FOOD PRICE VOLATILITY AND NATURAL HAZARDS IN PAKISTAN

Measuring the impacts on hunger and food assistance

WFP
World Food Programme

SISMod - Shock Impact Simulation Model

Food price volatility and natural hazards in Pakistan

Measuring the impacts on hunger and food assistance

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Foreword

In recent years, there has been much concern over the increased volatility of global food commodity prices, climate change leading to a higher frequency of severe natural disasters, and political crises, all of which have adverse effects on food security. Both food producing/exporting countries and Low Income Food Deficit Countries (LIFDCs) are affected by recurring crises, which often send shockwaves through national economies and households, leading to a heightened situation of food insecurity.

In order to take timely action to avert a food crisis, countries need to be able to rapidly assess the impact of such shocks. As disasters are unpredictable by nature, often little time is available for assessment, planning and response. Developing countries may not have the capacity to do such rapid assessments. Furthermore, these countries may be concurrently experiencing other types of economic or political crises, making assessment even more difficult.

Addressing the multi-dimensional factors that underpin food insecurity and poverty requires livelihoods-based analytical tools to better understand food security at global, national and household levels. The global food and financial crises have demonstrated that priority should be given to supporting national and global capacities for timely and forward-looking impact assessments.

Both the Global Information and Early Warning System (GIEWS) of FAO and the Food Security Analysis Service (ODXF/VAM) of WFP monitor the food security situation in all developing countries, and jointly conduct the FAO/WFP Crop and Food Security Assessment Missions (CFSAM) in countries with current or potential food emergencies. Estimating food availability, access and food assistance needs, and analyzing and targeting vulnerable groups for such rapid assessment missions have proven very difficult because of the lack of analytical tools and baseline information for vulnerable groups.

In light of the above, a Shock Impact Simulation Modeling System (SISMOD) was developed jointly by FAO and WFP to simulate the impacts of shocks on household food consumption. The SISMOD builds on existing nationally representative household survey data. This model is regarded as a strong alternative to nationwide assessments, as it can be used as a cost-effective, time-efficient tool prior to in-depth assessments conducted on the ground in the most affected areas and populations. The results of the simulation can also support early warning and contingency planning for potential shocks and a more rapid response to shocks as they occur. The SISMOD provides estimates of the proportion of undernourished people by livelihood and income group, as well as by geographical area. It thus contributes to geographic and community targeting in selected LIFDCs that are highly vulnerable to reoccurring crises.

This book presents the case study for Pakistan, which is the first of five case studies carried out in LIFDCs. The methodological and analytical approach of the SISMOD are presented here, together with extensive baseline information on the vulnerability situation of Pakistan by livelihood and income groups and geographical areas. The results of the simulation of the combined impacts of high food price crisis and climate shocks (floods) provide guidance to policymakers on the most affected areas and population groups. The methodology and the tools used for Pakistan have now been refined in order to ensure effective replication in other countries subject to large-scale shocks.

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Acronyms

AHM	Agriculture Household Models
AJK	Azad Jammu Kashmir
APC	Average Propensity to Consume
APS	Average Propensity to Save
CPI	Consumer Price Index
CRED	Centre for Research on the Epidemiology of Disasters
CV	Coefficient of Variation
DEC	Dietary Energy Consumption
DECR	Dietary Energy Consumption Requirement (or threshold)
ECM	Error Correction Model
FAO	Food and Agriculture Organization
FATA	Federally Administrated Tribal Area
FG	Food Gap
FR	Frontier Regions
FSRI	Food Security Risk Index
FY	Fiscal Year
GB	Gilgit- Baltistan
GDP	Gross Domestic Product
GIEWS	Global Information and Early Warning System of the Food and Agriculture Organization (FAO)
GOP	Government of Pakistan
H	Hectare
HIES	Household Integrated Economic Survey
IDPs	Internally Displaced Persons
ISIC	United Nations International Standards Industrial Classification of All Economic Activities
ISU	International System of Units
FATA	Federally Administered Tribal Areas
Kcal	Kilo Calories
KG	Kilogram
KM²	Square Kilometers
KPK	Khyber Pakhtunkhwa
LAIDS	Linear Approximate Almost Ideal Demand System
LES	Linear Expenditure System
LIFDC	Low Income Food Deficit Countries
MDGS	Millennium Development Goals
MINFA	Ministry of Food and Agriculture
MFN	Most Favorable Nations

MT	Metric tonnes
MMT	Million metric tonnes
MY	Market year
NDVI	Normalized Difference Vegetation Index
NFSS	National Food Security Strategy
ODXF	Food Security Analysis Service of World Food Programme
PAK	Pakistan Administered Kashmir
PARC	Pakistan Agriculture Research Council
PE	Partial Equilibrium
PSLM	Pakistan Social and Living Standards Measurement Survey
Rs	Rupees
SISMOD	Shock Impact Simulation Model
TTRI	Tariff Trade Restrictiveness Index
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
USD	United States Dollar
WFP	World Food Programme
WHO	World Health Organization
WTO	World Trade Organization

Glossary

Average propensity to consume (Apc)

APC is defined as the ratio of a household's spending or consumption to its disposable income. In turn, the 'average propensity to save' or APS is the ratio of the family's savings to its disposable income. The resulting sum of APC and APS is one; that is, one hundred percent of disposable income.

Crop income

The estimation of crop income accounts for the sale of crop production, crop by-product production, sharecropping, the consumption of household crop production, net of all expenditures incurred in realizing these activities, such as agricultural inputs (seeds, pesticides and fertilizers) and the hiring of farm labour.

Depth of hunger (kcal/person/day)

Refers to the difference between the average dietary energy intake of an undernourished population and its average minimum dietary energy consumption requirement (DECR). (Average gap between Minimum DECR and DEC for the undernourishment population).

