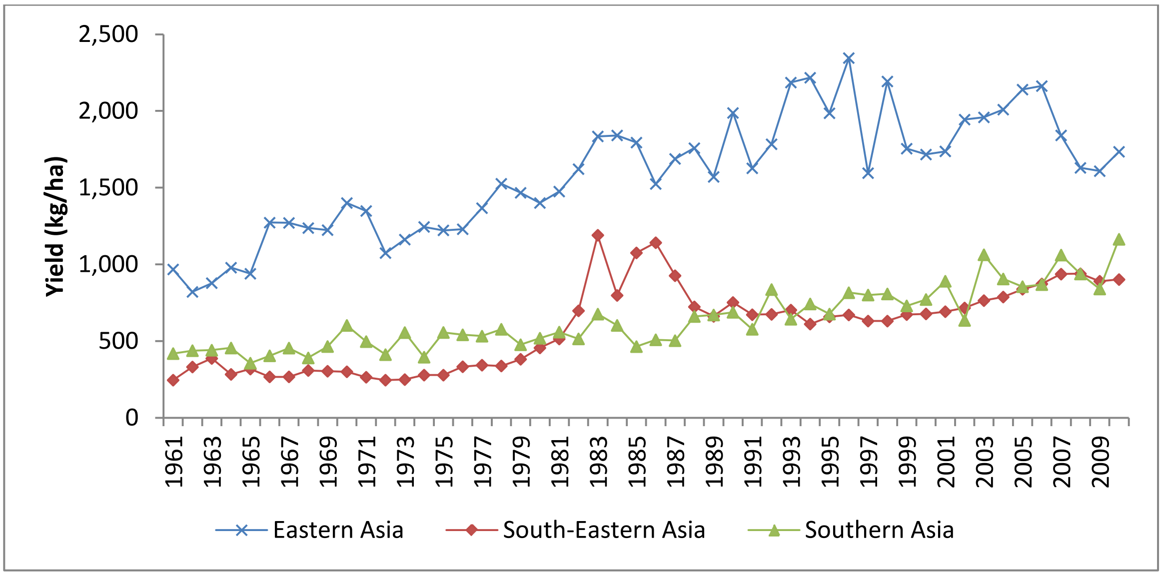
Appendix A Global trends in millet area, production and yield between 1960 and 2010



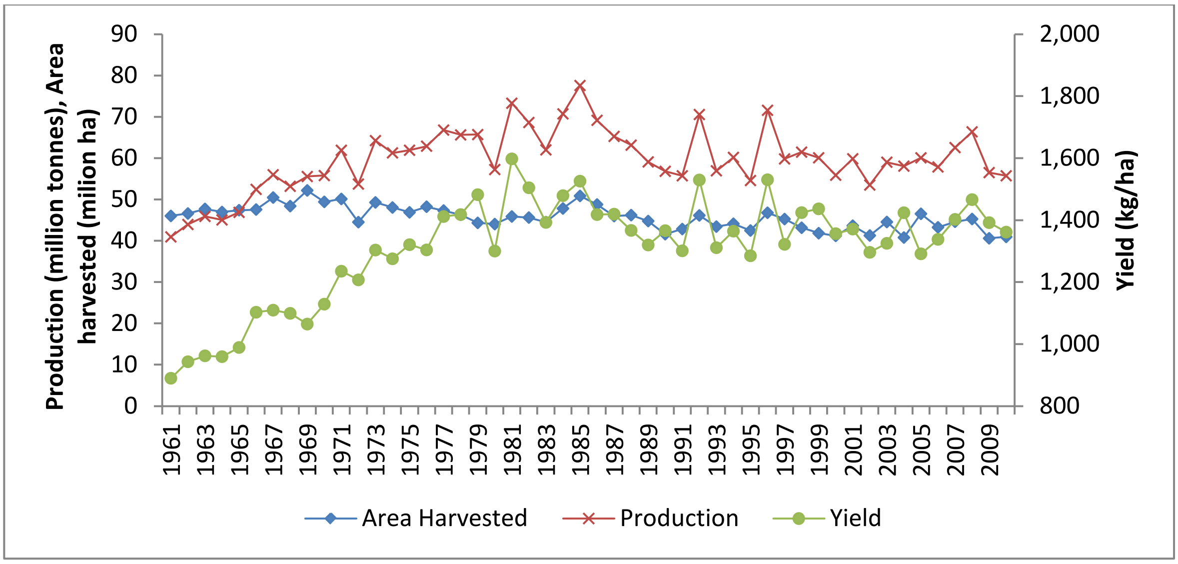
Appendix B Trends in millet area between 1960 and 2010 in Asia



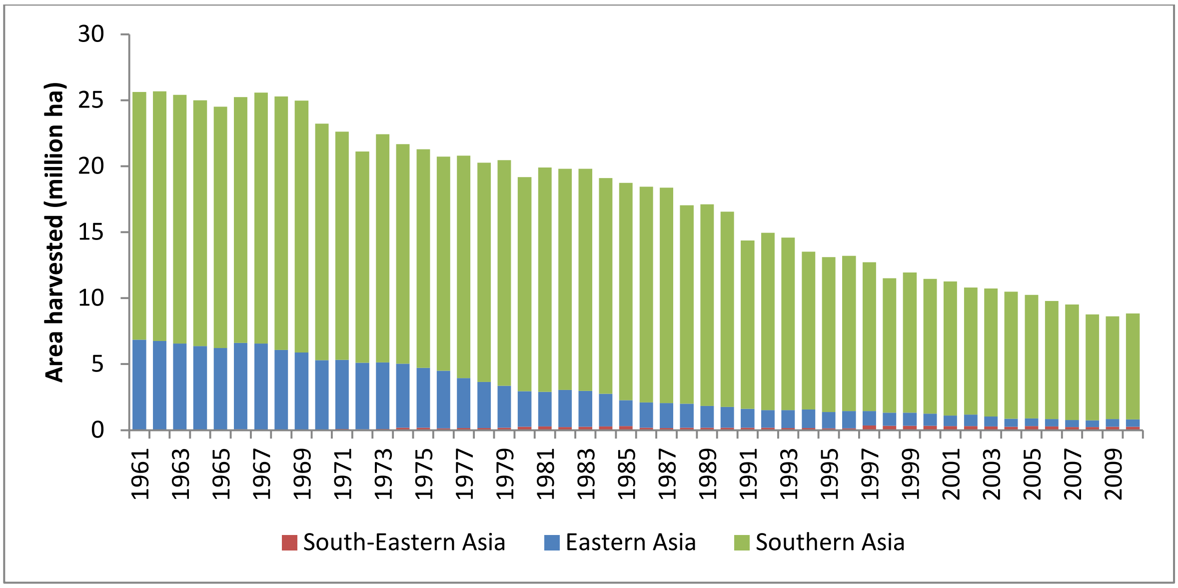
Appendix C Trends in millet production between 1960 and 2010 in Asia



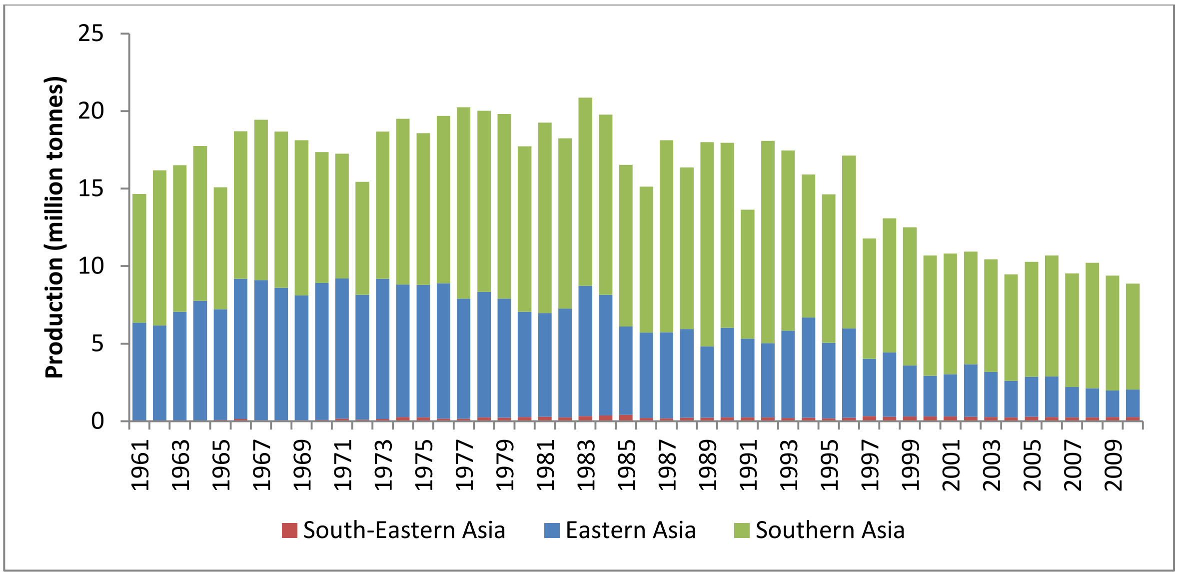
Appendix D Trends in millet yield between 1960 and 2010 in Asia



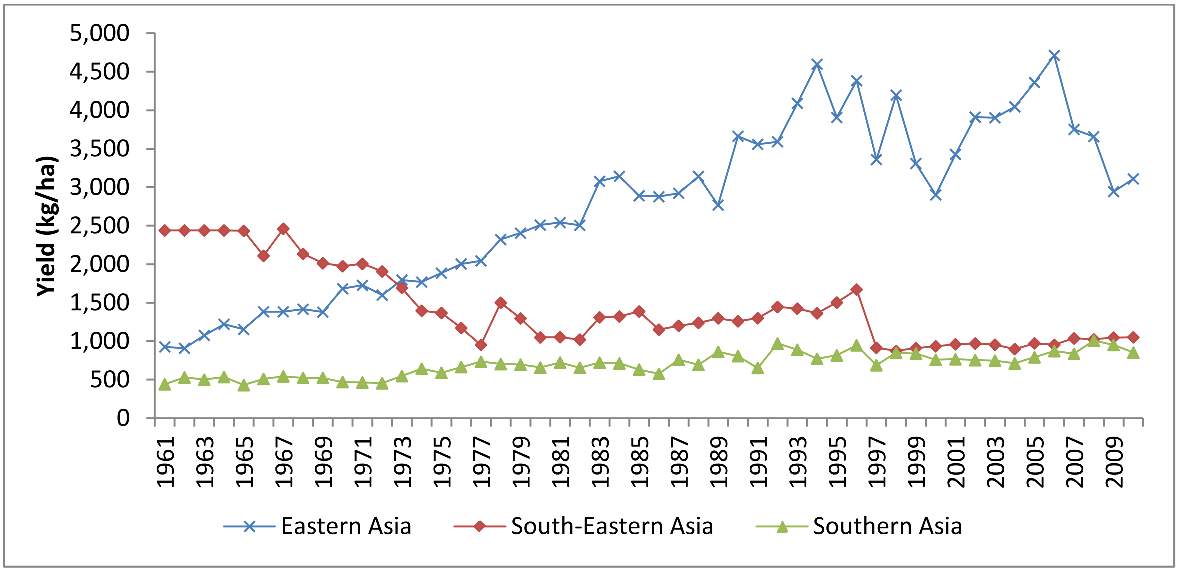
Appendix E Global trends in sorghum area, production and yield between 1960 and 2010



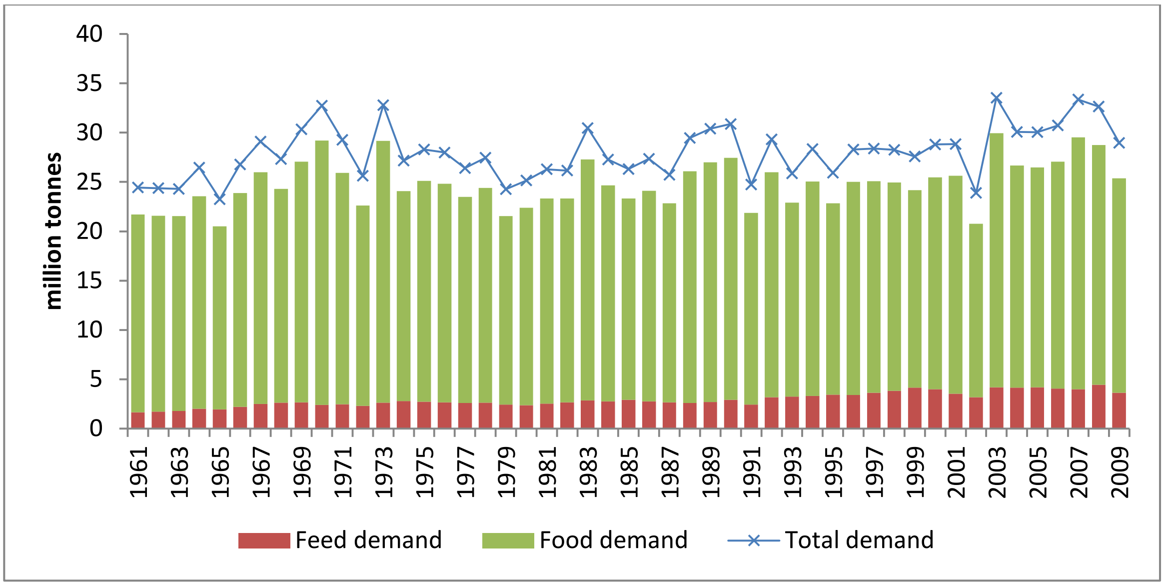
Appendix F Trends in sorghum area between 1960 and 2010 in Asia



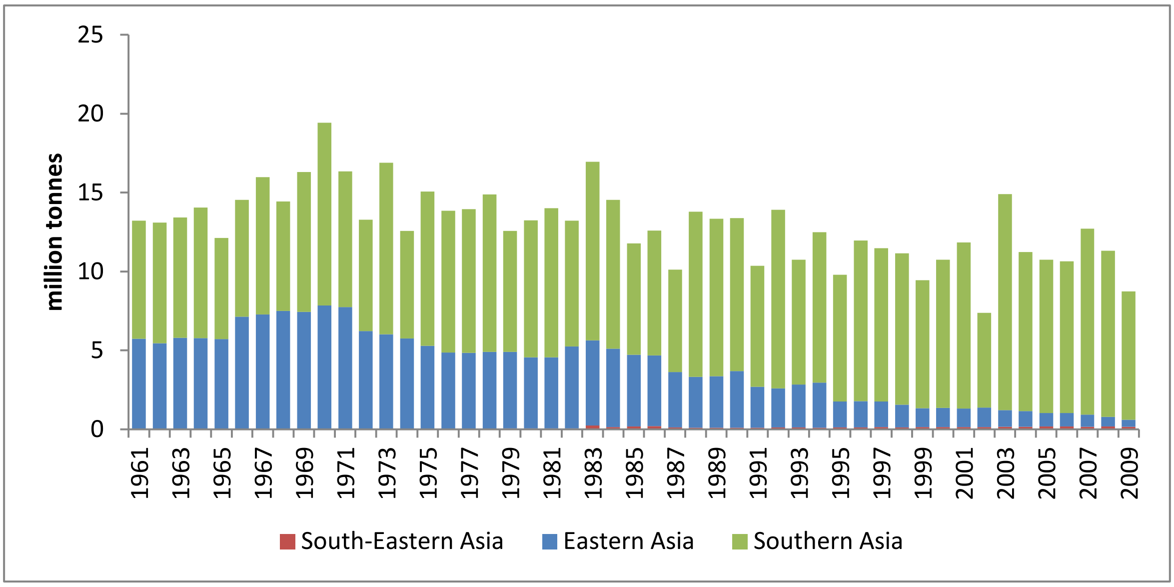
Appendix G Trends in sorghum production between 1960 and 2010 in Asia



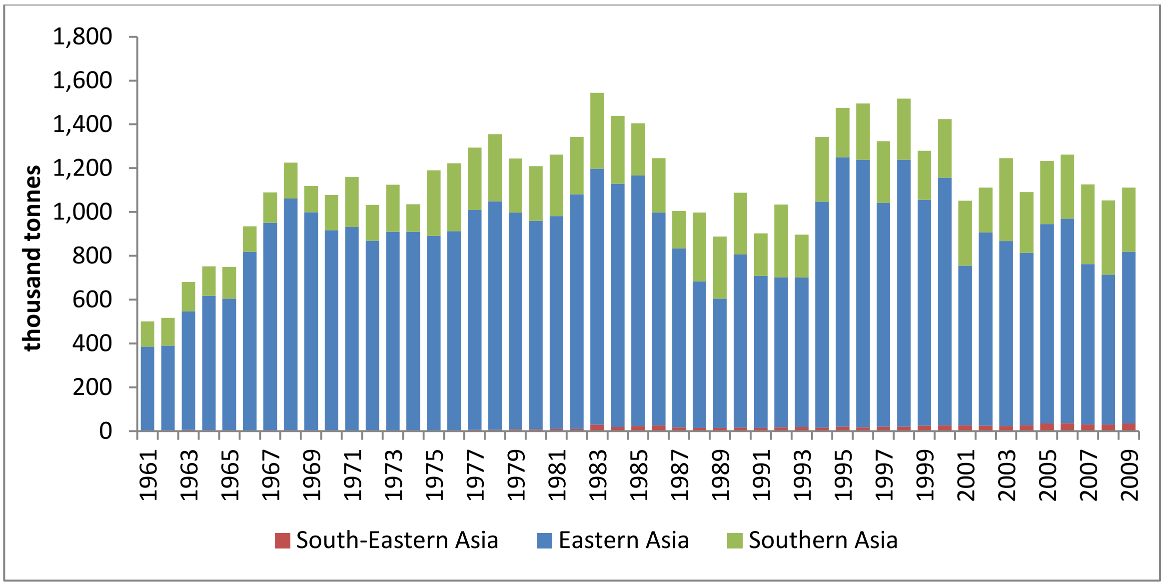
Appendix H Trends in sorghum yield between 1960 and 2010 in Asia



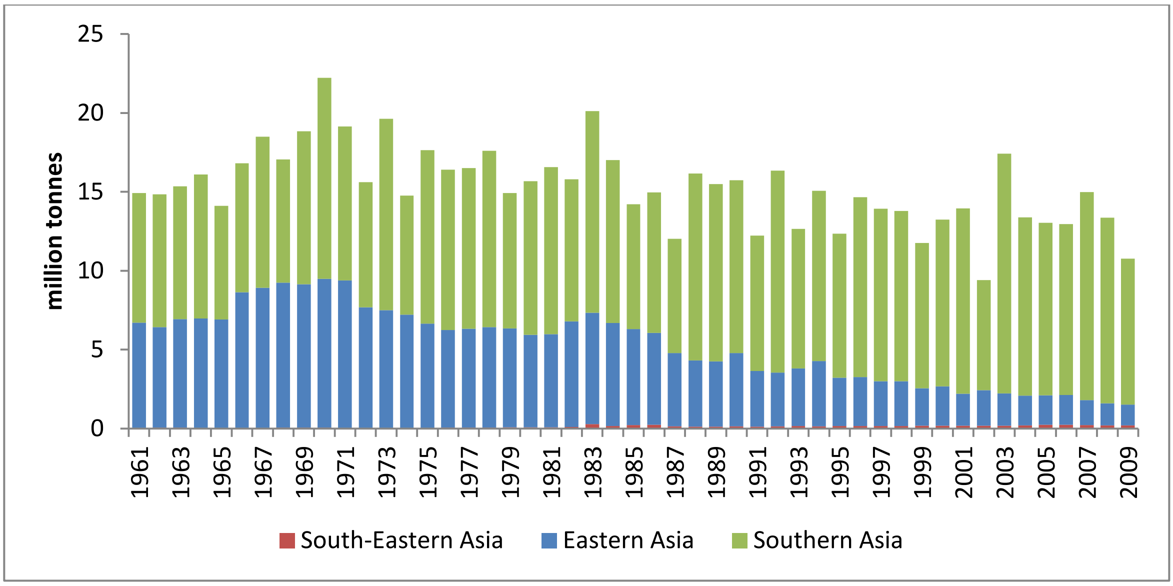
Appendix I Global trends in utilization of millet between 1960 and 2010