Dietary energy consumption (DEC) (kcal)

Food consumption expressed in energy terms. At sub-national levels it is estimated using food consumption data, with quantities collected from in national household surveys; these estimates refer to private food consumption. Average DEC is the average per capita daily total food calorie intake.

Dietary energy consumption requirement (DECR)

The threshold amount of dietary energy per person adequate to meet the energy needs for minimum acceptable limit of the range of body-weight for attained-height and the light physical activity norm. For a population, the overall daily dietary energy requirement per person is derived by aggregating the sex-age requirements weighted by the proportion of each sex and age group in the total population.

Disaster

A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.

Household income

Household income is disaggregated into crop income, livestock income, wage income and remittance income.

Livestock income

The livestock income category includes income from the sale and barter of livestock, livestock by-product production (i.e. milk, eggs, honey etc.), net of expenses related to livestock production (e.g. fodder, medicines) and livestock purchases, plus the value of household consumption of own livestock and livestock by-product production.

Percentage of people consuming less than the threshold of DECR (<2 350 kcal/person in adult eq./day)

Percentage of people with daily kilocalorie (kcal) intake <2 350 kcal in adult equivalent.

Percentage of people consuming less than the threshold of DECR (<2 100 kcal/person/day)

Percentage of people with daily kilocalorie (kcal) intake <2 100 kcal.

Percentage of people consuming less than the threshold of DECR (<1 730 kcal/person/day)

Percentage of people with daily kilocalorie (kcal) intake <1 730 kcal.

Remittance income

Remittance income is separated from other income. Remittance income can be sourced by domestic transfer income and overseas transfer income.

Total cereal gap in wheat equivalent (tonnes) (or food gap in quantity of wheat equivalent)

Total gap for all undernourished people in a year (converted from kcal to wheat equivalent).

Undernourishment

Refers to the condition of people whose dietary energy consumption is continuously below a minimum dietary energy requirement (MDER) for maintaining a healthy life and carrying out light physical activity. The number of undernourished people refers to those in this condition.

Number of people undernourished

Total number of people who are undernourished.

Wage income

Wage income consists of all income received in the form of employee compensation either in cash or in kind. Wage employment income is first disaggregated by industry in the survey. The classification is based on the United Nations International Standards Industrial Classification of all Economic Activities (ISIC). As the classification of industries changes over time, the most appropriate revision of the ISIC classification standards is chosen based on the year the survey was undertaken. In the survey, industries are grouped into ten principal categories: agriculture; forestry and fishing; mining; manufacturing; utilities; construction; commerce; transportation, communications and storage; finance and real estate; services; and miscellaneous. Using this industrial classification, total wage employment income is separated into three aggregate categories: agricultural wages, non-agricultural private wages, and non-agricultural public wages.

Preface

This book forms part of the output from the joint FAO/WFP Project (JP) created to develop a Shock Impact Simulation Model (SISMod) for Food Security Monitoring and Needs Assessment for selected vulnerable countries. The initial phase of the current project focused on shock-prone food-deficit countries representing different levels of exposure to shocks: Bangladesh, Nepal, Pakistan, Tajikistan, Niger, Tanzania and Uganda.

Pakistan is the first of five case studies. In recent years, Pakistan has faced the combined impacts of the global food price, fuel and financial crises and a series of climate shocks, which have increased undernourishment significantly. These events have also sent shockwaves through the national economy. To analyse the impact of these shocks on food security, the JP team processed household survey data, conducted a household food demand analysis, developed profiles on vulnerability to food insecurity at national, subnational and household levels, and carried out studies on market integration. The model developed for Pakistan was applied during the 2010 multi-agency Damage and Needs Assessment in Pakistan, which was led by the Asian Development Bank/World Bank and the UN Mission on Floods Impact on MDG Analysis in Pakistan led by UNDP. Furthermore, the model has been applied by the WFP for programme formulation activities in Pakistan for 2012.

Executive summary

Synopsis

- Recent increases in global food prices, high frequency of natural disasters and political crises have had adverse effects on household food security. Many countries are affected by reoccurring crises. In this first case study, the impact of market and climate-related shocks on household food consumption are quantified in Pakistan, using a series of modules that derive food consumption information from household income levels.

- The study first assesses the baseline vulnerability context in different geographic areas for a range of household livelihood groups through three profiles: market integration of staple food commodities, nationwide vulnerability to natural disasters, and household vulnerability.

- The results of the simulation model indicate that the number of undernourished people (as per the Government of Pakistan's calorie consumption threshold of 2 350 kcal/adult/day) increased from 77.6 million in 2005/06 to 95.7 million by the end of 2010. The increase can be attributed to price inflation (about 13 million people) and to the massive flood disaster in August 2010 (an additional five million people). The consumption shortfall for the undernourished population equals 6.2 million tonnes of wheat per annum to combat the impacts of the recent shocks.

- If a lower minimum per capita consumption standard of 2 100 kcal/person/day is applied, the number of undernourished people reaches 99.2 million (an additional 11.5 million owing to price inflation and five million because of floods, from a baseline value of 82.7 million). The national food gap becomes some 6 million tonnes of wheat per annum. If the minimum daily energy requirement of 1 730 kcal/person/day is used, the number of undernourished people becomes 65 million (an additional 14 million because of price inflation and 7 million because of floods, from a baseline value of 44 million), and the national food gap becomes 2.7 million tonnes per annum.

- Pakistan's per capita wheat consumption has been declining in recent years in response to high prices and the reduction in incomes, leading to a rise in wheat stocks. In terms of the national balance sheet, Pakistan is expected to be balanced in wheat while continuing to be a net exporter in rice, albeit with a reduction in volume by over one million tonne.