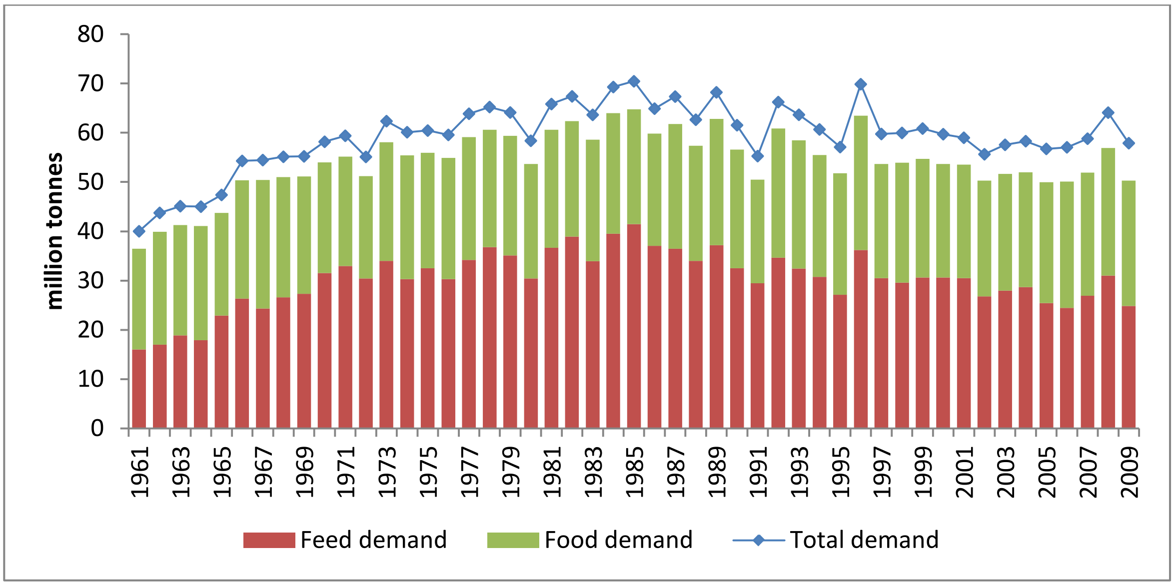
Appendix J Trends in food demand for millet between 1960 and 2010 in Asia



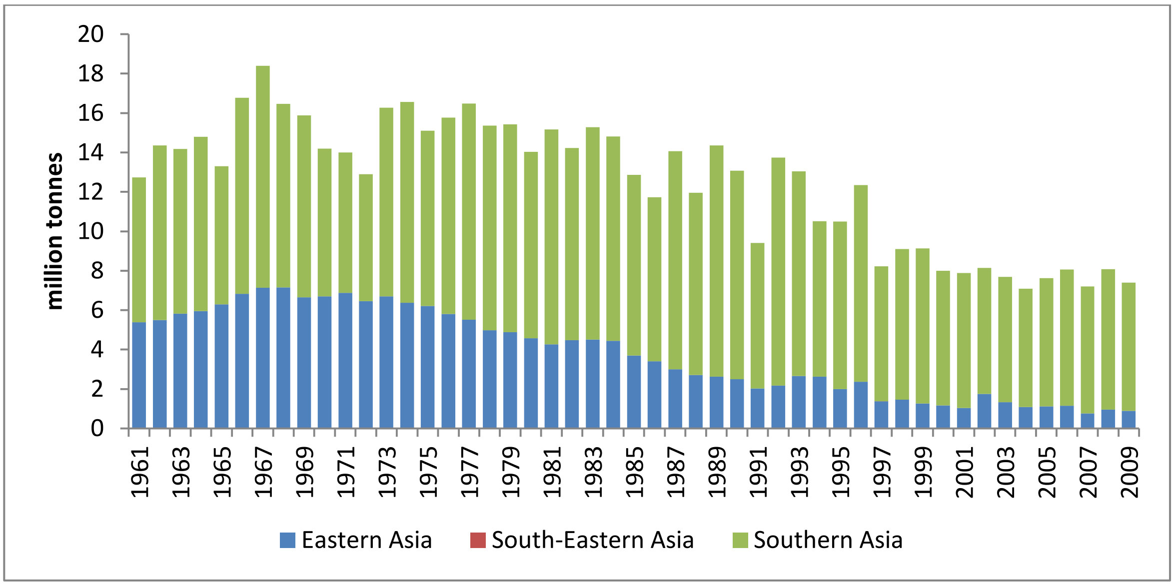
Appendix K Trends in feed demand for millet between 1960 and 2010 in Asia



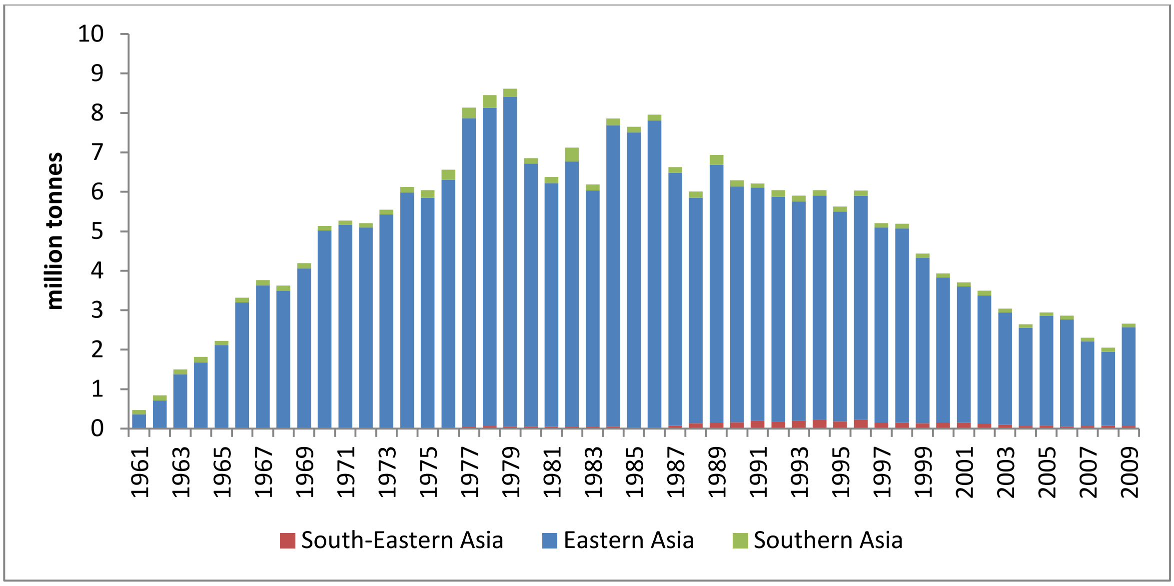
Appendix L Trends in total demand for millet between 1960 and 2009 in Asia



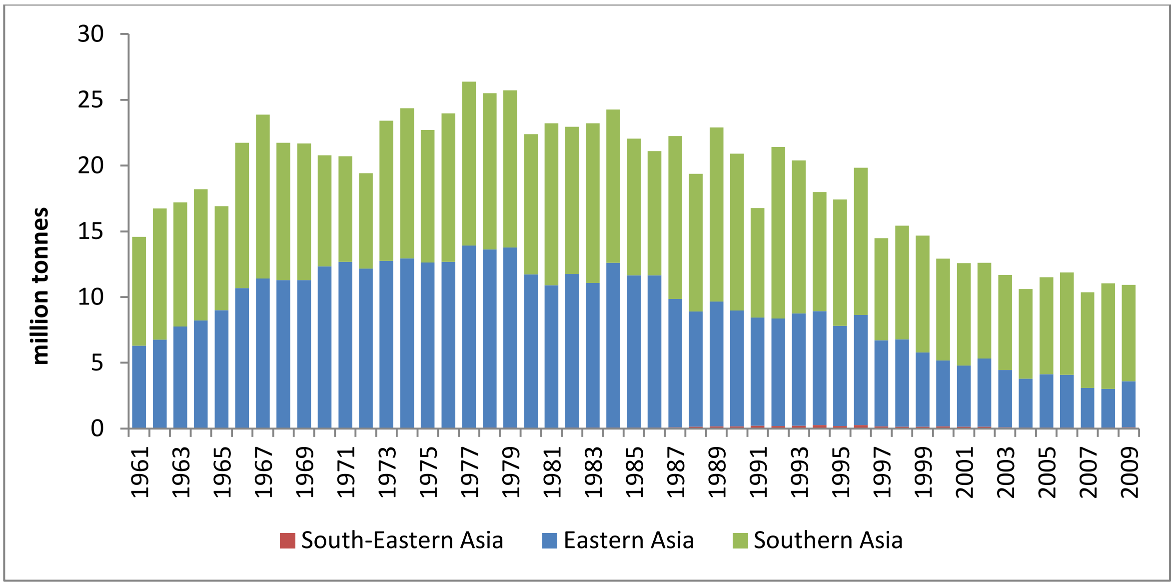
Appendix M Global trends in demand for sorghum between 1960 and 2010



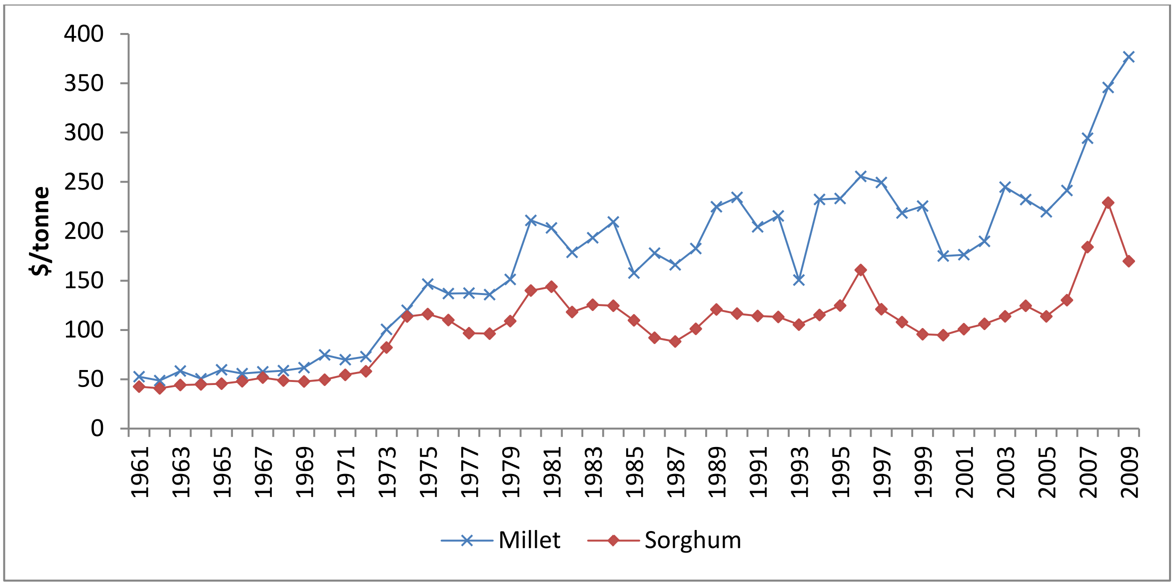
Appendix N Trends in food demand for sorghum between 1960 and 2009 in Asia



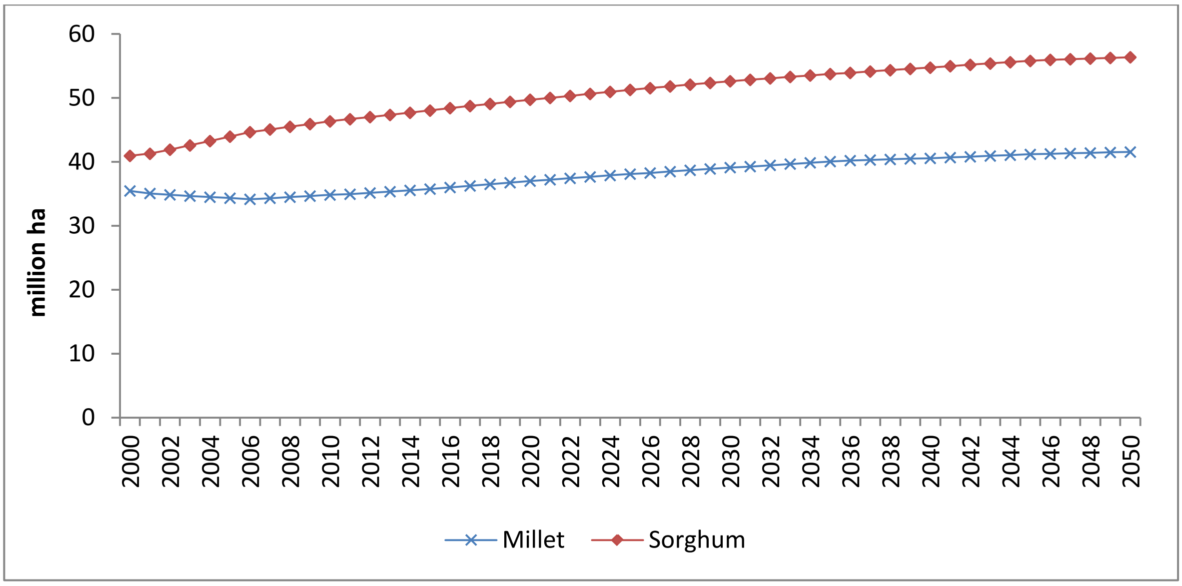
Appendix O Trends in feed demand for sorghum between 1960 and 2009 in Asia



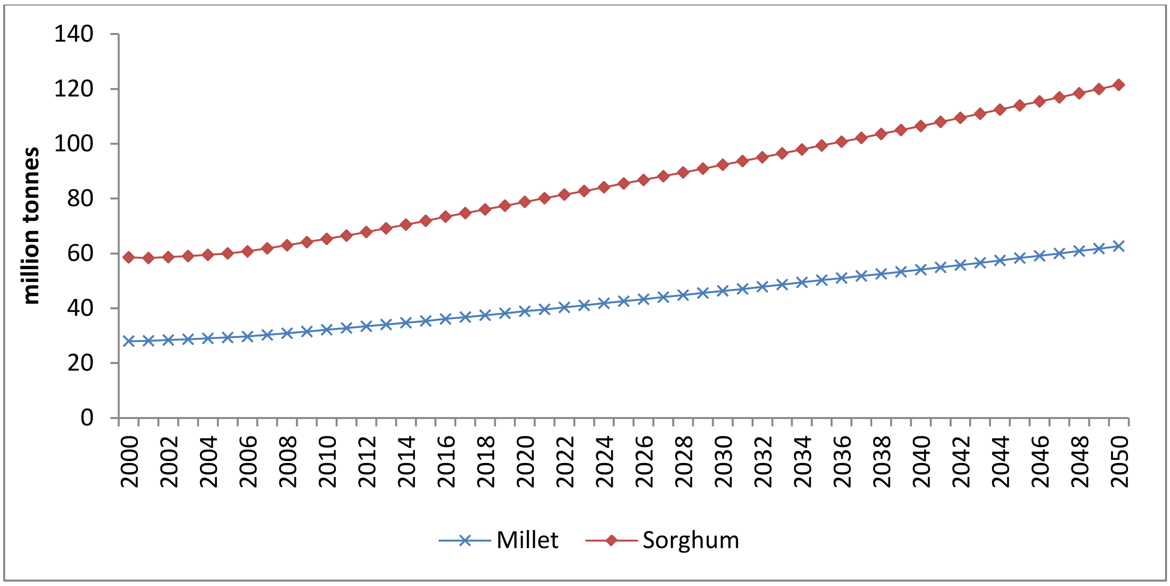
Appendix P Trends in total demand for sorghum between 1960 and 2009 in Asia



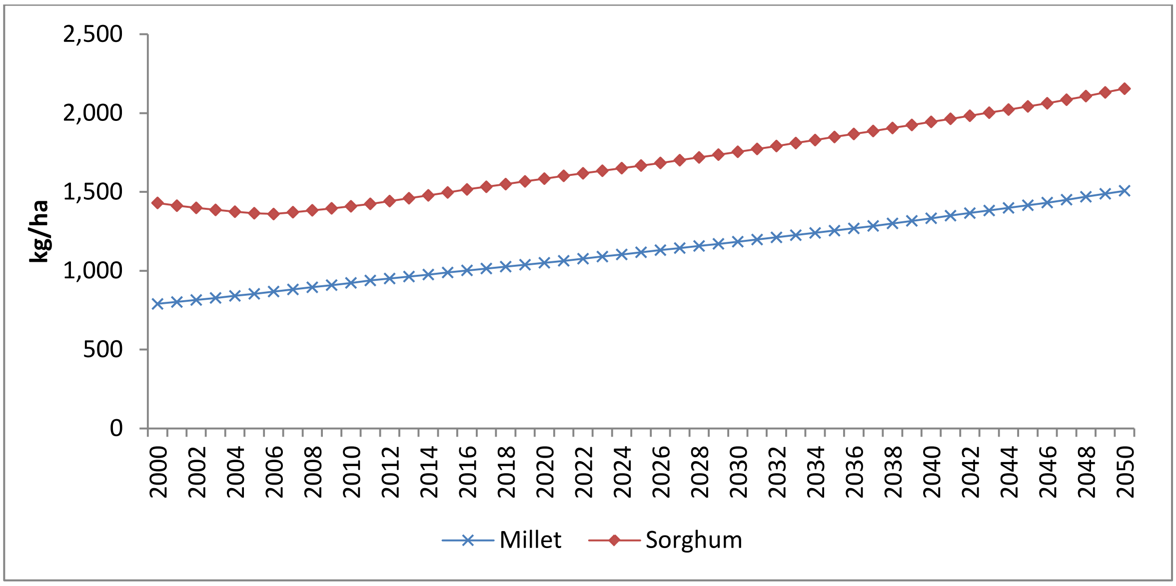
Appendix Q Trends in export prices of sorghum and millet between 1960 and 2009



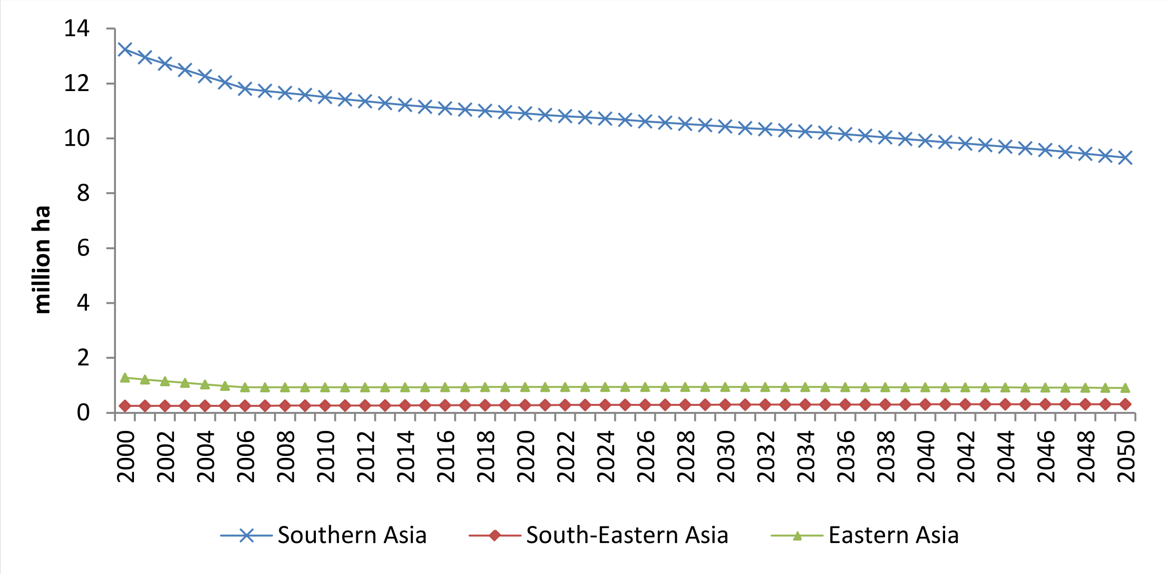
Appendix R Global area projections for sorghum and millet from 2000 to 2050



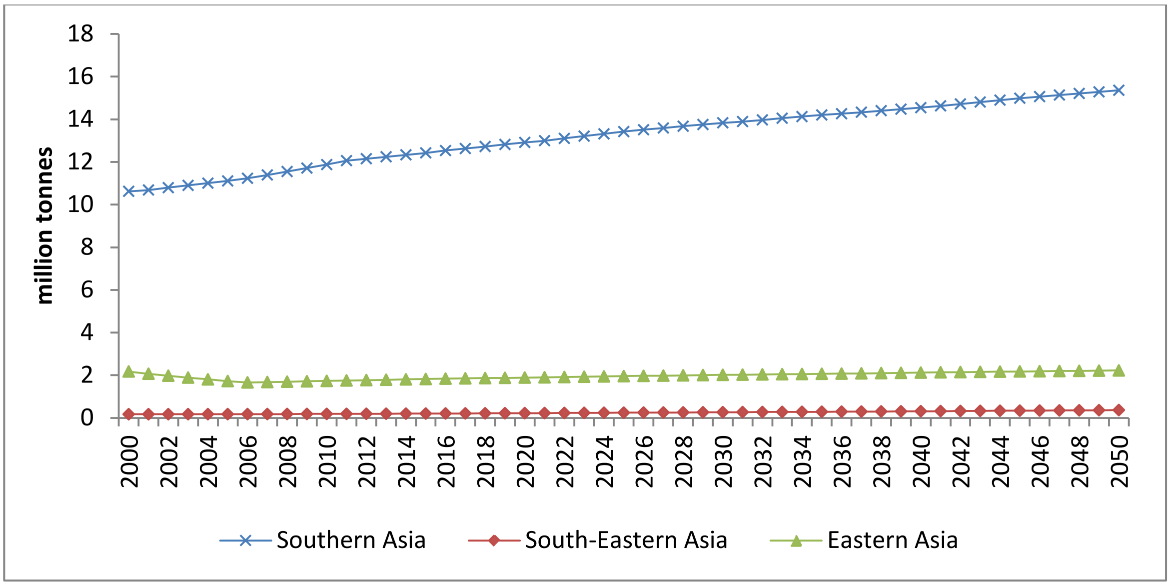
Appendix S Global supply projections for sorghum and millet from 2000 to 2050



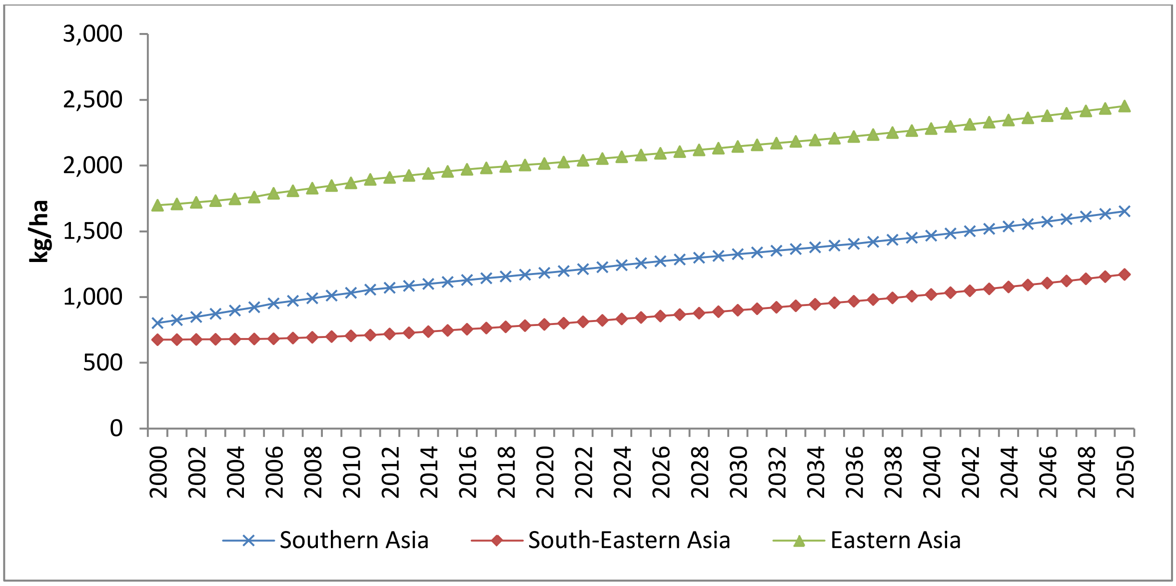
Appendix T Global yield projections for sorghum and millet from 2000 to 2050



Appendix U Millet area projections for Asia from 2000 to 2050



Appendix V Millet supply projections for Asia from 2000 to 2050



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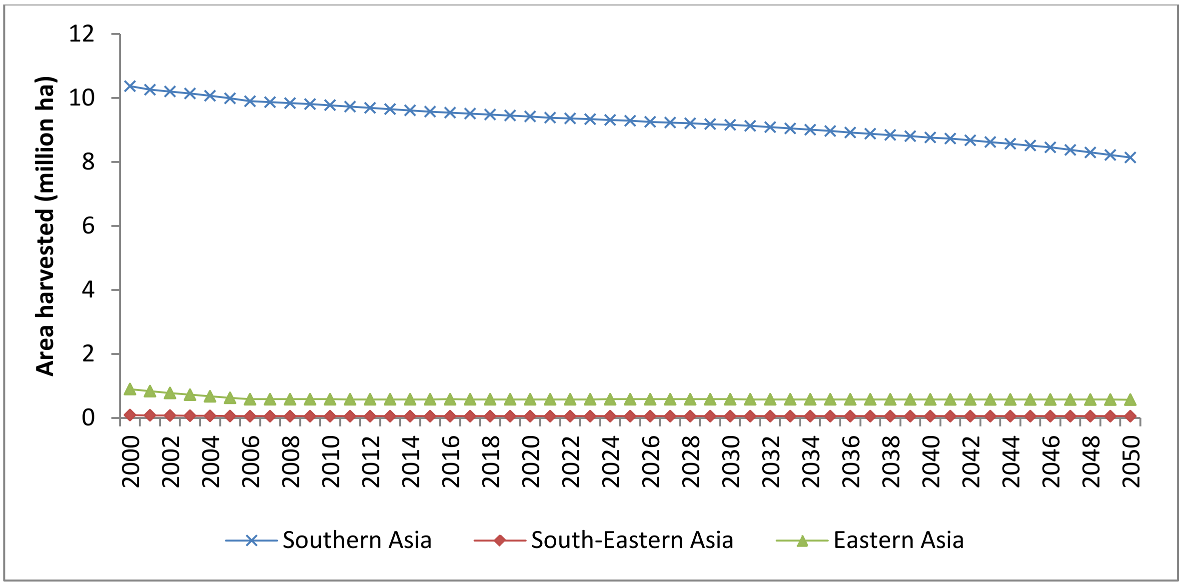
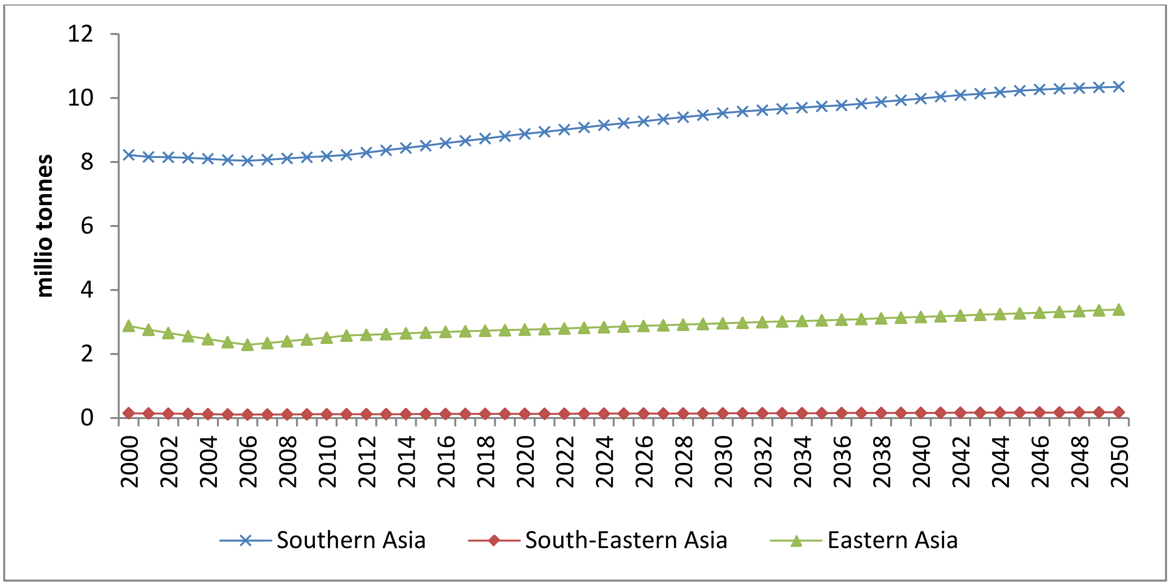
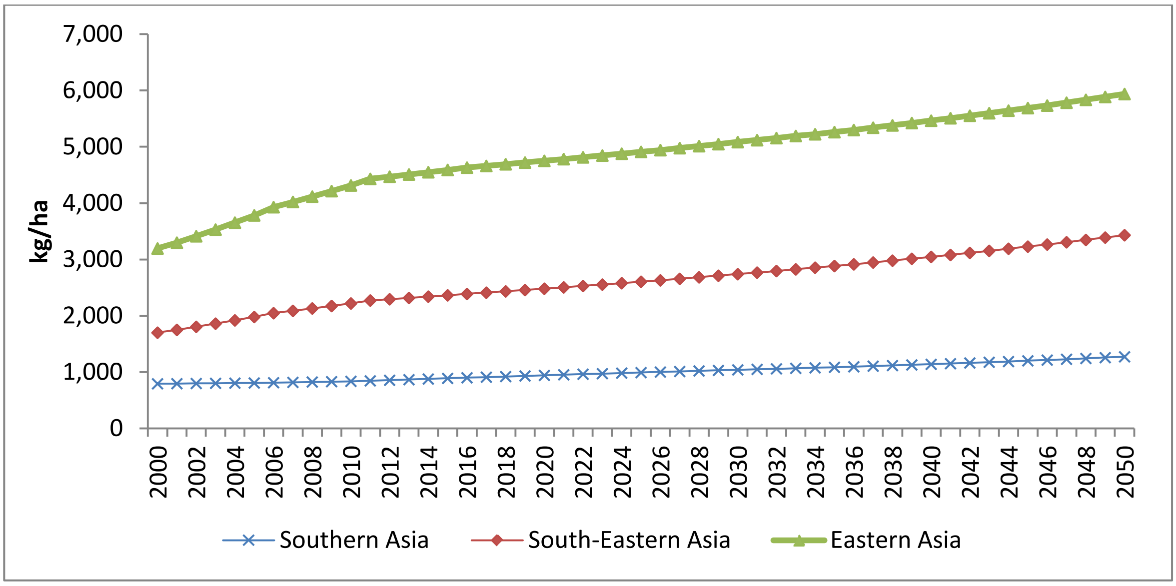


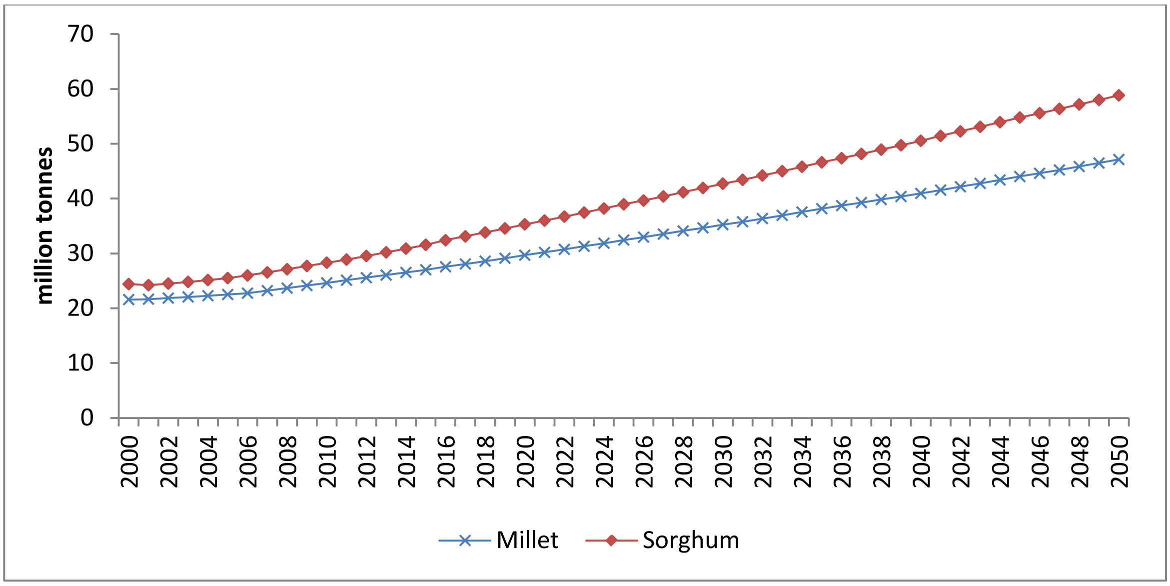
Appendix X Sorghum area projections for Asia from 2000 to 2050



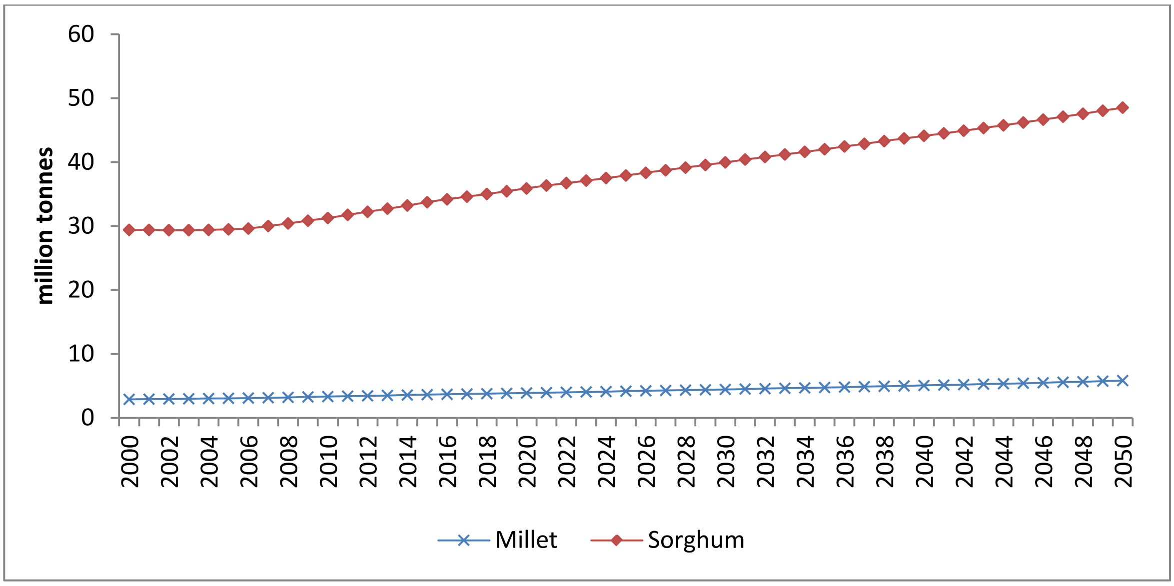
Appendix Y Sorghum supply projections for Asia from 2000 to 2050



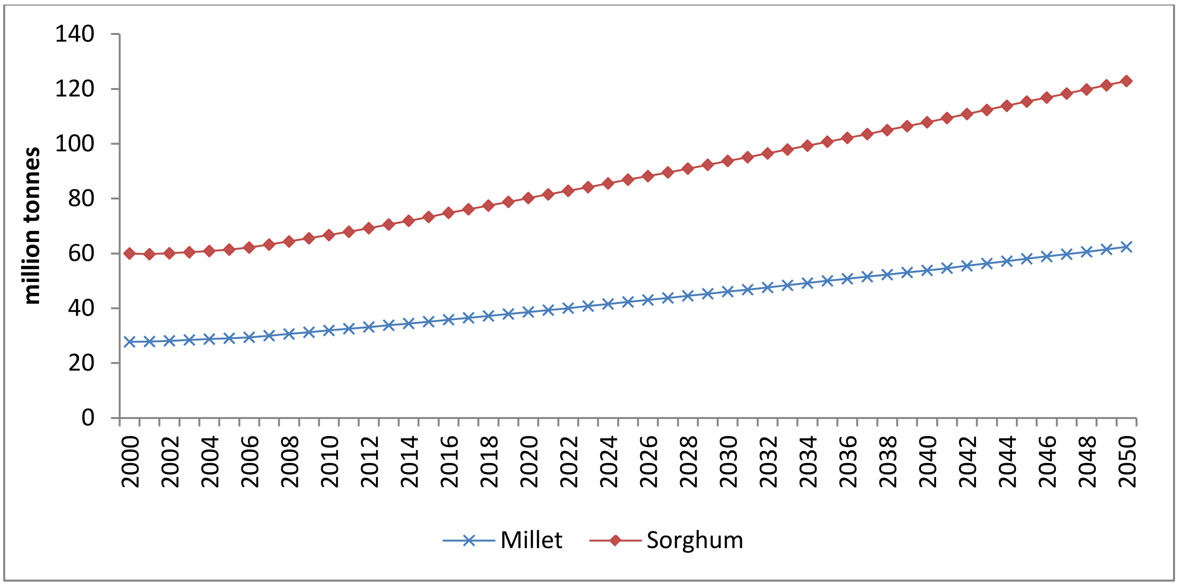
Appendix Z Sorghum yield projections for Asia from 2000 to 2050



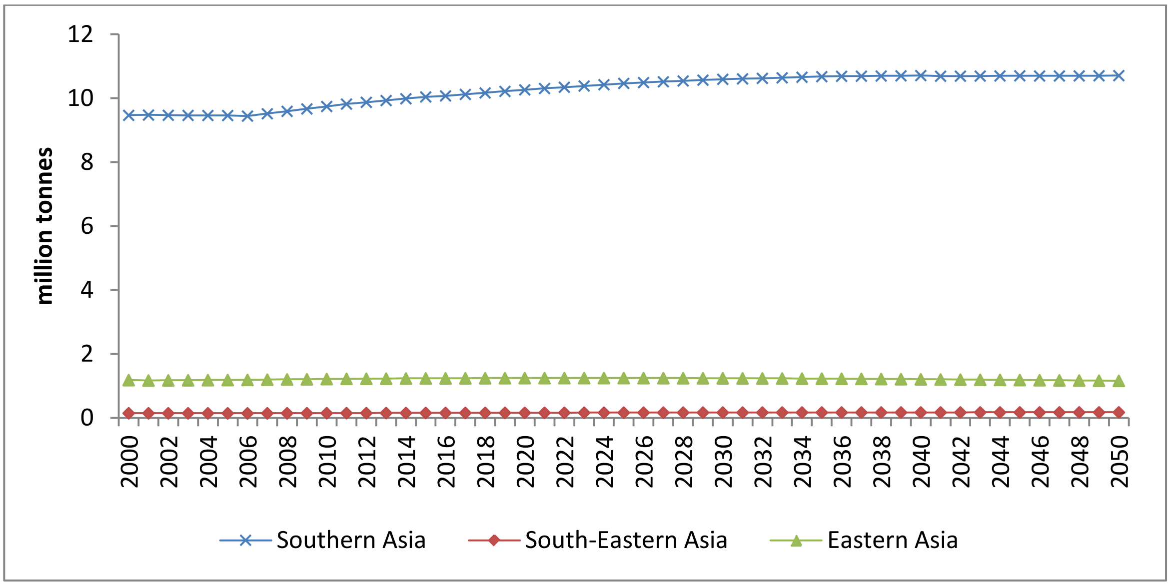
Appendix AA Global food demand projections for Asia from 2000 to 2050