Background and approach

Recently there has been a marked increase in the number of countries facing food crises. Some of the underlying causes have included higher global food commodity price and increased volatility, higher frequency of severe natural disasters and political crises. National and global methods for prompt assessments are weak in supporting timely responses to food crises in many developing countries. While many sudden-onset natural disasters leave little time for assessment and response, man-made disasters present even more challenges to conducting increasingly complex and in-depth analyses. Therefore, there has been an urgent need to develop an effective Early Warning System that signals potential shocks and allows a quick response to crises.

This report presents such a system: a shock impact modeling system (SISMOD) that was developed jointly by WFP and FAO, to simulate the impacts of shocks on household food consumption. The SISMOD builds on existing nationally representative household survey data. This model reduces the need for in-depth nationwide assessments, which can then be limited to the most affected areas and populations. Geographic and community targeting is made possible as the SISMOD provides estimates of the proportion of undernourished people by livelihood, income group and geographical area. It is being piloted in selected Low- Income Food- Deficit Countries (LIFDCs) that are highly vulnerable to reoccurring crises.[1]

The results of the Pakistan case study are presented here. In recent years, Pakistan has faced several crises, including the 2008 global food, fuel and financial crises, and a series of major natural disasters, which have increased undernourishment significantly and sent shockwaves through the national economy. In 2008, a UN Interagency mission was conducted in Pakistan in order to assess the impact of food price hikes in the country. This mission was supported by the Government of Pakistan and other stakeholders.[2] As the analytical method developed for this assessment was recognized to be very useful, the methodology was further refined, in order to enable effective replication in other countries vulnerable to large-scale shocks.

The project consisted of two parts. In part 1, the vulnerability context of Pakistan was assessed using baseline data (i.e. without shocks), and the areas and livelihood groups most vulnerable to potential shocks were identified. Three profiles were used to assess the vulnerability context. The first provides a market integration analysis of staple food commodities, and determines the markets that are most receptive or vulnerable to international and domestic food price shocks. The second profile reviews the historical records of nationwide vulnerability to natural disasters and highlights the areas that are most vulnerable to climate shocks. An understanding of the relationship between weather patterns and staple crop production, and the implications for household food security are provided. The third profile estimates the baseline caloric intake of households and analyses the vulnerability of livelihood groups to shocks by combining households' main income sources with the shock factors. These three baseline vulnerability profiles provided contextual information for the modeling by highlighting factors that make households sensitive to market and climate shocks.

The second part was the simulation of the impact of shocks on household food consumption (measured by caloric intake) through a series of modules following three steps: estimation of incomes, allocation of incomes through a two-stage budget allocation demand system by income group, and estimation of equivalent caloric intake. The simulation results show the population groups that were most affected by previous shocks and the groups that are most likely to be affected by future shocks.

1 These countries include: Bangladesh, Tajikistan, Tanzania, Nepal and Pakistan.

2 The UN Inter Agency (FAO/UNDP/UNICEF/WFP/WHO) Assessment Mission. High Food Prices in Pakistan: Impact Assessment and the Way Forward
http://www.un.org.pk/wfp/Pakistan_High%20Food%20Prices%20_11%20Aug%202008_.pdf

1. Introduction

1.1 Background and rationale

In recent years, the increase in global food commodity price and their volatility, climate change with higher frequency of severe natural disasters, and political crises have had adverse effects on food security. Both food producing/exporting countries and Low-Income Food-Deficit Countries (LIFDCs) are affected by reoccurring crises, which often send shockwaves through national economies and households, leading to a heightened situation of food insecurity. Estimates show that more than 1 billion people are undernourished worldwide; a substantial increase has occurred in the number of undernourished people in recent years as a result of these shocks (FAO, 2009).

National and global methods for prompt assessments and estimates of the impacts of shocks are weak in supporting timely national responses to food crises in many developing countries. Many sudden-onset natural disasters leave inadequate time for assessment, planning and response. Man-made disasters present even more technical challenges towards conducting increasingly complex and in-depth analyses of socio-economic factors.

In view of the above, a shock impact modeling system (SISMOD) is being developed jointly by the Food Security Analysis Service (OSZA/VAM) of the World Food Programme (WFP) and the Global Information and Early Warning System (GIEWS) of the Food and Agriculture Organization (FAO) to simulate the shock impact on household food consumption. The SISMOD builds on existing nationally representative household survey data. This model is regarded as a strong alternative to nationwide assessments, as it can be used as a cost and time-effective tool by reducing the scope of in-depth ground-truthing assessments to the most affected areas and populations. The results of the simulation can also support early warning for potential shocks and early response to shocks that have taken place. The SISMOD provides estimates of the proportion of undernourished people by livelihood and income groups, as well as by geographical area. Therefore, it can contribute to geographic and community targeting. It is being piloted in selected LIFDCs that are highly vulnerable to reoccurring crises.[3]

Pakistan is the first of the five case studies. In recent years, Pakistan has been faced with the combined impacts of the 2008 global food price, fuel and financial crises and a series of climate shocks, which have increased undernourishment significantly.

[3] These countries are Bangladesh, Burkina Faso, Malawi, Nepal and Pakistan.

Pakistan has experienced several natural disasters over the past few years, from the massive Kashmir earthquake in October 2005 to the August 2010 flood, which affected over twenty million people (EM-DAT, 2010). These events have all sent shockwaves through the national economy and aggravated the food insecurity situation especially of vulnerable population.

In 2008, a United Nations Interagency mission was conducted in Pakistan, supported by the Government of Pakistan and other stakeholders, to conduct an assessment of the impacts of food price hikes in the country.[4] The findings and recommendations of this assessment resulted in the rapid launch of a safety-net program for vulnerable populations in the most affected areas as well as in policy action within the framework of a National Task Force on Food Security established by the Prime Minister. The analytical method used for the inter-agency assessment was recognized as very useful. As a result, it was recommended that the methodology and tools be refined, in order to ensure effective replication in other countries that are subject to large-scale shocks.