Appendix BB Global feed demand projections for Asia from 2000 to 2050



Appendix CC Global demand (total) projections for Asia from 2000 to 2050



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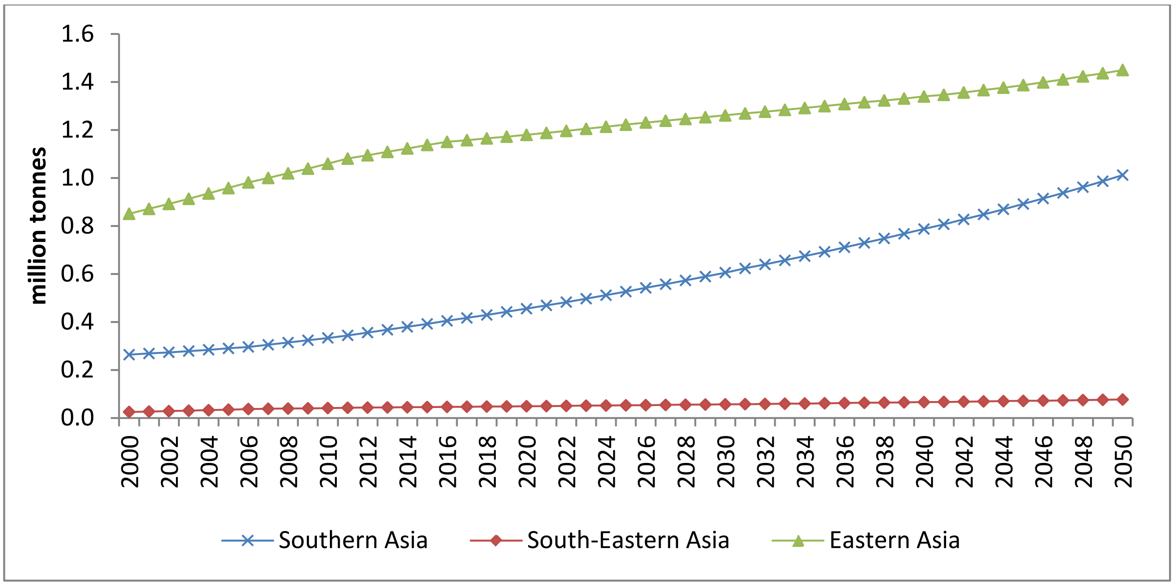
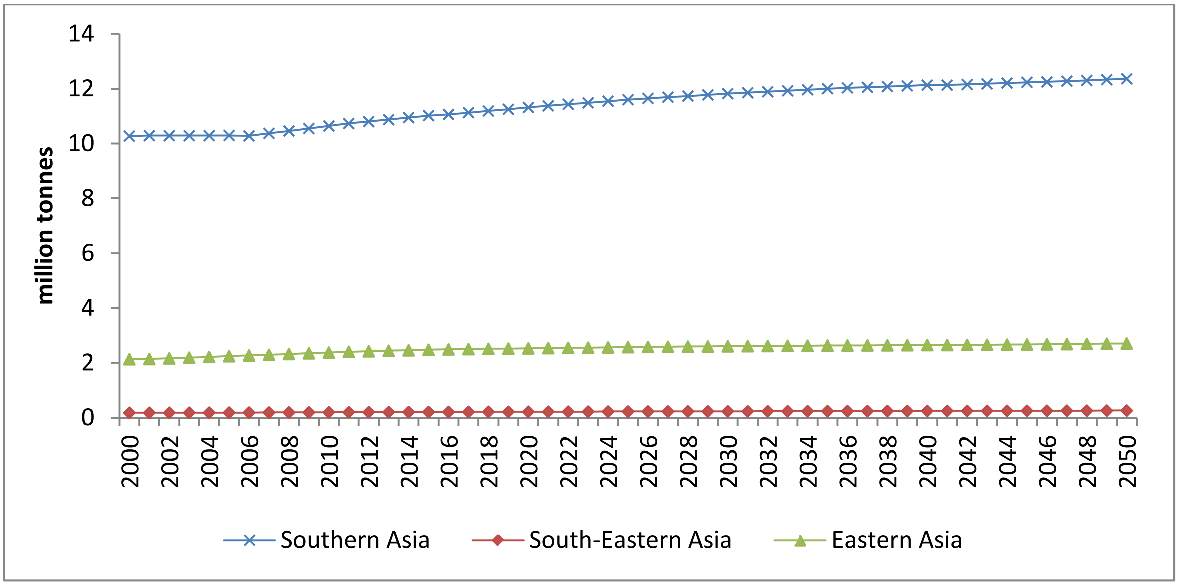
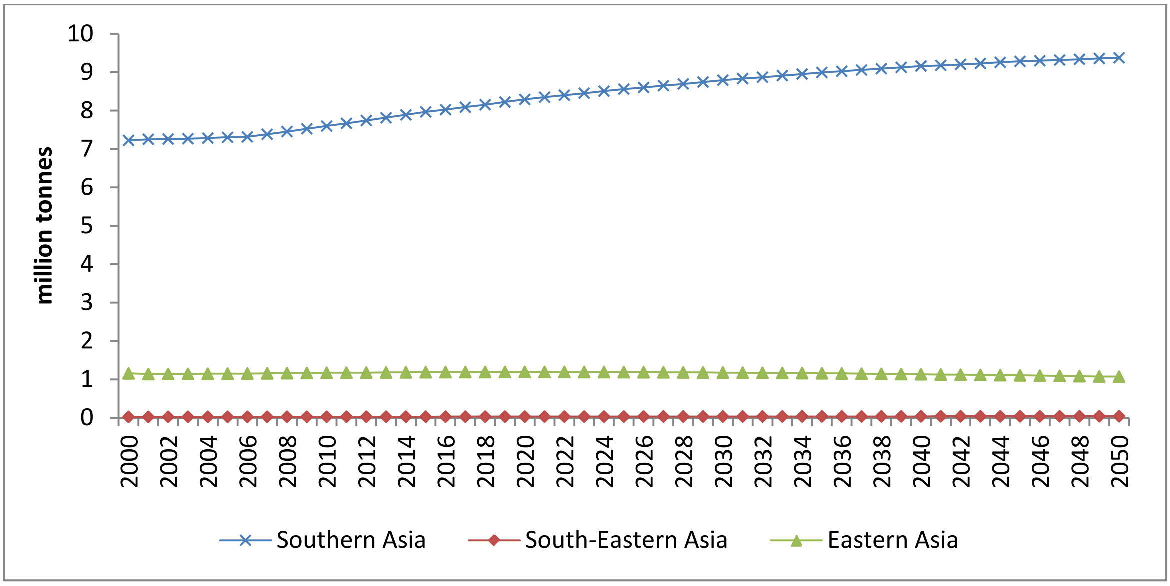


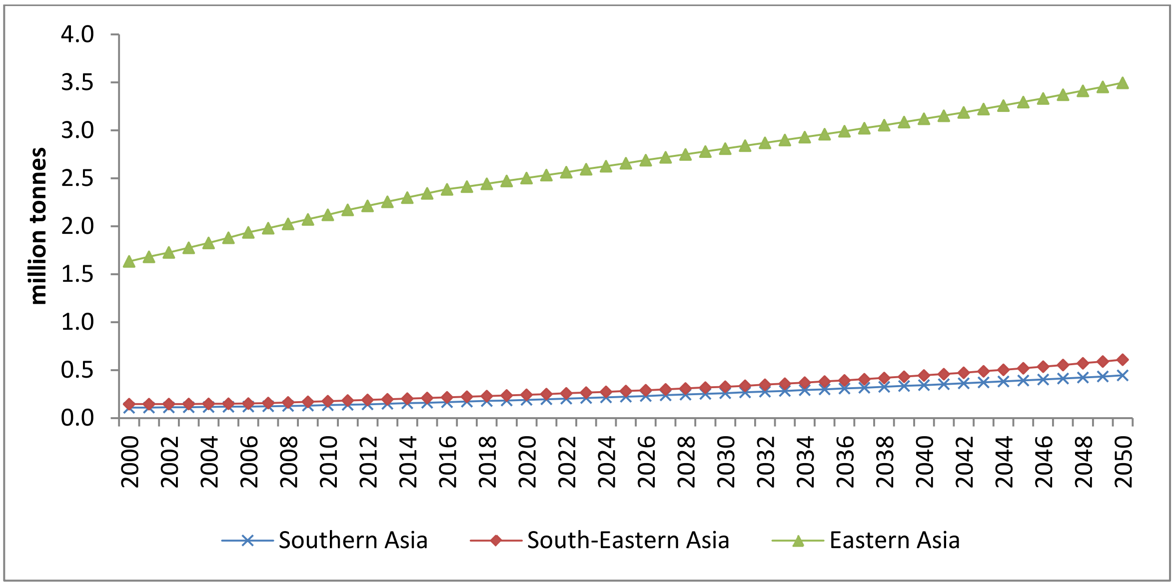
Appendix EE Millet feed demand projections for Asia from 2000 to 2050



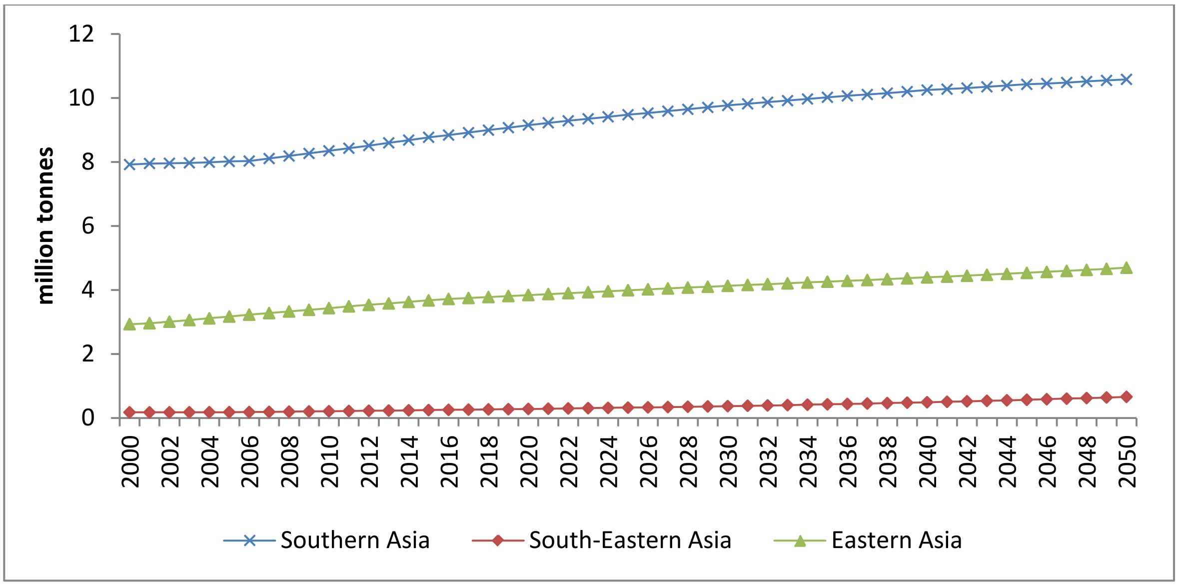
Appendix FF Millet demand (total) projections for Asia from 2000 to 2050



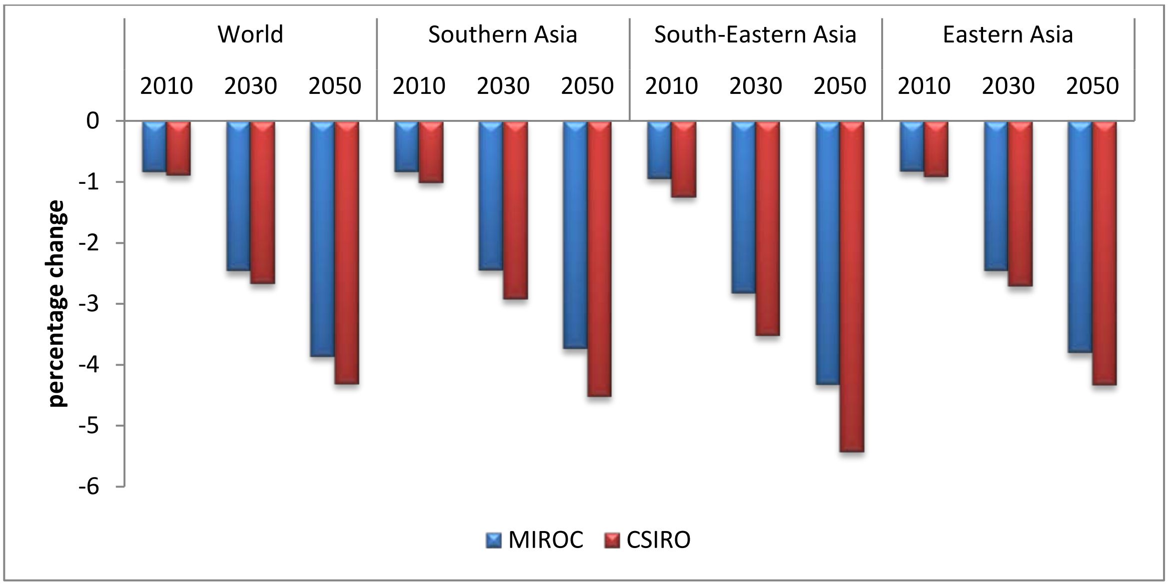
Appendix GG Sorghum food demand projections for Asia from 2000 to 2050



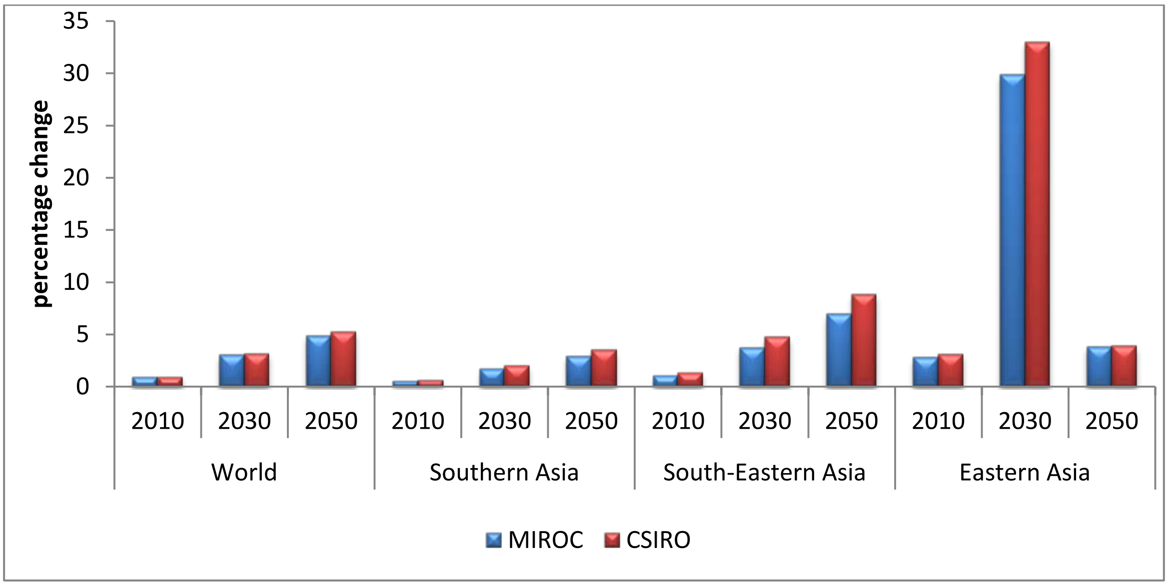
Appendix HH Sorghum feed demand projections for Asia from 2000 to 2050



Appendix II Sorghum demand (total) projections for Asia from 2000 to 2050



Appendix JJ Percentage Deviation of per capita calories intake from baseline projections under alternative climate scenarios



Appendix KK Deviation of number of malnourished children (under the age of 5) from baseline projections under alternative climate scenarios

Table 4 Baseline area projections for major regions in Asia ('000 ha)

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	36,238	38,594	40,870	42,442	43,529	47,969	51,547	54,610	56,874	58,622
Southern Asia	11,506	10,911	10,432	9,915	9,296	9,776	9,422	9,159	8,765	8,139
Afghanistan	9	10	10	10	9					
Bangladesh	43	45	45	45	45	1	1	1	1	1
Bhutan	5	5	5	5	5					
Iran	14	15	16	17	17					
Nepal	277	281	284	283	277					
India	10,693	10,083	9,596	9,083	8,480	9,499	9,145	8,880	8,488	7,864
Pakistan	459	466	469	466	456	276	276	277	276	274
Sri Lanka	6	6	6	6	6	0	0	0	0	0
South-Eastern Asia	261	278	293	304	311	51	51	52	52	51
Papua New Guinea						2	2	2	1	1
Thailand						49	50	50	50	50
Myanmar	261	278	293	304	311					
Eastern Asia	927	937	940	930	907	582	581	581	577	570
China	885	894	896	885	862	569	567	568	564	557
North Korea	39	41	42	42	42	11	11	11	11	11
South Korea	2	2	2	2	2	2	2	2	2	2

Table 5 Baseline projections of production for major regions in Asia ('000 tonnes)

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	32,152	38,884	46,332	54,066	62,645	65,290	78,791	92,335	1,06,441	1,21,470
Southern Asia	11,876	12,916	13,836	14,544	15,361	8,181	8,879	9,528	9,981	10,355
Afghanistan	7	8	9	9	10					
Bangladesh	65	77	86	92	99	2	2	2	3	3
Bhutan	6	7	8	9	9					
Iran	11	13	15	18	20					
Nepal	314	348	380	401	420					
India	11,238	12,197	13,041	13,690	14,447	8,004	8,682	9,309	9,740	10,089
Pakistan	227	256	287	315	344	174	194	216	238	263
Sri Lanka	7	8	9	10	11	0	0	0	0	0
South-Eastern Asia	184	220	264	310	365	113	128	142	158	176
Myanmar	184	220	264	310	365					
Papua New Guinea						5	5	5	6	6
Thailand						109	123	137	152	170
Eastern Asia	1,732	1,889	2,017	2,122	2,224	2,510	2,760	2,956	3,155	3,387
China	1,676	1,823	1,943	2,039	2,131	2,488	2,735	2,931	3,129	3,359
North Korea	54	63	71	80	89	20	21	22	23	23
South Korea	2	2	3	3	3	3	3	4	4	5

Table 6 Baseline demand projections for major regions in Asia ('000 tonnes)

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	31,882	38,614	46,062	53,796	62,375	66,681	80,182	93,726	1,07,832	1,22,860
Southern Asia	10,639	11,315	11,820	12,130	12,360	8,349	9,154	9,767	10,249	10,583
Afghanistan	46	64	85	112	144					
Bangladesh	61	70	76	81	86	1	1	1	2	2
Bhutan	30	34	37	39	41					
Iran	8	9	11	12	14					
India	9,935	10,464	10,824	10,987	11,062	8,096	8,844	9,400	9,824	10,099
Nepal	325	383	436	483	529					
Pakistan	229	284	343	407	477	252	309	365	424	483
Sri Lanka	7	7	7	8	8	0	0	0	0	0
South-Eastern Asia	197	217	233	246	260	209	280	369	490	658
Indonesia	7	7	7	7	6					
Malaysia	4	5	5	6	6	0	1	1	1	1
Myanmar	180	198	211	222	233					
Papua New Guinea						29	33	37	41	45
Philippines	2	2	3	3	4	10	13	16	21	26
Thailand	4	5	6	8	11	170	234	315	427	586
Eastern Asia	2,377	2,530	2,605	2,650	2,708	3,432	3,842	4,130	4,393	4,696
China	2,319	2,466	2,533	2,570	2,618	3,416	3,825	4,110	4,372	4,673
Mongolia	2	2	3	3	4					
North Korea	41	47	53	60	68	10	11	12	13	14
South Korea	15	16	16	17	17	6	7	7	8	9

Table 7 Baseline food demand projections for major regions in Asia ('000 tonnes)

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	24,628	29,671	35,247	40,942	47,119	28,307	35,304	42,716	50,539	58,822
Southern Asia	9,745	10,265	10,595	10,711	10,710	7,597	8,290	8,793	9,162	9,378
Afghanistan	39	55	73	96	124					
Bangladesh	61	70	76	81	86	1	1	1	1	1
Bhutan	27	30	33	35	36					
Nepal	289	341	388	430	471					
India	9,227	9,644	9,878	9,899	9,799	7,372	8,017	8,472	8,795	8,965
Pakistan	96	117	139	162	186	224	272	319	366	412
Sri Lanka	7	7	7	7	8	0	0	0	0	0
South-Eastern Asia	148	159	166	170	173	23	27	30	34	37
Indonesia	7	7	7	7	6					
Myanmar	140	152	159	164	167					
Papua New Guinea						23	27	30	34	37
Eastern Asia	1,215	1,245	1,239	1,208	1,160	1,168	1,192	1,175	1,132	1,068
China	1,181	1,209	1,201	1,168	1,118	1,160	1,183	1,166	1,122	1,059
Mongolia	0	0	0	0	0					
North Korea	25	26	28	29	31	8	9	9	10	10
South Korea	10	10	11	11	11					

Table 8 Baseline Projections of Feed Demand for Major Regions in Asia ('000 metric t)

	Millet					**Sorghum**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	3,317	3,880	4,441	5,058	5,826	31,261	35,877	39,968	44,110	48,527
Southern Asia	334	455	606	787	1,012	134	190	260	344	445
Afghanistan	1	2	2	2	3					
Bangladesh						0	0	0	0	0
Iran	7	9	10	12	14					
India	203	292	406	547	727	118	169	231	307	397
Pakistan	122	153	188	226	269	15	21	28	37	47
South-Eastern Asia	41	49	57	66	77	176	243	327	444	609
Malaysia	4	5	5	6	6	0	1	1	1	1
Myanmar	31	37	42	49	56					
Philippines	2	2	3	3	4	10	13	16	21	26
Thailand	4	5	6	8	11	166	229	310	423	581
Eastern Asia	1,059	1,180	1,261	1,340	1,450	2,120	2,503	2,810	3,121	3,496
China	1,039	1,155	1,231	1,303	1,406	2,112	2,495	2,800	3,110	3,483
Mongolia	2	2	3	3	4					
North Korea	15	19	23	28	35	1	2	2	3	4
South Korea	4	4	5	5	5	6	6	7	8	9

Table 9 Baseline Projections of Net Trade for Major Regions in Asia ('000 metric t)

	Millet					**Sorghum**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Southern Asia	899	1,262	1,677	2,076	2,662	-473	-579	-543	-572	-532
Afghanistan	-11	-28	-48	-74	-106					
Bangladesh	3	6	8	9	12	1	1	1	1	1
Bhutan	-6	-9	-11	-13	-14					
Iran	3	3	4	5	5					
Nepal	-12	-36	-57	-83	-110					
India	928	1,358	1,842	2,328	3,010		-459	-388	-381	-307
Pakistan	-7	-33	-61	-97	-138	-85	-122	-156	-193	-227
Sri Lanka	1	1	2	3	4	0	0	0	0	0
South-Eastern Asia	-18	-1	27	59	100	-96	-153	-226	-332	-482
Indonesia	-7	-7	-7	-6	-6					
Malaysia	-4	-5	-5	-6	-6	-0	-1	-1	-1	-1
Myanmar	-1	18	48	83	127					
Papua New Guinea						-23	-27	-31	-35	-38
Philippines	-2	-2	-3	-3	-4	-9	-12	-16	-20	-26
Thailand	-4	-5	-6	-8	-11	-63	-112	-179	-276	-417
Eastern Asia	-686	-682	-628	-568	-524	-893	-1,053	-1,144	-1,209	-1,280
China	-684	-683	-630	-571	-528	-899	-1,060	-1,150	-1,214	-1,285
Mongolia	-2	-2	-3	-3	-4					
North Korea	12	16	18	20	21	9	10	9	9	8
South Korea	-12	-13	-13	-14	-14	-3	-3	-3	-4	-4

Table 10 Baseline Projections of number of Malnourished Children (millions) and percentage deviation of optimistic and pessimistic scenario projections over baseline

	Baseline (million)					Optimistic (%)					Pessimistic (%)				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	205
World	149.9	142.0	128.1	117.3	106.0	-0.60	-4.94	-11.30	-17.54	-26.22	1.30	6.51	13.26	20.80	29
Southern Asia	75.6	70.2	61.9	56.6	50.9	-0.47	-3.73	-8.46	-13.51	-19.28	0.63	4.48	9.64	15.99	24
Afghanistan	1.1	1.3	1.2	1.0	0.8	-18.39	-30.32	-48.44	-77.22	-100.00	-1.97	-0.46	2.02	3.95	7
Bangladesh	8.9	8.5	7.8	7.0	6.2	-0.50	-4.24	-9.23	-14.38	-20.47	-0.32	2.77	7.12	12.40	20
Bhutan	0.0	0.0	0.0	0.0	0.0	-0.60	-6.20	-13.81	-22.82	-34.55	-0.72	2.16	6.31	10.44	16
Iran	1.2	1.0	0.7	0.6	0.4	5.75	4.52	-1.54	-12.91	-35.08	5.17	14.59	24.07	34.46	46
Nepal	1.8	1.7	1.6	1.5	1.3	-2.76	-8.41	-15.94	-24.48	-34.75	-0.45	2.41	6.56	11.11	17
India	54.8	50.1	43.8	40.6	37.3	0.05	-2.63	-6.53	-10.77	-15.94	1.14	5.35	10.95	17.64	26
Pakistan	7.5	7.3	6.6	5.6	4.6	-2.00	-5.95	-11.54	-17.49	-24.38	-2.00	0.70	4.85	10.38	19
Sri Lanka	0.3	0.3	0.3	0.2	0.2	-1.07	-6.34	-13.16	-20.78	-30.53	-1.68	-0.01	3.51	8.85	17
South-Eastern Asia	12.2	10.1	9.0	7.9	6.8	-3.62	-9.57	-17.23	-24.42	-32.57	-1.07	4.48	11.35	19.45	31
Indonesia	5.3	4.0	3.6	3.2	2.7	-4.36	-10.51	-18.07	-25.09	-33.15	-1.19	5.15	12.45	20.21	31
Malaysia	0.5	0.4	0.3	0.3	0.2	0.16	-2.90	-7.88	-13.96	-24.18	-2.93	1.90	10.72	25.49	56
Myanmar	0.8	0.7	0.6	0.6	0.6	-6.81	-19.00	-31.59	-44.55	-57.81	-1.11	2.39	7.58	13.30	21
Papua New Guinea	0.2	0.2	0.1	0.1	0.1	-11.07	-20.51	-32.57	-45.41	-56.96	-0.76	2.66	8.70	16.12	27
Philippines	1.8	1.6	1.4	1.2	1.1	-6.86	-14.72	-24.93	-34.31	-43.36	-2.86	3.50	11.30	20.07	32
Thailand	1.0	0.9	0.8	0.7	0.6	0.06	-2.56	-6.53	-11.25	-17.89	-0.36	4.88	11.84	20.52	33
Vietnam	2.6	2.3	2.0	1.8	1.6	-0.65	-4.90	-10.70	-15.68	-20.56	0.51	5.02	10.72	18.55	32
Eastern Asia	6.5	4.2	1.6	0.4	0.4	1.75	-19.34	-81.35	-45.39	-58.78	9.46	28.90	102.55	574.00	490
China	6.0	3.7	1.1			2.86	-18.76	-100.00			10.32	32.55	141.31		
Mongolia	0.0	0.0	0.0	0.0		-36.90	-100.00	-100.00	-100.00		-5.31	-2.72	3.56	12.87	
North Korea	0.5	0.5	0.4	0.4	0.4	-10.26	-20.80	-32.85	-44.75	-58.78	-0.84	1.64	5.38	9.52	16

Table 11 Per Capita Calorie intake under Alternative Scenarios

	Baseline (kcal)					Optimistic (%)					Pessimistic (%)				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	2,798	2,869	2,928	3,017	3,107	0.23	4.57	10.81	17.94	27.72	-1.18	-5.42	-10.47	-15.74	-22.08
Southern Asia	2,395	2,470	2,535	2,626	2,707	0.38	3.90	9.36	15.95	25.00	-1.26	-5.73	-10.88	-16.21	-22.35
Afghanistan	1,867	1,943	2,042	2,181	2,301	15.06	24.04	36.62	52.45	75.16	1.51	-0.24	-2.83	-5.29	-8.79
Bangladesh	2,130	2,146	2,148	2,162	2,170	1.04	6.16	13.43	21.73	32.71	0.67	-2.82	-7.35	-12.37	-18.85
Bhutan	2,227	2,223	2,203	2,190	2,169	0.43	5.15	12.13	20.79	33.52	0.51	-2.25	-5.87	-9.27	-13.72
Iran	3,218	3,321	3,427	3,591	3,738	-3.87	-1.49	3.82	12.37	27.08	-3.49	-9.02	-13.69	-17.53	-21.40
Nepal	2,281	2,334	2,383	2,463	2,526	5.29	13.90	26.58	43.33	67.51	0.85	-2.19	-6.28	-10.26	-15.22
India	2,404	2,484	2,552	2,639	2,711	-0.09	2.85	7.42	12.83	20.18	-1.99	-6.86	-12.44	-18.19	-24.64
Pakistan	2,326	2,437	2,555	2,728	2,911	2.71	7.26	13.98	20.99	29.35	2.72	-0.33	-4.55	-9.45	-15.81
Sri Lanka	2,401	2,395	2,395	2,415	2,426	0.84	5.55	12.22	20.60	33.07	1.32	-0.59	-3.90	-8.28	-14.38
South-Eastern Asia	2,799	2,943	3,036	3,130	3,228	3.30	8.68	16.07	23.45	32.47	0.96	-4.03	-9.24	-14.34	-20.82
Indonesia	3,120	3,335	3,462	3,581	3,701	4.31	9.85	17.37	24.70	33.96	1.16	-4.52	-9.95	-14.79	-20.78
Malaysia	3,096	3,345	3,586	3,843	4,136	-0.11	2.80	7.40	12.60	20.03	2.13	-2.07	-7.73	-14.02	-22.07
Myanmar	2,579	2,563	2,542	2,510	2,450	5.32	15.49	28.74	44.51	65.68	0.85	-2.35	-6.58	-10.86	-16.49
Papua New Guinea	2,417	2,542	2,639	2,706	2,709	8.66	15.31	23.66	32.26	41.47	0.58	-2.44	-6.77	-11.06	-16.37
Philippines	2,407	2,526	2,605	2,677	2,731	5.10	10.94	18.95	26.46	34.72	2.09	-3.01	-8.20	-12.98	-18.53
Singapore	2,297	2,312	2,302	2,302	2,306	-0.02	2.31	6.02	9.36	14.25	0.64	-2.25	-5.63	-8.61	-13.59
Thailand	2,663	2,796	2,899	3,009	3,125	-0.05	2.57	6.68	11.78	19.43	0.29	-4.12	-9.22	-14.64	-21.59
Vietnam	2,525	2,596	2,643	2,724	2,861	0.87	5.77	12.99	19.49	26.08	-0.67	-5.39	-10.61	-16.90	-25.93
Eastern Asia	3,102	3,276	3,423	3,598	3,817	-0.61	5.51	12.98	19.60	26.72	-2.80	-6.90	-11.99	-18.52	-27.46
China	3,121	3,303	3,457	3,640	3,868	-0.81	5.30	12.71	19.17	25.98	-2.89	-7.03	-12.18	-18.83	-27.90
Mongolia	2,380	2,536	2,738	2,973	3,145	16.16	46.79	80.60	108.90	133.41	2.18	-1.21	-5.53	-9.06	-14.54
North Korea	2,060	2,106	2,144	2,190	2,235	12.20	25.55	42.84	62.44	90.86	0.95	-1.57	-5.10	-8.69	-14.19
South Korea	3,122	3,163	3,183	3,248	3,335	-0.06	2.49	6.52	11.16	17.99	-1.99	-5.18	-8.92	-13.08	-19.25

Table 12 Percentage Deviation of World Prices from Baseline Projections

	Baseline Prices (USD/tonne)					**Optimistic**					**Pessimistic**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Millet	325	348	365	370	364	0.53	-0.76	-3.05	-6.58	-11.3	-2.06	-1.1	1.96	6.99	12.92
Sorghum	115	126	137	145	152	0.49	0.26	-0.71	-2.29	-4.33	-3.3	-3.91	-2.97	-0.72	2.75

Table 13 Percentage Deviation in Area harvested for Millet from Baseline projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.24	-0.43	-1.51	-3.08	-5.18	-0.56	-0.01	1.50	3.95	6.61
Southern Asia	0.24	-0.43	-1.49	-3.03	-5.10	-0.56	-0.02	1.46	3.87	6.48
Afghanistan	0.18	-0.32	-1.13	-2.33	-3.94	-0.41	0.00	1.12	2.95	4.94
Bangladesh	0.27	-0.47	-1.69	-3.53	-6.02	-0.75	-0.18	1.49	4.24	7.33
Bhutan	0.11	-0.18	-0.65	-1.37	-2.35	-0.28	-0.05	0.61	1.67	2.83
Iran	0.15	-0.24	-0.89	-1.88	-3.23	-0.40	-0.09	0.81	2.26	3.86
Nepal	0.21	-0.33	-1.27	-2.73	-4.73	-0.69	-0.27	1.02	3.13	5.48
India	0.30	-0.52	-1.83	-3.74	-6.30	-0.66	0.00	1.84	4.87	8.22
Pakistan	0.22	-0.37	-1.32	-2.74	-4.64	-0.54	-0.08	1.23	3.39	5.75
Sri Lanka	0.19	-0.29	-1.10	-2.32	-4.00	-0.51	-0.13	0.98	2.78	4.76
South-Eastern Asia	0.22	-0.37	-1.35	-2.82	-4.83	-0.69	-0.23	1.08	3.19	5.54
Myanmar	0.23	-0.37	-1.39	-2.95	-5.06	-0.74	-0.28	1.10	3.35	5.86
Eastern Asia	0.23	-0.37	-1.39	-2.95	-5.06	-0.74	-0.28	1.10	3.35	5.86
China	0.18	-0.32	-1.13	-2.32	-3.93	-0.41	0.00	1.12	2.95	4.94
North Korea	0.18	-0.32	-1.14	-2.37	-4.04	-0.44	-0.04	1.10	2.97	5.00
South Korea	0.24	-0.43	-1.50	-3.07	-5.17	-0.50	0.04	1.54	4.02	6.71

Table 14 Percentage Deviation in Millet Production from Baseline Projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.33	-0.55	-2.05	-4.31	-7.38	-0.95	-0.28	1.73	5.12	8.98
Southern Asia	0.29	-0.48	-1.74	-3.58	-6.02	-0.77	-0.16	1.58	4.39	7.47
Afghanistan	0.17	-0.27	-1.02	-2.17	-3.75	-0.53	-0.18	0.84	2.50	4.34
Bangladesh	0.22	-0.35	-1.31	-2.78	-4.77	-0.68	-0.24	1.07	3.20	5.56
Bhutan	0.28	-0.42	-1.64	-3.52	-6.09	-0.94	-0.40	1.25	3.96	7.03
Iran	0.34	-0.59	-2.09	-4.30	-7.26	-0.83	-0.09	2.00	5.47	9.35
Nepal	0.28	-0.46	-1.69	-3.53	-6.01	-0.79	-0.21	1.47	4.23	7.30
India	0.29	-0.49	-1.76	-3.61	-6.08	-0.78	-0.15	1.60	4.44	7.55
Pakistan	0.20	-0.30	-1.16	-2.47	-4.24	-0.62	-0.22	0.94	2.81	4.87
Sri Lanka	0.28	-0.46	-1.72	-3.62	-6.19	-0.94	-0.37	1.31	4.02	7.09
South-Eastern Asia	0.28	-0.44	-1.67	-3.54	-6.08	-0.92	-0.38	1.28	3.98	7.02
Myanmar	0.28	-0.44	-1.67	-3.54	-6.08	-0.92	-0.38	1.28	3.98	7.02
Eastern Asia	0.26	-0.40	-1.61	-3.10	-5.13	-0.53	0.02	1.48	4.03	6.81
China	0.26	-0.40	-1.61	-3.10	-5.11	-0.53	0.03	1.49	4.03	6.82
North Korea	0.24	-0.41	-1.51	-3.16	-5.42	-0.69	-0.17	1.34	3.81	6.54
South Korea	0.29	-0.50	-1.79	-3.70	-6.25	-0.70	-0.06	1.73	4.69	7.96

Table 15 Percentage Deviation in Total Demand for Millet from Baseline projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.33	-0.56	-2.07	-4.33	-7.41	-0.96	-0.28	1.75	5.14	9.02
Southern Asia	-0.05	-2.17	-5.11	-7.79	-10.64	2.70	7.40	12.72	18.50	26.09
Afghanistan	12.82	15.44	17.42	20.44	25.38	-0.01	0.78	1.44	1.49	2.31
Bangladesh	1.12	0.14	-2.21	-5.39	-9.48	0.10	1.85	4.00	5.88	9.57
Bhutan	0.47	-0.51	-3.37	-6.71	-10.83	-0.05	1.92	4.20	5.83	9.07
Iran	-0.24	0.60	1.63	2.73	3.82	-1.20	-2.15	-3.70	-6.21	-8.66
Nepal	2.32	0.97	-2.09	-5.82	-10.18	-0.01	1.99	4.34	6.27	9.70
India	-0.20	-2.50	-5.63	-8.53	-11.64	2.90	7.92	13.68	20.15	28.70
Pakistan	0.48	0.69	0.86	0.93	0.58	-0.29	-0.30	-0.64	-2.05	-3.22
Sri Lanka	0.50	-0.67	-3.23	-6.57	-10.77	0.21	2.07	3.85	5.42	9.16
South-Eastern Asia	3.80	3.28	0.44	-3.19	-6.89	-0.06	1.30	2.61	3.27	4.88
Indonesia	-2.96	-7.34	-12.98	-17.70	-21.97	0.16	5.14	10.76	16.77	25.43
Malaysia	-0.19	1.36	2.59	3.12	2.97	-2.26	-3.37	-4.88	-7.32	-9.46
Myanmar	4.28	3.79	0.76	-3.21	-7.33	0.03	1.42	2.80	3.61	5.51
Philippines	-0.24	1.06	2.31	3.33	4.11	-1.47	-2.34	-3.84	-6.37	-8.67
Thailand	-0.15	0.93	1.80	2.13	1.82	-1.67	-2.48	-3.64	-5.65	-7.61
Eastern Asia	-0.09	-0.62	-1.43	-2.15	-2.98	-0.63	0.26	0.90	1.08	2.01
China	-0.16	-0.75	-1.61	-2.39	-3.25	-0.63	0.27	0.92	1.14	2.12
Mongolia	-0.30	0.42	1.63	3.36	5.51	-0.52	-1.76	-4.09	-7.88	-11.87
North Korea	3.81	6.10	7.30	7.91	7.45	-0.36	0.23	0.42	-0.42	-0.52
South Korea	-0.19	-1.06	-2.30	-3.22	-4.27	-1.36	-0.74	-0.21	-0.89	-1.31

Table 16 Percentage Deviation in Food Demand for Millet from Baseline Projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.23	-0.85	-2.69	-5.35	-9.02	-0.71	0.29	2.82	6.92	11.63
Southern Asia	-0.23	-2.30	-5.49	-8.54	-11.95	3.25	7.81	13.63	20.23	29.21
Afghanistan	13.59	15.82	17.81	20.86	25.86	0.08	0.85	1.55	1.64	2.51
Bangladesh	1.13	0.14	-2.21	-5.39	-9.48	0.25	1.85	4.00	5.88	9.57
Bhutan	0.46	-0.51	-3.37	-6.71	-10.83	0.09	1.92	4.20	5.83	9.07
Nepal	2.27	0.97	-2.09	-5.82	-10.18	0.14	1.99	4.34	6.27	9.70
India	-0.40	-2.58	-5.89	-9.08	-12.68	3.42	8.20	14.34	21.48	31.23
Pakistan	1.27	0.49	-0.75	-2.19	-4.50	0.74	1.88	3.20	3.38	4.10
Sri Lanka	0.44	-0.67	-3.23	-6.57	-10.77	0.36	2.07	3.85	5.42	9.16
South-Eastern Asia	4.91	4.04	0.15	-5.04	-10.70	0.41	2.28	4.55	6.53	10.21
Indonesia	-3.37	-7.34	-12.98	-17.70	-21.97	0.56	5.14	10.76	16.77	25.43
Myanmar	5.33	4.58	0.72	-4.54	-10.28	0.40	2.15	4.28	6.12	9.64
Eastern Asia	-0.13	-2.03	-4.84	-7.80	-11.60	0.02	2.21	4.99	8.29	13.83
China	-0.27	-2.28	-5.21	-8.30	-12.23	0.03	2.24	5.05	8.43	14.08
Mongolia	3.52	5.48	6.17	6.43	4.99	0.31	2.34	4.58	5.79	8.49
North Korea	6.51	9.51	11.16	11.82	10.34	0.26	1.85	3.81	5.33	8.62
South Korea	-0.26	-1.92	-4.34	-6.51	-9.23	-1.55	-0.39	1.14	1.59	2.64