1.2 Approach

The approach to this project and the present report is two-fold: to assess the vulnerability profile of the country and to develop a shock simulation model. Part one assesses the vulnerability context of Pakistan using baseline data (i.e. without shocks). It identifies the areas and livelihood groups that are most vulnerable to potential shocks and describes the food security situation of households measured in terms of caloric intake. This vulnerability profile provides contextual information for the modeling exercise by highlighting factors that make households sensitive to market and climate shocks.

Part two develops a framework for the Shock Impact Modeling System (SISMOD) which quantifies the impact of the recent market and climate shocks on household food consumption in Pakistan. The simulation results show which population groups are most affected by previous shocks and which groups are most likely to be severely affected by future shocks. Chapter 2 provides a methodological note on the SISMOD and market integration and crop production monitoring analyses.

Part one: Vulnerability profiles

The vulnerability context of Pakistan was assessed through three profiles. The first vulnerability profile, Market Environment and Vulnerability to Food Price Shocks, provides a market integration analysis of staple food commodities, and determines the markets that are most receptive or vulnerable to international and domestic food

[4] The UN Inter Agency (FAO/UNDP/UNICEF/WFP/WHO) Assessment Mission. High Food Prices in Pakistan: Impact Assessment and the Way Forward
http://www.un.org.pk/wfp/Pakistan_High%20Food%20Prices%20_11%20Aug%202008_.pdf

price shocks. This chapter provides brief contextual information on the macroeconomic context, trends in the agricultural sector, and trade policies, to identify the current trends among shock factors. This profile also provides parameters on price transmission for the SISMOD.

The second profile, Vulnerability to Natural Risks, Shocks and Hazards, reviews the historical records of nationwide vulnerability to natural disasters and highlights the areas that are most vulnerable to climate shocks. It provides an understanding of the relationship between weather patterns and staple crop production and the implications for household food security. This profile provides the parameters for crop production monitoring, taking into account the impacts of weather related variables such as rainfall. The estimated productions are then used in the SISMOD.

The third profile, Household Vulnerability and Food Security, estimates the baseline caloric intake of households and analyses the vulnerability of livelihood groups to shocks by combining households' main income sources with the shock factors. In this third profile, it is assumed that the extent to which the impact of a shock is transmitted to households largely depends on their main income sources and on their level of dependency on markets.

Part two: Shock impact modeling system (SISMOD): Simulating the impacts of shocks on household food consumption

The second part, and core of this report, is the simulation of the impact of shocks on household food consumption measured by caloric intake. The simulation model (SISMOD) estimates the impacts of market and climate shocks on household caloric intake through a series of modules following three steps: estimation of incomes, allocation of incomes through a two-stage budget allocation demand system by income groups, and estimation of equivalent caloric intake. The SISMOD simulates the percentage change in households' caloric intake from the baseline situation, the corresponding number of undernourished people and the food requirements to meet the needs of the affected people. The simulation results show the population groups that were most affected by previous shocks and the groups that are most likely to be affected by future shocks.

2. Methodology

The following methodological note provides a detailed description of the approach and methods used in this assessment. This methodology chapter is organized into four main sections. The first section provides the theoretical background of the decision-making process of agricultural households. The second section explains the general framework of the Shock Impact Modeling System (SISMOD), to connect the various components which simulate shock factors on income, expenditures, and consumption. The third section describes the methods used in the market integration analysis and crop production analysis in the vulnerability profiling and in deriving parameters for market and crop monitoring in SISMOD. The fourth section provides an in-depth methodological note on SISMOD, which articulates the process of simulating the impacts of shock factors on household food consumption, by simulating shocks on household income, simulating household income to total/food expenditures, and measuring undernourishment and food needs.

2.1 Theoretical background: How household income and price variations impact food consumption

This study adopts the Agricultural Household Models (AHM) approach developed by Singh *et al.* (1986). Household-farm models are used to analyse how household-specific transaction costs shape the impacts of exogenous factors, like policy and market changes in rural areas. The application of such modeling techniques have included a gambit of research initiatives, ranging from technology adoption and migration to deforestation and biodiversity. It is now becoming a tool for price policy analysis.

The AHM approach developed by Singh *et al.* (1986) incorporates both the production and consumption sides, integrates the price effects on different markets, and takes in account the interaction between them. Previous models, like a single-market approach have not captured such a comprehensive effect, which consider consumers and producers separately. Household-farm models acknowledge that production and consumption decisions are linked because the deciding entity (rural household) is both a producer and consumer (Kuroda and Yotopoulos, 1978). An intricate source of the household income is farm profits, which include implicit profits from goods produced and consumed by the same household. Household consumption includes goods that are both purchased from the market and self-produced. As long as perfect markets for all goods, including labour, exist, the household is indifferent between consuming self-produced and market-purchased goods.

The fundamental difference between an AHM and pure consumer model is that the household budget is generally assumed to be fixed in a pure consumer model, while in AHM it is endogenous and depends on production decisions that contribute to income through farm profits in AHM. To the standard Slutsky effects of the consumer model, AHM adds an additional, "farm profit" effect, which can be positive or negative. Therefore, the traditional price effect, where household demand decreases as a result of price increases, is comprised by the farm profits effect, which adds a positive influence to the negative Slutsky effects on food demand that may increase household food consumption.

Full income represents the household budget constraint. As a consumer, the household selects a consumption bundle to maximize utility subject to his income, given prices of all consumption goods. Utility-maximizing consumption is expressed in the following form:

(1) $C^*_i = C_i \ (P, Y^*)$

In the standard consumer model, consumption of goods (C*i) depends on own prices, prices of related goods (P), and income (Y*). However, in the household-farm model, income is endogenous and depends upon production decisions.