Table 17 Percentage Deviation in Feed Demand of Millet from Baseline projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	-0.24	0.83	1.99	3.12	4.17	-1.10	-2.02	-3.63	-6.23	-8.76
Southern Asia	-0.21	0.52	1.43	2.46	3.55	-1.00	-1.92	-3.36	-5.60	-7.71
Afghanistan	-0.18	0.15	0.56	1.00	1.34	-1.02	-1.94	-3.27	-5.50	-7.97
Iran	-0.26	0.64	1.71	2.83	3.96	-1.28	-2.26	-3.86	-6.46	-8.96
India	-0.20	0.34	1.08	2.05	3.19	-0.93	-1.79	-3.13	-5.25	-7.24
Pakistan	-0.24	0.86	2.19	3.44	4.52	-1.09	-2.15	-3.83	-6.40	-8.90
South-Eastern Asia	-0.19	0.51	1.23	1.81	2.17	-1.20	-2.07	-3.39	-5.59	-7.80
Malaysia	-0.19	1.36	2.59	3.12	2.97	-2.26	-3.37	-4.88	-7.32	-9.46
Myanmar	-0.19	0.31	0.90	1.50	2.02	-0.98	-1.82	-3.14	-5.32	-7.59
Philippines	-0.24	1.06	2.31	3.33	4.11	-1.47	-2.34	-3.84	-6.37	-8.67
Thailand	-0.15	0.93	1.80	2.13	1.82	-1.67	-2.48	-3.64	-5.65	-7.61
Eastern Asia	-0.22	0.99	2.20	3.37	4.51	-1.18	-1.96	-3.47	-5.96	-8.24
China	-0.22	0.99	2.20	3.36	4.49	-1.18	-1.96	-3.46	-5.94	-8.20
Mongolia	-0.35	0.35	1.57	3.33	5.52	-0.53	-1.81	-4.19	-8.02	-12.07
North Korea	-0.32	0.97	2.32	3.58	4.72	-1.24	-2.21	-3.97	-6.79	-9.19
South Korea	-0.39	1.21	2.97	4.91	7.07	-0.71	-1.65	-3.68	-7.01	-10.36

Table 18 Deviation in Net Trade for Millet from Baseline Projections under Alternative Scenarios

	Optimistic					**Pessimistic**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Southern Asia	39.2	183.4	363.2	425.2	389.7	-379.3	-858.2	-1285.3	-1605.1	-2077.6
Afghanistan	-5.9	-9.9	-14.9	-23.0	-37.0	-0.0	-0.5	-1.2	-1.4	-2.9
Bangladesh	-0.5	-0.4	0.6	1.8	3.4	-0.5	-1.5	-2.1	-1.8	-2.7
Bhutan	-0.1	0.1	1.1	2.3	3.8	-0.0	-0.7	-1.5	-1.9	-3.0
Iran	0.1	-0.1	-0.5	-1.1	-2.0	0.0	0.2	0.7	1.7	3.1
Nepal	-6.6	-5.3	2.7	14.0	28.6	-2.5	-8.4	-13.3	-13.3	-20.6
India	53.0	201.7	380.4	442.6	410.0	-375.5	-847.5	-1272.6	-1605.4	-2083.7
Pakistan	-0.6	-2.7	-6.3	-11.6	-17.3	-0.7	0.3	4.9	17.2	32.1
Sri Lanka	-0.0	0.0	0.1	0.1	0.1	-0.1	-0.2	-0.2	0.0	0.1
South-Eastern Asia	-7.0	-8.1	-5.4	-3.1	-4.3	-1.6	-3.7	-2.7	4.3	12.9
Indonesia	0.2	0.5	0.9	1.2	1.4	-0.0	-0.4	-0.7	-1.1	-1.6
Malaysia	0.0	-0.1	-0.1	-0.2	-0.2	0.1	0.2	0.3	0.4	0.6
Myanmar	-7.2	-8.5	-6.0	-3.9	-5.1	-1.8	-3.6	-2.5	4.3	12.8
Philippines	0.0	-0.0	-0.1	-0.1	-0.2	0.0	0.1	0.1	0.2	0.3
Thailand	0.0	-0.0	-0.1	-0.2	-0.2	0.1	0.1	0.2	0.5	0.8
Eastern Asia	6.6	8.3	4.9	-8.7	-33.4	5.7	-6.3	6.5	56.7	97.0
China	8.0	11.3	9.5	-1.8	-23.8	5.7	-6.3	5.6	52.8	89.8
Mongolia	0.0	-0.0	-0.0	-0.1	-0.2	0.0	0.0	0.1	0.3	0.5
North Korea	-1.4	-3.1	-4.9	-7.2	-9.9	-0.2	-0.2	0.7	3.3	6.2
South Korea	0.0	0.2	0.3	0.4	0.5	0.2	0.1	0.1	0.3	0.5

Table 19 Percentage Deviation in Area harvested for Sorghum from Baseline projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.22	0.08	-0.32	-0.87	-1.53	-1.20	-1.46	-1.02	0.11	1.69
Southern Asia	0.22	0.08	-0.31	-0.86	-1.50	-1.19	-1.45	-1.01	0.10	1.66
Bangladesh	0.16	0.06	-0.22	-0.61	-1.07	-0.82	-1.00	-0.70	0.08	1.17
India	0.25	0.10	-0.36	-1.04	-1.86	-1.47	-1.80	-1.33	-0.07	1.75
Pakistan	0.18	0.09	-0.22	-0.68	-1.24	-1.01	-1.23	-0.91	-0.06	1.15
Sri Lanka	0.13	0.08	-0.11	-0.41	-0.78	-0.74	-0.92	-0.72	-0.16	0.66
South-Eastern Asia	0.20	0.08	-0.30	-0.88	-1.59	-1.25	-1.49	-1.11	-0.16	1.23
Papua New Guinea	0.23	0.07	-0.35	-0.94	-1.63	-1.20	-1.46	-1.01	0.16	1.78
Thailand	0.20	0.08	-0.30	-0.89	-1.62	-1.22	-1.46	-1.07	-0.11	1.29
Eastern Asia	0.23	0.07	-0.35	-0.94	-1.63	-1.20	-1.46	-1.01	0.16	1.79
China	0.16	0.06	-0.22	-0.61	-1.07	-0.82	-1.00	-0.69	0.08	1.17
North Korea	0.17	0.08	-0.21	-0.63	-1.14	-0.94	-1.16	-0.85	-0.02	1.17
South Korea	0.22	0.09	-0.29	-0.82	-1.44	-1.14	-1.42	-1.00	0.13	1.69

Table 20 Percentage Deviation in Production of Sorghum from Baseline projections under Alternative Scenarios

	Optimistic					**Pessimistic**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.31	0.13	-0.46	-1.31	-2.37	-1.78	-2.19	-1.61	-0.07	2.18
Southern Asia	0.28	0.12	-0.40	-1.14	-2.05	-1.61	-1.95	-1.41	-0.01	1.98
Bangladesh	0.24	0.12	-0.31	-0.97	-1.80	-1.46	-1.76	-1.30	-0.16	1.49
India	0.29	0.12	-0.40	-1.16	-2.07	-1.62	-1.97	-1.42	-0.01	2.01
Pakistan	0.16	0.10	-0.17	-0.60	-1.15	-1.01	-1.24	-0.98	-0.25	0.82
Sri Lanka	0.26	0.11	-0.39	-1.15	-2.11	-1.64	-1.97	-1.48	-0.26	1.55
South-Eastern Asia	0.28	0.10	-0.42	-1.17	-2.06	-1.53	-1.87	-1.33	0.05	2.00
Papua New Guinea	0.25	0.11	-0.38	-1.15	-2.11	-1.60	-1.91	-1.41	-0.19	1.60
Thailand	0.28	0.10	-0.42	-1.17	-2.05	-1.53	-1.86	-1.33	0.05	2.02
Eastern Asia	0.24	0.07	-0.54	-1.08	-1.80	-1.06	-1.23	-0.73	0.59	2.31
China	0.24	0.07	-0.54	-1.08	-1.80	-1.06	-1.22	-0.73	0.59	2.32
North Korea	0.22	0.11	-0.29	-0.91	-1.66	-1.34	-1.64	-1.21	-0.10	1.50
South Korea	0.27	0.11	-0.36	-1.04	-1.85	-1.46	-1.79	-1.28	0.06	1.96

Table 21 Percentage Deviation in Total Demand for Sorghum from Baseline projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.30	0.12	-0.45	-1.30	-2.34	-1.75	-2.15	-1.59	-0.07	2.16
Southern Asia	-0.14	-2.65	-6.01	-9.44	-13.46	1.45	4.94	9.06	13.25	18.62
Bangladesh	1.06	-0.29	-2.88	-6.25	-10.37	0.62	2.86	5.51	7.75	10.94
India	-0.19	-2.75	-6.20	-9.71	-13.82	1.47	5.03	9.24	13.60	19.22
Pakistan	1.22	0.18	-1.30	-3.14	-5.98	0.95	2.57	4.35	5.08	6.06
Sri Lanka	0.52	-1.21	-4.43	-8.69	-14.12	0.91	3.64	6.57	9.53	14.49
South-Eastern Asia	-0.82	-0.64	-0.56	-0.77	-1.50	-1.14	-1.29	-1.69	-2.97	-4.36
Malaysia	-0.19	1.13	2.06	2.12	1.29	-1.99	-2.76	-3.85	-5.80	-7.59
Papua New Guinea	-5.09	-10.73	-17.46	-23.29	-27.87	0.41	3.21	7.17	11.26	16.78
Philippines	-0.22	0.66	1.36	1.54	1.08	-0.98	-1.23	-1.96	-3.61	-5.24
Thailand	-0.13	0.73	1.34	1.29	0.43	-1.40	-1.94	-2.73	-4.31	-5.96
Eastern Asia	-0.14	-0.54	-1.12	-1.86	-2.99	-0.29	0.67	1.29	1.29	1.40
China	-0.16	-0.56	-1.15	-1.90	-3.02	-0.29	0.66	1.29	1.28	1.39
North Korea	5.24	7.63	8.32	7.84	5.35	0.44	2.34	4.32	5.63	7.80
South Korea	-0.36	0.52	1.34	1.82	1.83	0.12	0.23	-0.47	-2.27	-4.54

Table 22 Percentage Deviation in Food Demand for Sorghum from Baseline projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.55	-0.51	-2.14	-3.68	-5.02	-2.62	-2.72	-0.80	3.19	8.08
Southern Asia	-0.35	-2.70	-6.18	-9.78	-14.06	1.79	5.06	9.34	13.79	19.60
Bangladesh	1.10	-0.34	-3.26	-7.25	-12.41	0.94	3.22	6.37	9.44	14.17
India	-0.40	-2.80	-6.36	-10.04	-14.39	1.81	5.14	9.50	14.12	20.17
Pakistan	1.25	0.15	-1.53	-3.62	-6.86	1.21	2.85	4.91	5.96	7.39
Sri Lanka	0.42	-1.21	-4.43	-8.69	-14.12	1.14	3.64	6.57	9.53	14.49
South-Eastern Asia	-5.61	-10.73	-17.46	-23.29	-27.87	0.63	3.21	7.17	11.26	16.78
Papua New Guinea	-5.61	-10.73	-17.46	-23.29	-27.87	0.63	3.21	7.17	11.26	16.78
Eastern Asia	-0.23	-2.43	-5.62	-9.10	-13.57	0.38	2.95	6.29	10.33	16.59
China	-0.28	-2.52	-5.75	-9.26	-13.77	0.37	2.95	6.30	10.35	16.63
North Korea	6.50	9.10	10.18	9.98	7.29	0.79	2.94	5.73	8.28	12.48

Table 23 Percentage Deviation in Feed Demand for Sorghum from Baseline projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	-0.26	0.62	1.46	1.86	1.67	-0.81	-1.23	-2.22	-4.15	-6.15
Southern Asia	-0.19	0.01	0.28	0.47	0.39	-0.46	-0.74	-1.36	-2.63	-4.02
Bangladesh	-0.16	0.27	0.72	0.90	0.65	-0.96	-1.61	-2.61	-4.42	-6.48
India	-0.18	-0.06	0.14	0.28	0.19	-0.43	-0.68	-1.24	-2.44	-3.77
Pakistan	-0.23	0.54	1.42	1.99	2.06	-0.70	-1.26	-2.31	-4.17	-6.16
South-Eastern Asia	-0.14	0.74	1.36	1.32	0.46	-1.42	-1.94	-2.73	-4.33	-5.97
Malaysia	-0.19	1.13	2.06	2.12	1.29	-1.99	-2.76	-3.85	-5.80	-7.59
Philippines	-0.22	0.66	1.36	1.54	1.08	-0.98	-1.23	-1.96	-3.61	-5.24
Thailand	-0.14	0.74	1.36	1.30	0.43	-1.44	-1.97	-2.77	-4.36	-6.01
Eastern Asia	-0.20	0.48	1.00	1.09	0.65	-0.56	-0.55	-1.06	-2.39	-3.81
China	-0.20	0.48	0.99	1.09	0.65	-0.56	-0.56	-1.06	-2.39	-3.81
North Korea	-0.30	0.40	0.96	1.01	0.38	-0.53	-0.62	-1.27	-2.81	-4.26
South Korea	-0.37	0.53	1.36	1.85	1.85	0.12	0.23	-0.47	-2.30	-4.60

Table 24 Deviation in Net Trade of Sorghum from Baseline Projections under Alternative Scenarios

	Optimistic					Pessimistic				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Southern Asia	35.1	252.6	549.2	853.5	1212.3	-253.0	-626.0	-1018.4	-1359.4	-1766.1
India	37.9	253.0	544.8	841.6	1186.3	-248.8	-615.6	-1000.2	-1337.1	-1738.9
Pakistan	-2.8	-0.3	4.4	11.9	25.9	-4.1	-10.3	-18.0	-22.1	-27.1
Sri Lanka	0.0	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0
South-Eastern Asia	2.0	1.9	1.5	2.0	6.3	0.6	1.2	4.4	14.6	32.2
Papua New Guinea	1.5	3.6	6.5	9.6	12.5	-0.2	-1.2	-2.7	-4.7	-7.5
Philippines	0.0	-0.1	-0.2	-0.3	-0.3	0.1	0.2	0.3	0.7	1.4
Thailand	0.5	-1.6	-4.8	-7.3	-6.0	0.7	2.2	6.8	18.5	38.3
Eastern Asia	10.9	22.5	30.5	47.7	79.4	-16.8	-59.5	-75.0	-38.2	12.4
China	11.4	23.3	31.7	49.1	80.9	-16.4	-58.8	-74.2	-37.6	12.7
North Korea	-0.5	-0.8	-1.1	-1.2	-1.2	-0.3	-0.6	-0.8	-0.8	-0.8
South Korea	0.0	-0.0	-0.1	-0.2	-0.2	-0.1	-0.1	-0.0	0.2	0.5

Table 25 Baseline Projections for Irrigated Area of Millet and Sorghum

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	1,685	1,688	1,702	1,713	1,721	4,165	4,353	4,521	4,640	4,723
Southern Asia	1,284	1,279	1,288	1,302	1,318	1,181	1,170	1,183	1,186	1,179
India	1,119	1,112	1,121	1,137	1,157	994	983	996	1,000	994
Afghanistan	10	10	10	10	9					
Bangladesh	24	24	24	24	24	0	0	0	0	0
Pakistan	132	133	133	131	127	188	187	188	186	184
Eastern Asia	265	266	265	260	251	240	239	239	236	232
China	265	266	265	260	251	240	239	239	236	232

Table 26 Baseline Projections for Rainfed Area of Millet and Sorghum

	Millet					**Sorghum**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	35,560	37,580	39,477	40,587	41,065	44,597	47,778	50,379	52,138	53,250
Southern Asia	10,508	9,798	9,212	8,585	7,845	8,735	8,343	8,017	7,568	6,888
India	9,844	9,127	8,538	7,920	7,199	8,643	8,251	7,926	7,477	6,798
Bangladesh	20	21	21	21	21	1	1	1	1	1
Iran	15	16	17	17	17					
Pakistan	336	338	339	334	324	91	90	91	90	89
Bhutan	5	5	5	5	5					
Nepal	283	285	286	282	274					
Sri Lanka	6	6	6	6	6	0	0	0	0	0
South-Eastern Asia	268	283	295	304	307	52	52	52	52	51
Myanmar	268	283	295	304	307					
Thailand						50	50	51	50	49
Papua New Guinea						2	2	2	1	1
Eastern Asia	679	682	680	668	646	347	345	345	341	335
China	636	638	636	624	602	334	332	331	327	322
South Korea	2	2	2	2	2	2	2	2	2	2
North Korea	40	41	42	42	42	11	11	11	11	11

Table 27 Baseline Projections for Yield of Millet and Sorghum from Irrigated Area

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	2.46	2.87	3.28	3.69	4.17	2.79	3.24	3.66	4.12	4.63
Southern Asia	2.43	2.84	3.24	3.64	4.10	0.80	0.94	1.09	1.25	1.44
Afghanistan	0.71	0.81	0.91	1.02	1.16					
Bangladesh	1.46	1.75	1.96	2.17	2.44	2.40	3.00	3.59	4.27	5.08
India	2.61	3.06	3.50	3.91	4.39	0.81	0.96	1.11	1.28	1.48
Pakistan	1.17	1.34	1.53	1.73	1.98	0.78	0.88	0.99	1.12	1.26
Eastern Asia	3.21	3.68	4.15	4.67	5.25	5.77	6.77	7.66	8.66	9.76
China	3.21	3.68	4.15	4.67	5.25	5.77	6.77	7.66	8.66	9.76

Table 28 Baseline Projections for Yield of Millet and Sorghum from Rainfed Area

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.77	0.9	1.03	1.18	1.37	1.19	1.34	1.5	1.68	1.89
Southern Asia	0.84	0.96	1.07	1.18	1.31	0.82	0.94	1.04	1.15	1.29
Bangladesh	1.44	1.68	1.86	2.03	2.24	2.15	2.38	2.55	2.77	3.12
Bhutan	1.31	1.54	1.74	1.92	2.16					
India	0.85	0.98	1.09	1.2	1.34	0.83	0.94	1.05	1.16	1.31
Iran	0.77	0.85	0.94	1.03	1.13					
Nepal	1.09	1.22	1.36	1.48	1.62					
Pakistan	0.22	0.23	0.25	0.26	0.28	0.3	0.32	0.35	0.38	0.41
Sri Lanka	1.13	1.33	1.52	1.71	1.96	0.88	1.05	1.25	1.48	1.76
South-Eastern Asia	0.68	0.78	0.91	1.06	1.25	2.22	2.49	2.75	3.05	3.43
Myanmar	0.68	0.78	0.91	1.06	1.25					
Papua New Guinea						2.86	3.14	3.44	3.84	4.47
Thailand						2.2	2.47	2.72	3.03	3.4
Eastern Asia	1.46	1.52	1.56	1.6	1.66	3.45	3.61	3.66	3.73	3.9
China	1.47	1.52	1.55	1.58	1.63	3.52	3.68	3.73	3.81	3.97
North Korea	1.36	1.54	1.71	1.9	2.14	1.83	1.94	1.97	2.01	2.06
South Korea	0.99	1.05	1.11	1.2	1.35	1.4	1.5	1.59	1.7	1.9

Table 29 Baseline Projections for Production of Millet and Sorghum from Irrigated Area

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	4,141	4,846	5,576	6,323	7,179	11,619	14,092	16,540	19,132	21,869
Southern Asia	3,121	3,637	4,180	4,741	5,407	951	1,105	1,293	1,485	1,701
Afghanistan	7	8	9	10	11					
Bangladesh	35	42	48	53	58	0	0	0	0	1
India	2,925	3,409	3,920	4,451	5,086	804	939	1,106	1,276	1,469
Pakistan	155	178	204	227	252	146	165	186	208	231
Eastern Asia	850	979	1,101	1,214	1,317	1,387	1,619	1,829	2,044	2,261
China	850	979	1,101	1,214	1,317	1,387	1,619	1,829	2,044	2,261

Table 30 Baseline Projections for Production of Millet and Sorghum from Rainfed Area

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	27,414	33,665	40,685	48,050	56,289	52,987	64,223	75,659	87,611	1,00,536
Southern Asia	8,801	9,401	9,863	10,099	10,291	7,178	7,806	8,351	8,701	8,915
Bangladesh	29	35	39	43	46	2	2	2	2	2
Bhutan	6	7	8	9	10					
India	8,367	8,910	9,318	9,514	9,668	7,149	7,774	8,317	8,665	8,876
Iran	11	13	15	17	19					
Nepal	307	349	388	418	445					
Pakistan	73	78	84	88	90	27	29	32	34	36
Sri Lanka	7	8	10	11	12	0	0	0	0	0
South-Eastern Asia	181	221	269	322	383	115	129	143	158	174
Myanmar	181	221	269	322	383					
Papua New Guinea						4	5	5	6	6
Thailand						111	124	138	152	168
Eastern Asia	992	1,038	1,060	1,068	1,074	1,198	1,246	1,261	1,273	1,305
China	935	971	986	985	982	1,175	1,221	1,235	1,247	1,278
North Korea	54	64	72	80	89	20	21	22	23	23
South Korea	2	3	3	3	3	3	3	4	4	4