Market equilibrium conditions for individual goods or factors depend upon whether the item or factor in question is tradable or non-tradable for the household. For tradable goods, prices are exogenous, determined by outside markets. Markets clear through supply and demand and determine the marketed surplus (MS*):

(2) $MS^*_i = Q^*_i - C^*_i$, where Q = Supply, and C = Demand

Use of household-farm models for comparative static analysis for simulation

The motivation for constructing AHM is to understand impacts of polices and other exogenous shocks on household-farm behavior. Following Ulimwengu and Ramadan (2009), the most general form of the comparative static equations in term of own-price shock is the following:

(3) $$\frac{dq_i}{dp_i} = \left(\frac{\partial q_i}{\partial p_i}\right) + \left(\frac{\partial q_i}{\partial R_i}\right)\left(\frac{\partial R_i}{\partial p_i}\right)$$

A change in the price (p_i) of a given commodity (i) affects both the supply and the demand decisions. The net impact on household food consumption (qi)depends on the importance of the commodity in terms of both consumption and profit. In equation 3, the first term on the right-hand side of above equation is the direct impact on consumption. The second term on the right-hand side of the above equation is the profit/income effect, which indirectly effects through profit/income (R_i). In other words, the change in price affects the farm profit/income, which in turn affects the full income available for the household. The final impact of the price change on the quantity consumed is a net effect from both terms, which depends on which effect is the most important.

The above equation can be rewritten in term of elasticities as:

(4) $$\frac{dq_i p_i}{dp_i q_i} = \left(\frac{\delta q_i p_i}{\delta p_i q_i}\right) + \left(\frac{\delta q_i R_i}{\delta R_i q_i}\right)\left(\frac{\delta R_i p_i}{\delta p_i R_i}\right) = \eta^{p_i} + \eta^R \Theta^{p_i}$$

The change of food price is a function of own-price elasticity (η^{pi}), income elasticity (η^R), and profit elasticity ($\Theta^{\uparrow pi}$).

The equation can be reordered as the following:

(5) $$\frac{dq_i}{q_i} = \frac{\delta p_i}{p_i}(\eta^{p_i} + \eta^R \Theta^{p_i})$$

Similarly, the cross price effects of commodity j on the consumed quantity i of commodity I can be derived in the elasticity terms as follows:

(6) $$\frac{dq_i}{q_i} = \frac{\delta p_j}{p_j}(\eta^{p_{ij}} + \eta^R \Theta^{p_{ij}})$$

Hence, the net impact of food price changes on food consumption of each commodity is a function of own-price elasticity, cross-price elasticities, income elasticity, and profit elasticity with respect to food prices.

In terms of climate shocks, such as droughts or floods, both prices and profit/income may be affected. The price effects can be analysed by partial equilibrium of commodities at market level. The shock impact on income/profit can be assessed by linking household production and profit to the shock factors (the framework is presented in the next section).

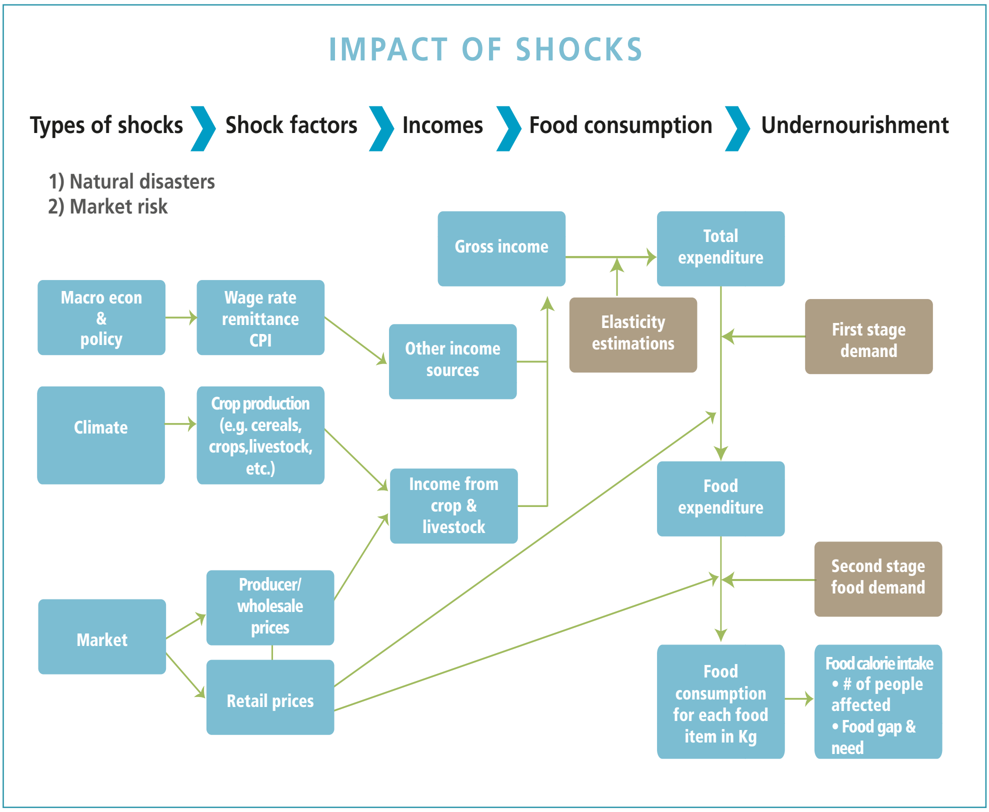
The own-price elasticity, cross-price elasticities, and income elasticity will be estimated by a demand system based on household survey data. The details on the data and estimation methods are provided in the following sections.