Table 31 Percentage Deviation of Irrigated Area of Millet from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.32	0.53	0.78	1.04	1.31	-0.15	-0.04	-0.11	-0.18	-0.26
Southern Asia	0.32	0.54	0.80	1.07	1.34	-0.16	-0.05	-0.12	-0.20	-0.28
Afghanistan	0.30	0.52	0.76	1.01	1.25	-0.08	0.06	0.04	0.02	-0.01
Bangladesh	0.32	0.55	0.81	1.08	1.34	-0.04	0.12	0.14	0.15	0.15
Pakistan	0.34	0.60	0.88	1.17	1.45	-0.03	0.16	0.19	0.22	0.24
India	0.32	0.53	0.79	1.06	1.33	-0.17	-0.08	-0.17	-0.26	-0.35
Eastern Asia	0.27	0.46	0.67	0.90	1.12	-0.12	-0.01	-0.06	-0.11	-0.17
China	0.27	0.46	0.67	0.90	1.12	-0.12	-0.01	-0.06	-0.11	-0.17

	CSIR0-A1B					CSIRO-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.08	0.14	0.22	0.30	0.38	0.05	0.07	0.23	0.29	0.34
Southern Asia	0.08	0.14	0.22	0.30	0.37	0.05	0.07	0.23	0.30	0.35
Afghanistan	0.09	0.17	0.27	0.36	0.46	0.06	0.09	0.25	0.33	0.39
Bangladesh	0.11	0.21	0.31	0.42	0.53	0.07	0.12	0.29	0.38	0.46
Pakistan	0.12	0.23	0.35	0.47	0.59	0.08	0.14	0.33	0.43	0.51
India	0.07	0.13	0.20	0.27	0.35	0.04	0.06	0.22	0.28	0.33
Eastern Asia	0.07	0.13	0.20	0.28	0.35	0.04	0.06	0.21	0.27	0.32
China	0.07	0.13	0.20	0.28	0.35	0.04	0.06	0.21	0.27	0.32

Table 32 Percentage Deviation of Rainfed Area of Millet from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	-2.95	-6.05	-8.80	-11.20	-13.34	-0.23	0.14	0.11	0.09	0.07
Southern Asia	2.28	4.42	6.72	9.17	11.72	-0.33	-0.13	-0.30	-0.46	-0.62
Bangladesh	0.64	1.11	1.63	2.17	2.70	-0.09	0.25	0.28	0.31	0.31
Bhutan	0.63	1.07	1.58	2.10	2.62	-0.06	0.33	0.41	0.48	0.53
Iran	0.63	1.02	1.49	2.02	2.54	-0.47	-0.33	-0.61	-0.88	-1.15
Nepal	0.58	0.98	1.44	1.93	2.41	-0.20	0.04	-0.02	-0.09	-0.16
Pakistan	6.08	12.41	19.18	26.38	33.99	-0.06	0.32	0.39	0.44	0.47
Sri Lanka	0.66	1.12	1.66	2.23	2.77	0.02	0.49	0.65	0.80	0.93
India	2.21	4.25	6.43	8.74	11.13	-0.35	-0.15	-0.34	-0.51	-0.69
South-Eastern Asia	0.63	1.05	1.54	2.06	2.57	-0.03	0.41	0.52	0.63	0.71
Myanmar	0.63	1.05	1.54	2.06	2.57	-0.03	0.41	0.52	0.63	0.71
Eastern Asia	3.18	6.21	9.42	12.79	16.30	-0.23	-0.03	-0.13	-0.23	-0.34
China	3.37	6.58	10.00	13.60	17.36	-0.23	-0.02	-0.12	-0.22	-0.34
North Korea	0.45	0.74	1.08	1.46	1.83	-0.23	-0.07	-0.18	-0.28	-0.40
South Korea	0.44	0.68	1.00	1.37	1.75	-0.44	-0.37	-0.64	-0.90	-1.17
	CSIR0-A1B					**CSIRO-B1**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.27	0.53	0.83	1.15	1.47	0.19	0.34	0.83	1.10	1.36
Southern Asia	0.15	0.27	0.41	0.57	0.72	0.09	0.12	0.45	0.58	0.68
Bangladesh	0.22	0.41	0.63	0.85	1.07	0.15	0.25	0.59	0.76	0.92
Bhutan	0.29	0.56	0.86	1.16	1.46	0.22	0.39	0.82	1.07	1.29
Iran	0.12	0.21	0.32	0.45	0.59	0.06	0.05	0.38	0.48	0.55
Nepal	0.17	0.33	0.50	0.68	0.86	0.11	0.18	0.50	0.65	0.77
Pakistan	0.24	0.46	0.70	0.95	1.19	0.17	0.29	0.66	0.85	1.03
Sri Lanka	0.35	0.69	1.05	1.41	1.77	0.28	0.52	1.01	1.32	1.61
India	0.15	0.27	0.40	0.55	0.69	0.09	0.11	0.44	0.56	0.65

South-Eastern Asia	0.33	0.64	0.99	1.33	1.67	0.25	0.46	0.93	1.22	1.49
Myanmar	0.33	0.64	0.99	1.33	1.67	0.25	0.46	0.93	1.22	1.49
Eastern Asia	0.14	0.26	0.40	0.55	0.70	0.09	0.13	0.41	0.53	0.63
China	0.15	0.27	0.41	0.56	0.71	0.09	0.13	0.42	0.53	0.63
North Korea	0.13	0.23	0.35	0.48	0.61	0.08	0.12	0.37	0.48	0.56
South Korea	0.06	0.11	0.17	0.24	0.33	0.01	-0.03	0.22	0.27	0.30

Table 33 Percentage Deviation of Irrigated Yield of Millet from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.77	1.29	1.76	2.27	2.70	0.30	0.67	0.84	1.08	1.26
Southern Asia	0.21	0.36	0.54	0.73	0.92	0.07	0.28	0.40	0.51	0.64
Afghanistan	0.24	0.42	0.62	0.82	1.01	0.06	0.25	0.35	0.45	0.53
Bangladesh	0.27	0.48	0.71	0.94	1.16	0.07	0.29	0.41	0.51	0.61
India	0.28	0.50	0.75	1.00	1.25	0.08	0.30	0.43	0.55	0.68
Pakistan	-1.15	-2.29	-3.38	-4.42	-5.36	0.06	0.23	0.32	0.41	0.49
Eastern Asia	3.07	5.10	6.81	8.76	10.49	1.27	2.43	2.90	3.79	4.42
China	3.07	5.10	6.81	8.76	10.49	1.27	2.43	2.90	3.79	4.42
	CSIR0-A1B					**CSIRO-B1**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.09	0.17	0.21	0.35	0.46	0.03	0.05	0.08	0.17	0.22
Southern Asia	0.13	0.25	0.39	0.52	0.66	0.10	0.19	0.35	0.46	0.58
Afghanistan	0.14	0.27	0.41	0.55	0.69	0.11	0.21	0.38	0.50	0.62
Bangladesh	0.16	0.31	0.48	0.64	0.80	0.13	0.24	0.44	0.58	0.71
India	0.13	0.26	0.40	0.53	0.68	0.10	0.19	0.36	0.47	0.59
Pakistan	0.12	0.25	0.38	0.51	0.64	0.10	0.19	0.35	0.46	0.57
Eastern Asia	-0.08	-0.16	-0.56	-0.39	-0.49	-0.28	-0.57	-1.11	-1.19	-1.52
China	-0.08	-0.16	-0.56	-0.39	-0.49	-0.28	-0.57	-1.11	-1.19	-1.52

Table 34 Percentage Deviation of Rainfed Yield of Millet from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	2.33	5.35	8.17	10.79	13.23	0.82	0.50	0.99	1.48	1.95
Southern Asia	2.39	4.68	6.82	8.83	10.86	1.56	2.79	3.87	4.92	5.95
Bangladesh	0.61	1.18	1.77	2.36	2.95	0.07	0.29	0.41	0.51	0.61
Bhutan	2.54	5.16	7.87	10.66	13.51	0.06	0.25	0.35	0.45	0.53
Iran	-1.28	-3.13	-5.04	-7.25	-9.52	-0.51	-1.21	-1.97	-2.75	-3.76
Nepal	0.33	0.61	0.90	1.19	1.48	0.06	0.25	0.35	0.45	0.53
India	2.63	5.19	7.63	9.97	12.38	1.64	2.92	4.06	5.17	6.27
Pakistan	-0.81	-1.37	-2.07	-3.32	-5.13	0.92	2.28	3.72	5.34	6.80
Sri Lanka	0.10	-1.86	-5.11	-8.29	-11.33	3.06	5.31	5.84	6.32	6.82
South-Eastern Asia	1.03	2.03	3.05	4.08	5.11	0.05	0.19	0.26	0.33	0.40
Myanmar	1.03	2.03	3.05	4.08	5.11	0.05	0.19	0.26	0.33	0.40
Eastern Asia	5.19	10.63	16.36	22.56	29.38	0.73	1.48	2.08	2.65	3.32
China	5.20	10.70	16.53	22.91	30.03	0.77	1.56	2.21	2.83	3.58
North Korea	4.70	9.68	14.92	20.40	26.12	0.06	0.25	0.35	0.45	0.53
South Korea	2.36	4.69	7.08	9.53	12.01	0.05	0.20	0.28	0.36	0.42

	CSIR0-A1B					CSIRO-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	-0.06	-0.08	-0.10	-0.12	-0.15	0.07	0.25	-0.24	-0.26	-0.28
Southern Asia	-0.20	-0.20	-0.19	-0.15	-0.12	-0.37	-0.55	-0.66	-0.80	-0.96
Bangladesh	0.16	0.31	0.48	0.64	0.80	0.13	0.24	0.44	0.58	0.71
Bhutan	0.14	0.27	0.41	0.55	0.69	0.11	0.21	0.38	0.50	0.62
Iran	0.92	2.00	3.01	4.17	5.12	0.80	1.80	2.81	3.80	4.69
Nepal	0.14	0.27	0.41	0.55	0.69	0.11	0.21	0.38	0.50	0.62
India	-0.22	-0.24	-0.25	-0.22	-0.21	-0.41	-0.62	-0.75	-0.92	-1.11
Pakistan	0.60	1.45	2.50	3.62	4.87	1.22	2.83	3.96	4.56	5.09

Sri Lanka	0.65	1.15	1.65	2.13	2.63	1.02	1.77	2.56	3.29	4.05
South-Eastern Asia	0.10	0.20	0.31	0.41	0.52	0.08	0.16	0.29	0.38	0.46
Myanmar	0.10	0.20	0.31	0.41	0.52	0.08	0.16	0.29	0.38	0.46
Eastern Asia	0.18	0.33	0.47	0.57	0.66	-0.18	-0.36	-0.47	-0.64	-0.91
China	0.18	0.34	0.47	0.57	0.66	-0.20	-0.40	-0.53	-0.74	-1.05
North Korea	0.14	0.27	0.41	0.55	0.69	0.11	0.21	0.38	0.50	0.62
South Korea	0.11	0.22	0.33	0.44	0.55	0.09	0.17	0.31	0.40	0.49

Table 35 Percentage Deviation of Production from Irrigated Area of Millet from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	1.09	1.82	2.56	3.33	4.04	0.15	0.63	0.73	0.89	0.99
Southern Asia	0.53	0.91	1.34	1.80	2.27	-0.08	0.23	0.27	0.31	0.36
Afghanistan	0.54	0.94	1.38	1.83	2.27	-0.02	0.31	0.40	0.47	0.52
Bangladesh	0.59	1.04	1.53	2.03	2.52	0.03	0.41	0.55	0.67	0.77
India	0.60	1.04	1.55	2.07	2.59	-0.09	0.22	0.26	0.29	0.33
Pakistan	-0.81	-1.70	-2.53	-3.30	-3.99	0.03	0.39	0.52	0.63	0.73
Eastern Asia	3.35	5.58	7.53	9.73	11.73	1.16	2.41	2.84	3.67	4.24
China	3.35	5.58	7.53	9.73	11.73	1.16	2.41	2.84	3.67	4.24

	CSIR0-A1B					CSIRO-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.17	0.32	0.43	0.65	0.84	0.07	0.11	0.31	0.46	0.56
Southern Asia	0.21	0.40	0.60	0.82	1.04	0.15	0.25	0.58	0.76	0.93
Afghanistan	0.23	0.44	0.68	0.92	1.15	0.17	0.31	0.63	0.83	1.01
Bangladesh	0.27	0.52	0.79	1.06	1.33	0.20	0.37	0.73	0.96	1.17
India	0.20	0.39	0.60	0.81	1.03	0.14	0.25	0.58	0.75	0.92
Pakistan	0.24	0.48	0.73	0.98	1.23	0.18	0.34	0.68	0.89	1.09
Eastern Asia	-0.01	-0.03	-0.35	-0.12	-0.14	-0.24	-0.50	-0.91	-0.93	-1.21
China	-0.01	-0.03	-0.35	-0.12	-0.14	-0.24	-0.50	-0.91	-0.93	-1.21

Table 36 Percentage Deviation of Production from Rainfed Area of Millet from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	-0.69	-1.02	-1.34	-1.62	-1.88	0.60	0.64	1.10	1.58	2.02
Southern Asia	4.73	9.31	14.00	18.81	23.85	1.22	2.66	3.56	4.44	5.29
Bangladesh	1.25	2.30	3.43	4.58	5.73	-0.02	0.54	0.69	0.82	0.92
Bhutan	3.18	6.29	9.58	12.99	16.48	0.00	0.58	0.76	0.93	1.06
Iran	-0.66	-2.14	-3.62	-5.38	-7.22	-0.97	-1.54	-2.57	-3.60	-4.86
Nepal	0.91	1.59	2.35	3.15	3.93	-0.14	0.29	0.33	0.36	0.37
India	4.89	9.66	14.55	19.59	24.89	1.29	2.77	3.71	4.63	5.54
Pakistan	5.23	10.88	16.72	22.18	27.11	0.85	2.60	4.13	5.80	7.31
Sri Lanka	0.75	-0.76	-3.53	-6.25	-8.88	3.08	5.83	6.53	7.17	7.81
South-Eastern Asia	1.67	3.10	4.63	6.23	7.82	0.02	0.60	0.79	0.96	1.11
Myanmar	1.67	3.10	4.63	6.23	7.82	0.02	0.60	0.79	0.96	1.11
Eastern Asia	8.54	17.49	27.32	38.24	50.47	0.50	1.45	1.94	2.41	2.96
China	8.75	17.98	28.18	39.63	52.59	0.54	1.54	2.08	2.60	3.23
North Korea	5.17	10.49	16.16	22.15	28.43	-0.17	0.18	0.17	0.16	0.13
South Korea	2.81	5.40	8.15	11.03	13.97	-0.39	-0.17	-0.36	-0.55	-0.75

	CSIR0-A1B					CSIRO-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.21	0.45	0.73	1.02	1.32	0.26	0.59	0.58	0.83	1.07
Southern Asia	-0.04	0.07	0.22	0.42	0.60	-0.28	-0.43	-0.21	-0.23	-0.29
Bangladesh	0.37	0.72	1.11	1.49	1.87	0.27	0.49	1.03	1.35	1.63
Bhutan	0.43	0.83	1.28	1.72	2.16	0.33	0.60	1.20	1.57	1.92
Iran	1.05	2.22	3.34	4.64	5.74	0.86	1.85	3.21	4.30	5.27
Nepal	0.31	0.60	0.92	1.24	1.56	0.23	0.40	0.88	1.15	1.39
India	-0.07	0.03	0.15	0.33	0.48	-0.32	-0.51	-0.32	-0.36	-0.46

Pakistan	0.84	1.91	3.22	4.60	6.12	1.39	3.13	4.64	5.45	6.18
Sri Lanka	1.01	1.85	2.72	3.57	4.44	1.30	2.30	3.59	4.65	5.73
South-Eastern Asia	0.43	0.85	1.30	1.75	2.20	0.33	0.62	1.22	1.60	1.95
Myanmar	0.43	0.85	1.30	1.75	2.20	0.33	0.62	1.22	1.60	1.95
Eastern Asia	0.33	0.60	0.87	1.12	1.37	-0.09	-0.23	-0.06	-0.12	-0.29
China	0.33	0.60	0.88	1.13	1.37	-0.11	-0.27	-0.12	-0.21	-0.42
North Korea	0.27	0.51	0.77	1.04	1.31	0.19	0.33	0.76	0.98	1.18
South Korea	0.17	0.32	0.50	0.69	0.89	0.10	0.14	0.53	0.67	0.79

Table 37 Percentage Deviation of Irrigated Area of Sorghum from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.27	0.48	0.66	0.78	0.88	-0.08	-0.10	-0.13	-0.20	-0.20
Southern Asia	0.28	0.51	0.72	0.86	0.98	-0.06	-0.06	-0.08	-0.14	-0.14
Bangladesh	0.28	0.53	0.75	0.91	1.06	0.03	0.11	0.17	0.19	0.25
India	0.28	0.51	0.71	0.84	0.96	-0.07	-0.10	-0.13	-0.20	-0.22
Pakistan	0.29	0.54	0.76	0.92	1.06	0.05	0.12	0.19	0.23	0.29
Eastern Asia	0.24	0.43	0.61	0.72	0.82	-0.03	-0.03	-0.03	-0.07	-0.07
China	0.24	0.43	0.61	0.72	0.82	-0.03	-0.03	-0.03	-0.07	-0.07
	CSIR0-A1B					**CSIRO-B1**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.03	0.06	0.11	0.17	0.23	0.02	0.04	0.08	0.12	0.16
Southern Asia	0.03	0.06	0.09	0.14	0.18	0.02	0.03	0.07	0.10	0.12
Bangladesh	0.07	0.14	0.21	0.30	0.38	0.05	0.10	0.16	0.22	0.28
India	0.02	0.04	0.07	0.11	0.15	0.01	0.02	0.05	0.07	0.09
Pakistan	0.06	0.13	0.21	0.29	0.37	0.05	0.10	0.16	0.21	0.27
Eastern Asia	0.03	0.06	0.10	0.14	0.19	0.02	0.04	0.07	0.10	0.12
China	0.03	0.06	0.10	0.14	0.19	0.02	0.04	0.07	0.10	0.12

Table 38 Percentage Deviation of Rainfed Area of Sorghum from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					**MIROC-B1**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	-1.23	-2.53	-3.80	-5.11	-6.43	-0.07	-0.01	0.02	-0.01	0.08
Southern Asia	1.76	3.49	5.21	6.86	8.56	-0.15	-0.19	-0.26	-0.40	-0.43
Bangladesh	0.57	1.07	1.51	1.83	2.13	0.07	0.22	0.34	0.39	0.50
India	1.72	3.39	5.05	6.63	8.24	-0.15	-0.19	-0.27	-0.41	-0.44
Pakistan	6.19	12.49	19.09	25.91	33.08	0.09	0.25	0.39	0.45	0.59
Sri Lanka	0.58	1.08	1.54	1.87	2.16	0.18	0.46	0.71	0.88	1.13
South-Eastern Asia	0.36	0.64	0.87	1.00	1.09	-0.18	-0.26	-0.35	-0.51	-0.57
Papua New Guinea	0.55	1.00	1.42	1.73	2.00	0.15	0.39	0.60	0.75	0.96
Thailand	0.36	0.63	0.86	0.98	1.06	-0.19	-0.28	-0.38	-0.54	-0.62
Eastern Asia	2.42	4.77	7.16	9.53	11.98	-0.07	-0.06	-0.07	-0.15	-0.14
China	2.50	4.93	7.41	9.88	12.43	-0.07	-0.06	-0.07	-0.14	-0.13
North Korea	0.38	0.70	0.97	1.14	1.29	-0.08	-0.09	-0.13	-0.21	-0.21
South Korea	0.36	0.63	0.85	0.96	1.05	-0.25	-0.40	-0.58	-0.80	-0.94
	CSIR0-A1B					**CSIRO-B1**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.13	0.28	0.47	0.67	0.89	0.10	0.22	0.39	0.55	0.71
Southern Asia	0.04	0.09	0.14	0.22	0.30	0.02	0.05	0.10	0.15	0.19
Bangladesh	0.13	0.27	0.43	0.59	0.76	0.10	0.20	0.32	0.44	0.55
India	0.04	0.09	0.14	0.22	0.30	0.02	0.05	0.10	0.15	0.19
Pakistan	0.13	0.27	0.42	0.58	0.75	0.10	0.20	0.31	0.43	0.54
Sri Lanka	0.27	0.54	0.84	1.14	1.44	0.23	0.47	0.73	0.98	1.23
South-Eastern Asia	0.03	0.07	0.14	0.22	0.32	0.01	0.03	0.10	0.14	0.19
Papua New Guinea	0.24	0.49	0.76	1.04	1.32	0.20	0.41	0.64	0.87	1.09
Thailand	0.02	0.06	0.12	0.19	0.29	0.01	0.02	0.08	0.12	0.16
Eastern Asia	0.06	0.12	0.19	0.28	0.38	0.04	0.07	0.13	0.19	0.24
China	0.06	0.12	0.20	0.28	0.38	0.04	0.07	0.14	0.19	0.25
North Korea	0.05	0.10	0.16	0.24	0.32	0.03	0.07	0.12	0.17	0.22
South Korea	-0.04	-0.06	-0.08	-0.07	-0.04	-0.05	-0.10	-0.10	-0.12	-0.15