2.2 Framework of shock impact modeling system (SISMOD): Simulating effects on household food consumption

The shock impact modeling system is composed of several modules that represent the decision-making process of an agricultural household. This process determines the interaction between production decisions (profit effect) and consumption (price effect), which quantifies the impacts of price changes and production changes on household food consumption. Figure 1 provides a simple schematic description of the model structure. The model links several components together, such as market monitoring component, crop production monitoring, income generation module, a two-stage budget allocation module, and food consumption module.

Climate and market shocks are measured directly by the changes in production, wages, and prices from the baseline year to any given year when a shock takes place. These changes in the shock factors are then used to estimate new incomes in the shock year(s) to account for the shock in determining its impact on food consumption. Climate shocks (droughts/floods, landslide, cyclones etc.) are linked to income in different ways: direct production changes, yield changes or area changes. Income is explicitly specified to be determined by three major factors: production level, price, and cost of production. A climate shock will directly or indirectly impact crop income.

Figure 1. Shock impact modeling system framework



Crop production monitoring and market monitoring are two modules used to track the changes in the shock factors, either based on past patterns for simulating the impact of past shocks for ex-post analysis or based on forecasted changes for ex-ante analysis. For early warning purpose, crop harvested area of a specific crop i (for example, maize) is a function of own price, competing crop prices, total land owned in the household, and household size. Crop production is specified as a area and yield, which is a function of rainfall and time trend, a proxy indicator of technology development.

The market monitoring module includes a commodity partial equilibrium[5] model(PE) and a set of price transmission equations. Price formulation, in individual country sub-models, is specified as either price transmission from the world price or market clearing when there are significant restrictions in trade flow. The PE aims to clear the market and generate market prices in the national/regional leading market. Prices in local markets are derived by estimated price transmission elasticities.

The income generation module is used to link shocks to household income, which is aggregated into the following categories: crop income, livestock income, agricultural wage income,[6] non-agricultural wage income, public wage income, remittance income, and other income. Each income category is subject to different shocks directly or indirectly. Crop income is categorized by major crop in order to assess the impact of different shocks in different seasons. Crop income is separated into wheat, rice, maize, pulses, cotton, sugarcane, and other crop income. Other income in the households such as wage income is a function of GDP, wage rate, and CPI.

The food consumption module is the core of the system, which simulates the impacts of income and price changes on food consumption. Food consumption impact analyses hinge critically on the underling functional form for representing consumer demand. Simple functional forms can lead to unrealistic estimations by failing to capture changes in income and price elasticities of demand for different population groups. The two-stage budgeting procedure assumes that the consumer's utility maximization decision can be decomposed into two separate steps. In the first stage, total household expenditure is broken down over eight broad commodity groups which include: food, clothing, fuel, housing, durable goods, education, medical, and other items. In the second stage, household food expenditure is allocated over ten food subgroups which include: rice;

5 In structure of the partial equilibrium models, the following identity is satisfied for each country/region and the world: Beginning Stock + Production + Imports = Ending Stock + Consumption + Exports. Production is divided into yield and area equations, while consumption is divided into food, feed and other demand. To satisfy the identity, two different methods are used. In most of the countries, domestic price is modeled as a function of the world price with a price transmission equation, and the identity is satisfied with one of the variables set as the residual. In other cases, prices are solved to satisfy the identity

6 The shock model assumes that macroeconomic variables, such as GDP, population (urban/rural), employment and wage rates, and exchange rates, are exogenous variables that are monitored for ex-post analysis or are based on the projections by other studies.

wheat; other Cereals; potatoes; meat; fish and eggs; milk products; vegetables and fruits; fats and oils; spices and sugar; and non-alcoholic beverages.

The food consumption in quantity is converted to calorie intake by using a food composition table. Food security indicators related to household undernourishment are then calculated based on daily per capita calorie intake. The major indicators include: mean and distribution (CV) of per capita calorie intake, undernourishment (head count, gap and square of gap), ratio of calorie intake from cereal in total calorie intake (food quality indicator), food gap (in wheat/rice/maize equivalent) for vulnerable groups. Percentage of people who cannot meet a certain requirement dietary energy consumption is measured by several levels of daily caloric intake consumption requirements for food aid/assistance intervention analysis (Smith *et al.*, 2006).

2.3 Methodological note on market and climate shock modules

2.3.1 Market integration and estimates of price transmission elasticities

The following methodology is used to measure both the degree of price integration among major commodities to identify the most vulnerable markets to price shocks, and to derive parameters on price transmission for SISMOD. The degree of price transmission between markets reflects the level of market integration. Integrated markets are those where price signals are transferred from one to another, allowing physical arbitrage to adjust any disturbances in these markets; integrated markets are thus a sign of efficiency. Spatial market integration refers to co-movements or the long-run relationship among prices. It is defined as the smooth transmission of price signals and information across spatially separated markets. Two markets are assumed integrated if price changes in one market are manifested in an identical price response in another market (Barret, 1996).

The most common measures of spatial market integration between time series of commodity prices are the bivariate correlation coefficients. However, there are weaknesses associated with the use of price correlation coefficients as measures of market integration: there is the chance that the correlations could be spurious, rather than resulting from the integrated nature of the markets (Barrett, 1996). This analysis recognized these weaknesses and augmented the correlation coefficient approach by co-integration tests and Granger causality tests.

- **Co-integration tests:**

The first step of our analysis consists in determining the order of integration of our variables by using ADF, Phillips Perron and KPSS tests. It is well known that regressing non-stationary time series is likely to give spurious results (Granger and Newbold, 1974). Spurious regression refers to the regression that tends to accept a false relation or reject a true relation by flawing regression schemes. That is the reason why for non-stationary time series it is advisable to work with their differences.

However, regressing first order integrated, i.e. I(1) dependant variables Y_t on I(1) independent variables X_t can be informative, but only if these variables are related in a precise sense, i.e., if they are co-integrated. Price co-integration implies that prices move together in the long-run, although in the short run they may drift apart, and this is consistent with the concept of market integration.

If Y_t and X_t are two I(1) processes, then, in general, $Y_t - \beta X_t$ is an I(1) process for any number β. Nevertheless, it is possible that for some $\beta \neq 0$, $Y_t - \beta X_t$ is a I(0) process. If such a β exists, then Y and X are said to be co-integrated. If the data are cointegrated, then we can legitimately estimate a model using the levels of the data to estimate the long-run equilibrating relationship between the variables.

The long-run relationship is given as:

$$Y_t = \alpha + \beta X_t + \mu_t$$

- **Error correction model estimation:**

If two variables are co-integrated, the following error correction model can be estimated:

$$\Delta y_t = a + \theta\,(y_{t-1} - \beta x_{t-1}) + \delta \Delta x_{t-1} + \rho \Delta y_{t-1} + \varepsilon_t$$

y_t and x_t are the log of two different markets

Δ is the difference operator
α, θ, β, δ, and ρ are the estimated parameters, and
ε_t is the error term

The term $\theta\,(y_{t-1} - \beta x_{t-1})$ is called the error correction term. If $y_{t-1} > x_{t-1}$ that means that y_{t-1} is too high above its equilibrium value, then the negative value of θ corrects the error. θ reflects the speed of adjustment: the speed by which prices adjust to their long-run relationship

Since prices are expressed in logarithms, the coefficient of change in the market x_t (δ) is the short-run elasticity of the price in the market y relative to the price on the market x. It represents the percentage adjustment of price on market y after 1 percent shock in price on market x. The co-integration factor (β) is the long-run elasticity of price transmission of market y in relation to market x.

The distinction between short-run and long-run price transmission is important as changes in the price at one market may take time to be transmitted to the other markets (due to policies, transportation costs etc.).

- **Granger causality tests:**

If two time-series are cointegrated, then there must be Granger causality between them - either one-way or in both directions. Cointegration tests themselves cannot establish the direction of causality but tests can be applied to cointegrating VARs. Therefore, Granger causality provides additional evidence as to whether, and in which direction, price transmission is occurring between two series.

If past X contains useful information (in addition to the information in past Y) to predict future values of Y, X is said to "Granger causes" Y. Granger causality tests help us to identify the leading markets. A market is considered to be a leading market when past prices significantly contribute to the formation of current prices on other domestic and/or regional markets. There is a possibility of unidirectional causality, bidirectional causality or none. An unidirectional causality may indicate the direction of information flow or of trade, but it is also a sign of information inefficiency (Gupta and Mueller, 1982).

2.3.2 Staple crop production monitoring

The following methodological note on crop production monitoring is used both to display the relationship between weather patterns and crop production in the vulnerability profiling, as well as to derive parameters that estimate changes in crop production for application in SISMOD. Traditionally, econometric models for forecasting crop production or crop yield can be characterized as empirical statistical regression equations. These regression equations link regional production or yield with independent "predictor variables", known as factors. In such models, the dependent variable is the regional production/yield whereas the independent variables can be defined by environmental variables such as weather variables or indices. Predictor variables include the NDVI (Normalized Difference Vegetation Index – satellite index), farm inputs (e.g. fertilizer use), or outputs from simulation models (e.g. average soil moisture).

The main premise behind this forecasting approach, termed as "parametric", is that the model is derived on the basis of historical production, yield and climatic data through a "calibration" process. The model is then applied to data from a more recent time period by using current crop and within-season data, to produce a production or yield forecast.

The approach taken in this work can be characterized as parametric due to two factors:

a) it derives or requires a number of parameters, such as regression coefficients, and these parameters in turn define the crop simulation models;
b) it seeks to pinpoint specific factors commonly associated with crop production/ yield and to measure the impact.

In the context of Pakistan, the forecasting process relies on a crop simulation model developed by using regression equations, by rainfall data, NDVI, soil moisture, surface temperature, production and yield dataset for the respective region. This model is contingent on the idea that physical factors (e.g. rainfall, NDVI, surface temperature, and soil moisture) are significant in determining crop production. As with rainfall data, data on NDVI, soil moisture, and surface temperature are used on a temporal annual average basis from July 1974 to June 2010, and be adjusted to account for the crop calendar. For the purpose of this study, we use cumulative monthly rainfall data covering the period July 1974 to June 2010, where precipitation is measured in millimeters.

Crop production data are calculated on an annual basis from 1974 to 2008. *Crop production* data are measured in metric tonnes and *cultivated land area* is measured in hectares. It follows that *crop yield* is calculated by dividing the annual crop production data (in MTs) by the cultivated area (Hectares). To account for the varying climate and geography of Pakistan, we use data gathered at the provincial level, classified according to four of the largest Provinces: Baluchistan, Khyber Pakhtunkhwa (KPK—formerly known as North-West Frontier Province, NWFP), Punjab and Sindh.

This model uses regression coefficients for rainfall and intercept to forecast annual crop production and yield. The rationale for the use of only two parameters in defining our crop simulation model is that the relationship between rainfall and crop production/ yield will demonstrate a strong, positive relationship in countries characterized by rain-fed agricultural systems.

Estimation equation

This simple regression describes the nature of the relationship between annual crop production or crop yield, as being dependent on the amount of rainfall. The implicit stipulation of this simple model is that the relationship between these two variables is positive and strong.

(7) $$y = c_1 + a_1 RF + \varepsilon$$

where y = crop production or crop yield, a_1 = slope of rainfall, RF = cumulative monthly rainfall (July 1974 to June 2010 in millimeters), c_1 = regression constant and ε = error term.

Crop production or yield forecasting

We substitute the values for the intercept (c_1) and the regression coefficient (a_1) to estimate the trend crop production or yield. The equation used to forecast trend crop production or yield is as follows:

(8) $$y_t = c_1 + a_1 (t) + \varepsilon$$

where t = trendline, 1974 (first year in the dataset).