Table 39 Percentage Deviation of Irrigated Yield of Sorghum from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.43	0.62	0.71	0.72	0.75	0.16	0.30	0.36	0.43	0.48
Southern Asia	-0.28	-0.57	-0.83	-1.11	-1.38	0.11	0.25	0.38	0.48	0.60
Bangladesh	0.25	0.47	0.67	0.83	0.97	0.12	0.28	0.42	0.54	0.68
India	0.23	0.43	0.61	0.76	0.89	0.11	0.26	0.39	0.49	0.62
Pakistan	-3.10	-6.21	-9.34	-12.49	-15.62	0.10	0.22	0.34	0.44	0.56
Eastern Asia	2.21	3.27	3.93	4.77	5.37	1.57	2.68	3.09	3.85	4.39
China	2.21	3.27	3.93	4.77	5.37	1.57	2.68	3.09	3.85	4.39
	CSIR0-A1B					**CSIRO-B1**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.02	0.07	0.11	0.19	0.28	0.00	0.02	0.03	0.08	0.12
Southern Asia	0.12	0.24	0.37	0.49	0.62	0.10	0.20	0.31	0.42	0.53
Bangladesh	0.13	0.26	0.41	0.55	0.69	0.11	0.23	0.35	0.47	0.59
India	0.12	0.24	0.37	0.50	0.63	0.10	0.21	0.32	0.43	0.54
Pakistan	0.10	0.21	0.33	0.45	0.57	0.09	0.18	0.28	0.38	0.48
Eastern Asia	-0.12	-0.16	-0.49	-0.29	-0.33	-0.33	-0.55	-1.04	-1.05	-1.28
China	-0.12	-0.16	-0.49	-0.29	-0.33	-0.33	-0.55	-1.04	-1.05	-1.28

Table 40 Percentage Deviation of Rainfed Yield of Sorghum from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					**MIROC-B1**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.54	1.42	2.46	3.80	5.22	0.18	0.20	0.33	0.65	0.72
Southern Asia	2.10	4.57	6.72	8.73	10.74	1.69	3.00	4.21	5.40	6.58
Bangladesh	0.56	1.11	1.64	2.12	2.57	0.12	0.28	0.42	0.54	0.68
India	2.14	4.67	6.88	8.95	11.06	1.69	3.00	4.22	5.41	6.59
Pakistan	-1.24	-2.39	-3.75	-5.65	-8.05	0.88	2.02	3.25	4.59	5.77
Sri Lanka	-0.30	-1.86	-4.92	-7.99	-11.03	2.86	5.46	6.22	6.88	7.49
South-Eastern Asia	-1.85	-3.52	-5.28	-7.11	-9.06	-1.05	-1.89	-2.81	-3.79	-4.82
Papua New Guinea	-0.58	-1.16	-1.76	-2.39	-3.03	0.10	0.23	0.35	0.45	0.56
Thailand	-1.90	-3.62	-5.41	-7.28	-9.29	-1.10	-1.98	-2.94	-3.95	-5.03
Eastern Asia	4.11	8.41	12.95	18.00	23.73	0.94	1.70	2.40	3.11	3.95
China	4.07	8.31	12.81	17.81	23.49	0.95	1.73	2.44	3.17	4.02
North Korea	4.54	9.54	14.78	20.22	25.90	0.11	0.24	0.37	0.47	0.59
South Korea	2.32	4.66	7.04	9.44	11.86	0.09	0.19	0.29	0.38	0.47
	CSIR0-A1B					**CSIRO-B1**				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	-0.11	-0.21	-0.28	-0.34	-0.41	-0.06	-0.09	-0.17	-0.20	-0.24
Southern Asia	-0.22	-0.20	-0.16	-0.11	-0.06	-0.50	-0.78	-1.05	-1.32	-1.61
Bangladesh	0.13	0.26	0.41	0.55	0.69	0.11	0.23	0.35	0.47	0.59
India	-0.22	-0.20	-0.17	-0.12	-0.08	-0.50	-0.79	-1.06	-1.34	-1.63
Pakistan	0.53	1.26	2.13	3.05	4.04	1.11	2.50	3.38	3.84	4.24
Sri Lanka	0.59	1.14	1.70	2.23	2.74	0.93	1.80	2.67	3.51	4.32
South-Eastern Asia	0.44	0.84	1.24	1.65	2.06	0.37	0.71	1.04	1.39	1.74
Papua New Guinea	0.11	0.22	0.34	0.46	0.57	0.09	0.19	0.29	0.39	0.49
Thailand	0.46	0.86	1.27	1.69	2.11	0.38	0.72	1.07	1.42	1.78
Eastern Asia	0.26	0.49	0.71	0.92	1.16	0.08	0.16	0.24	0.32	0.40
China	0.27	0.50	0.72	0.93	1.17	0.08	0.16	0.24	0.32	0.39
North Korea	0.11	0.23	0.36	0.48	0.60	0.10	0.20	0.31	0.41	0.51
South Korea	0.09	0.18	0.28	0.38	0.48	0.08	0.16	0.24	0.33	0.41

Table 41 Percentage Deviation of Production from Irrigated Area of Sorghum from Baseline Projections under Alternative Climate Scenarios

			MIROC-A1B					MIROC-B1		
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.70	1.10	1.38	1.51	1.63	0.08	0.19	0.23	0.24	0.28
Southern Asia	-0.00	-0.05	-0.11	-0.26	-0.42	0.05	0.19	0.29	0.34	0.46
Bangladesh	0.53	1.00	1.43	1.75	2.04	0.16	0.39	0.59	0.73	0.93
India	0.50	0.94	1.33	1.61	1.86	0.04	0.16	0.25	0.29	0.39
Pakistan	-2.82	-5.70	-8.65	-11.68	-14.72	0.14	0.35	0.54	0.67	0.85
Eastern Asia	2.45	3.72	4.56	5.53	6.23	1.54	2.65	3.05	3.77	4.33
China	2.45	3.72	4.56	5.53	6.23	1.54	2.65	3.05	3.77	4.33
			CSIR0-A1B					**CSIRO-B1**		
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	0.05	0.13	0.22	0.35	0.51	0.02	0.05	0.11	0.20	0.29
Southern Asia	0.15	0.29	0.46	0.63	0.81	0.12	0.24	0.38	0.52	0.65
Bangladesh	0.20	0.40	0.62	0.85	1.08	0.16	0.33	0.51	0.69	0.87
India	0.14	0.28	0.44	0.61	0.78	0.11	0.23	0.37	0.50	0.63
Pakistan	0.17	0.35	0.54	0.74	0.95	0.14	0.28	0.44	0.60	0.76
Eastern Asia	-0.09	-0.10	-0.39	-0.15	-0.14	-0.32	-0.51	-0.97	-0.96	-1.16
China	-0.09	-0.10	-0.39	-0.15	-0.14	-0.32	-0.51	-0.97	-0.96	-1.16

Table 42 Percentage Deviation of Production from Rainfed Area of Sorghum from Baseline Projections under Alternative Climate Scenarios

	MIROC-A1B					MIROC-B1				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
World	-0.69	-1.15	-1.44	-1.51	-1.55	0.11	0.20	0.35	0.64	0.80
Southern Asia	3.90	8.22	12.28	16.18	20.22	1.54	2.80	3.94	4.98	6.12
Bangladesh	1.14	2.19	3.17	3.99	4.75	0.19	0.50	0.76	0.93	1.18
Pakistan	4.88	9.81	14.63	18.80	22.37	0.98	2.27	3.65	5.06	6.40
India	3.90	8.21	12.28	16.18	20.22	1.54	2.81	3.94	4.98	6.12
Sri Lanka	0.28	-0.80	-3.46	-6.26	-9.10	3.04	5.94	6.96	7.82	8.71
South-Eastern Asia	-1.49	-2.90	-4.45	-6.18	-8.07	-1.23	-2.15	-3.16	-4.28	-5.37
Papua New Guinea	-0.03	-0.17	-0.37	-0.71	-1.09	0.25	0.63	0.95	1.20	1.52
Thailand	-1.55	-3.01	-4.60	-6.37	-8.32	-1.29	-2.26	-3.31	-4.48	-5.62
Eastern Asia	6.63	13.57	21.04	29.25	38.55	0.87	1.64	2.32	2.96	3.81
China	6.67	13.65	21.17	29.45	38.84	0.88	1.67	2.37	3.02	3.89
North Korea	4.94	10.31	15.90	21.59	27.53	0.02	0.15	0.24	0.26	0.37
South Korea	2.69	5.32	7.95	10.49	13.04	-0.16	-0.21	-0.28	-0.43	-0.47
	CSIR0-A1B					**CSIRO-B1**				
World	0.02	0.07	0.19	0.32	0.47	0.05	0.13	0.22	0.34	0.47
Southern Asia	-0.17	-0.11	-0.01	0.11	0.24	-0.47	-0.74	-0.95	-1.17	-1.42
Bangladesh	0.26	0.54	0.84	1.15	1.46	0.21	0.42	0.68	0.92	1.14
Pakistan	0.67	1.53	2.56	3.65	4.82	1.21	2.70	3.70	4.29	4.80
India	-0.18	-0.12	-0.02	0.10	0.22	-0.48	-0.75	-0.97	-1.19	-1.45
Sri Lanka	0.86	1.68	2.55	3.39	4.23	1.16	2.28	3.41	4.52	5.59
South-Eastern Asia	0.48	0.91	1.38	1.88	2.39	0.39	0.74	1.14	1.53	1.93
Papua New Guinea	0.35	0.71	1.10	1.50	1.90	0.29	0.59	0.94	1.26	1.58
Thailand	0.48	0.92	1.39	1.89	2.41	0.39	0.74	1.15	1.54	1.95
Eastern Asia	0.32	0.61	0.90	1.20	1.54	0.11	0.23	0.38	0.52	0.64
China	0.33	0.62	0.91	1.21	1.56	0.11	0.23	0.38	0.52	0.64
North Korea	0.17	0.33	0.52	0.72	0.93	0.13	0.27	0.43	0.59	0.73
South Korea	0.06	0.12	0.21	0.31	0.44	0.03	0.06	0.14	0.21	0.26

Table 43 Baseline Prices and Deviation of Prices from Baseline Scenarios under Climate Scenarios

	Millet					Sorghum				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
Baseline	324.8	347.6	365.4	370.0	364.2	115.2	125.6	136.9	144.9	152.2
MIROC-A1B	1.98	3.55	5.27	7.02	8.71	1.81	3.45	4.97	6.17	7.26
MIROC-B1	0.52	2.11	2.97	3.78	4.51	0.89	2.04	3.11	3.98	5.00
CSIRO-A1B	1.15	2.27	3.50	4.71	5.91	0.95	1.93	3.01	4.07	5.14
CSIRO-B1	0.94	1.79	3.23	4.27	5.25	0.82	1.66	2.58	3.47	4.34

Table 44 Percentage deviation in area under maize, millet and sorghum from baseline scenario estimates under alternative climatic conditions

MAIZE	MIROC-A1B			MIROC-B1			CSIRO-A1B			CSIRO-B1		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	3.00	9.59	15.18	0.54	2.04	2.87	-0.38	-1.02	-1.73	-0.45	-1.27	-2.10
Southern Asia	3.57	11.06	17.25	1.43	4.41	6.31	-0.04	-0.33	-0.98	-0.04	-0.37	-0.99
India	3.93	12.12	18.91	2.26	6.91	10.57	0.41	1.06	1.50	0.40	0.97	1.44
South-Eastern Asia	2.33	7.25	11.27	-0.18	-0.41	-1.24	-0.77	-2.43	-4.24	-0.89	-2.79	-4.75
Eastern Asia	2.72	8.49	13.40	0.15	0.52	0.20	-0.58	-1.92	-3.49	-0.91	-2.89	-4.95
China	2.74	8.56	13.51	0.17	0.59	0.29	-0.56	-1.88	-3.43	-0.90	-2.86	-4.90

MILLET	MIROC-A1B			MIROC-B1			CSIRO-A1B			CSIRO-B1		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	-2.80	-8.40	-12.76	-0.22	0.10	0.06	0.26	0.80	1.43	0.18	0.80	1.32
Southern Asia	2.07	5.99	10.24	-0.31	-0.28	-0.57	0.15	0.39	0.67	0.09	0.42	0.63
India	2.01	5.77	9.79	-0.33	-0.32	-0.64	0.14	0.38	0.65	0.08	0.41	0.61
South-Eastern Asia	0.63	1.54	2.57	-0.03	0.52	0.71	0.33	0.99	1.67	0.25	0.93	1.49
Eastern Asia	2.36	6.96	12.07	-0.20	-0.11	-0.29	0.12	0.35	0.60	0.08	0.35	0.54
China	2.45	7.25	12.60	-0.20	-0.11	-0.29	0.12	0.35	0.60	0.08	0.35	0.54

SORGHUM	MIROC-A1B			MIROC-B1			CSIRO-A1B			CSIRO-B1		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	-0.98	-3.43	-5.84	-0.06	0.01	0.06	0.11	0.44	0.83	0.09	0.36	0.67
Southern Asia	1.43	4.63	7.46	-0.12	-0.23	-0.39	0.04	0.14	0.29	0.02	0.10	0.18
India	1.42	4.57	7.32	-0.13	-0.25	-0.41	0.04	0.13	0.28	0.02	0.09	0.17
South-Eastern Asia	0.33	0.87	1.09	-0.16	-0.35	-0.57	0.03	0.14	0.32	0.01	0.10	0.19
Eastern Asia	1.38	4.48	7.43	-0.05	-0.06	-0.11	0.04	0.15	0.30	0.03	0.11	0.20
China	1.40	4.56	7.58	-0.05	-0.05	-0.10	0.04	0.15	0.30	0.03	0.11	0.20

Table 45 Percentage deviation in maize, millet and sorghum yields over respective baseline scenario yields under alternative climatic conditions

MAIZE	**MIROC-A1B**			**MIROC-B1**			**CSIRO-A1B**			**CSIRO-B1**		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	-5.07	-14.48	-21.72	-2.03	-6.24	-9.58	-0.52	-1.45	-2.43	-0.33	-0.82	-1.49
Southern Asia	-3.57	-10.76	-17.56	-0.26	-1.30	-2.30	-1.00	-3.07	-5.04	-0.93	-2.70	-4.16
India	-1.74	-6.41	-11.68	0.76	1.06	0.91	-0.59	-1.89	-3.33	-0.51	-1.40	-2.07
South-Eastern Asia	-2.05	-6.76	-12.71	-0.65	-2.27	-4.72	-0.62	-1.86	-2.96	-0.78	-2.26	-3.44
Eastern Asia	-0.85	-3.49	-6.05	0.74	1.48	2.52	-0.39	-1.35	-2.24	-0.75	-2.33	-3.56
China	-0.84	-3.50	-6.06	0.75	1.49	2.52	-0.40	-1.36	-2.27	-0.76	-2.36	-3.61
MILLET	**MIROC-A1B**			**MIROC-B1**			**CSIRO-A1B**			**CSIRO-B1**		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	2.40	8.20	13.21	0.76	0.95	1.85	-0.06	-0.11	-0.16	0.05	-0.25	-0.30
Southern Asia	1.52	4.00	5.65	1.20	2.87	4.20	-0.12	-0.05	0.08	-0.26	-0.39	-0.50
India	1.72	4.66	6.82	1.26	3.01	4.43	-0.14	-0.09	0.02	-0.28	-0.46	-0.59
South-Eastern Asia	1.03	3.05	5.11	0.05	0.26	0.40	0.10	0.31	0.52	0.08	0.29	0.46
Eastern Asia	3.82	10.16	16.46	0.99	2.48	3.93	0.06	-0.06	-0.01	-0.23	-0.82	-1.29
China	3.76	9.93	16.01	1.02	2.56	4.07	0.05	-0.08	-0.04	-0.24	-0.86	-1.38
SORGHUM	**MIROC-A1B**			**MIROC-B1**			**CSIRO-A1B**			**CSIRO-B1**		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	0.66	2.58	5.15	0.17	0.32	0.65	-0.10	-0.24	-0.35	-0.05	-0.17	-0.23
Southern Asia	1.83	5.72	8.81	1.50	3.70	5.62	-0.18	-0.09	0.05	-0.43	-0.87	-1.27
India	1.95	6.14	9.60	1.53	3.77	5.75	-0.19	-0.10	0.02	-0.44	-0.90	-1.33
South-Eastern Asia	-1.85	-5.28	-9.06	-1.05	-2.81	-4.82	0.44	1.24	2.06	0.37	1.04	1.74
Eastern Asia	2.86	6.75	10.46	1.28	2.80	4.24	0.06	0.00	0.21	-0.14	-0.51	-0.66
China	2.84	6.64	10.25	1.29	2.82	4.27	0.06	-0.00	0.20	-0.14	-0.51	-0.67

Table 46 Percentage deviation in production projections of maize, millet and sorghum over baseline scenario projections under alternative climatic conditions

MAIZE	MIROC-A1B			MIROC-B1			CSIRO-A1B			CSIRO-B1		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	-2.22	-6.27	-9.83	-1.51	-4.34	-6.98	-0.90	-2.46	-4.12	-0.77	-2.09	-3.55
Southern Asia	-0.13	-0.89	-3.34	1.17	3.06	3.86	-1.04	-3.39	-5.97	-0.96	-3.06	-5.11
India	2.12	4.93	5.02	3.03	8.04	11.57	-0.18	-0.86	-1.88	-0.11	-0.44	-0.66
South-Eastern Asia	0.23	-0.00	-2.87	-0.82	-2.67	-5.90	-1.38	-4.24	-7.08	-1.66	-4.99	-8.03
Eastern Asia	1.85	4.70	6.55	0.89	2.01	2.72	-0.97	-3.24	-5.65	-1.66	-5.15	-8.34
China	1.88	4.76	6.63	0.92	2.08	2.82	-0.96	-3.21	-5.61	-1.66	-5.15	-8.34
MILLET	**MIROC-A1B**			**MIROC-B1**			**CSIRO-A1B**			**CSIRO-B1**		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	-0.47	-0.89	-1.23	0.54	1.05	1.90	0.20	0.70	1.27	0.24	0.55	1.02
Southern Asia	3.62	10.23	16.46	0.88	2.58	3.60	0.02	0.33	0.75	-0.17	0.03	0.13
India	3.77	10.70	17.27	0.93	2.69	3.76	0.00	0.28	0.67	-0.20	-0.05	0.01
South-Eastern Asia	1.67	4.63	7.82	0.02	0.79	1.11	0.43	1.30	2.20	0.33	1.22	1.95
Eastern Asia	6.27	17.83	30.51	0.79	2.37	3.62	0.18	0.28	0.59	-0.16	-0.47	-0.76
China	6.31	17.90	30.63	0.82	2.46	3.78	0.18	0.27	0.56	-0.17	-0.51	-0.84
SORGHUM	**MIROC-A1B**			**MIROC-B1**			**CSIRO-A1B**			**CSIRO-B1**		
	2010	2030	2050	2010	2030	2050	2010	2030	2050	2010	2030	2050
World	-0.45	-0.94	-0.98	0.11	0.33	0.71	0.02	0.19	0.48	0.04	0.20	0.44
Southern Asia	3.44	10.62	16.92	1.36	3.45	5.22	-0.14	0.05	0.33	-0.40	-0.77	-1.09
India	3.55	10.99	17.62	1.39	3.51	5.31	-0.15	0.03	0.30	-0.42	-0.81	-1.15
South-Eastern Asia	-1.49	-4.45	-8.07	-1.23	-3.16	-5.37	0.48	1.38	2.39	0.39	1.14	1.93
Eastern Asia	4.43	11.53	18.66	1.22	2.75	4.13	0.10	0.16	0.51	-0.11	-0.40	-0.47
China	4.43	11.50	18.61	1.23	2.77	4.16	0.10	0.15	0.50	-0.12	-0.41	-0.48