It is worth noting that when linking changes in annual crop production or yield to changes in the amount of monthly cumulative rainfall (monthly average or long-run pattern), exogenous factors should be removed from the model.

The output from the forecast equation (10) represents the trend crop production or yield for each year from 1974 to 2010, based on historical trends in the dataset. In turn, this annually estimated trend crop production or yield figure is subsequently used alongside the actual crop production or yield figure to calculate the deviation from the forecast. Hence, the deviation from the forecast is equal to the difference between actual crop production or yield (y) and estimated crop production or yield, based on historical trends in the data (y_t).

Moving forward, the goal is to expand on the earlier regression analysis by incorporating the impact of independent physical factors such as rainfall, NDVI, soil moisture and surface temperature on annual crop production or crop yield in developing countries such that:

(9) $$y = c_1 + a_1 RF + a_2 NDVI + a_3 ST + a_4 SM + \varepsilon$$

where y = crop production or crop yield, a_1 = slope of rainfall, a_2 = slope of the NDVI, a_3 = slope of ST, a_4 = slope of SM, RF = cumulative monthly rainfall (July 1974 to June 2010 in millimeters), NDVI = Normalized Difference Vegetation Index, ST = Surface Temperature, SM = Soil Moisture, c_1 = regression constant and ε = error term.

Accounting for weather shocks

Explaining the linkages between climatic variability and crop production or yield also entails investigating the impact of unexpected weather shocks. For the purpose of this analysis, we specify an annual rainfall threshold which stands as a benchmark against which to compare the effect of a loss in crop production and yield that arises as a consequence of natural disasters. Furthermore, by identifying the particular year and type of natural disaster that occurs in a given country, it would be possible to remove abnormalities in the dataset based on historical trends. These abnormalities would otherwise distort the relationship between crop production/yield and rainfall. These outliers in the rainfall dataset are pinpointed by using a specific threshold to categorize a particular event as a natural disaster. For the purposes of this study, the types of natural disaster that are of particular concern are droughts and flooding.

The XY scatter plots shown in this report were produced with both the regression line and regression equations. The strength of the relationship between cumulative rainfall and annual wheat production is represented by the correlation coefficient, the R^2 value. For Pakistan, the predictive power of the relationship is higher for the cumulative rainfall.

2.4 Pass-through of shocks: The income generation module

As mentioned above, the market monitoring and crop production monitoring modules are used to derive the changes in the shocks factors (production, prices, wages) from the baseline year (without shock) to any given year when a shock takes place. These two modules track the changes in shocks factors either based on past patterns for stimulating the impacts of past shocks for ex-post analysis, or based on forecasted changes for ex-ante analysis. Production changes are estimated by field missions (ex-post) or forecast based on rainfall/temperature (ex-ante). Producer price of output is based on the real price changes (ex-post) or forecast based on the partial equilibrium or/and price transmission (ex-ante). Therefore, the income generation module estimates new incomes in the shock year(s) based on the changes in the shock factors to account for the shock in determining its impact on food consumption.

2.4.1 Components of aggregate income

Household income sources are disaggregated by the following components:

Crop income: The estimation of crop income accounts for the sale of crop production, crop by-product production, sharecropping, the consumption of household crop production, net of all expenditures incurred in realizing these activities, such as agricultural inputs (seeds, pesticides and fertilizers) and the hiring of farm labour.

Livestock income: The livestock income category includes income from the sale and barter of livestock, livestock by-product production (i.e. milk, eggs, honey etc.), net of expenses related to livestock production (e.g. fodder, medicines) and livestock purchases, plus the value of household consumption of own livestock and livestock by-product production. The values of own consumption are estimates based on the food consumption/expenditure section of the questionnaire. In cases where this information is not available in that module, the consumption amount is obtained from the agricultural module. The approach for valuation of own consumption is the same as for the valuation of crop own-consumption.

Wage income: Wage income consists of all income received in the form of employee compensation either in cash or in kind. Wage employment income is first disaggregated by industry in the survey. The classification is based on the UN International Standards Industrial Classification of all Economic Activities (ISIC). As the classification of industries changes over time, the most appropriate revision of the ISIC classification standards is chosen based on the year the survey was undertaken. In the survey, industries are grouped into ten principal categories: agriculture; forestry and fishing; mining; manufacturing; utilities; construction; commerce; transportation, communications and storage; finance and real estate; services; and miscellaneous. Using this industrial classification, total wage employment income is separated into three aggregate categories: agricultural wages, non-agricultural private wages, and non-agricultural public wages.

Remittance income: Given the increasing importance of remittance income in food security for poor households, remittance income is separated from other income. Remittance income can be sourced by domestic transfer income and overseas transfer income.

Summary tables of the percentage income by each category and the share of each crop in total crop income are presented in Appendix 1 (see Table A1.1). In Pakistan, crop income constitutes the largest part of income for rural agriculturalists. The crop income in Pakistan is disaggregated into wheat, rice, maize, cotton, sugarcane, pulse, and fruits.

2.4.2 Net income of total crop production

Since the survey did not report input and cost of production of individual crops, the net income of crop production is estimated at the aggregated level: net income of total crop production = sum of gross crop income – total cost of crop production.

Crop area harvested for a specific crop (for example: wheat, rice, maize) is a function of own price (P_{io}), competing crop prices (P_{ic}), total land owned in the household ($Land_j$), and household size.

(10) $A_{ij} = f\,(P_{io}, P_{ic}, Land_{j}, Househols\ Size_{j})$

Crop yield is specified as a function of rainfall or the Normalized Difference Vegetation Index, and time trend (representing the technology development), expressed as:

(11) $y_1 = f\begin{pmatrix} \underline{NVP_I} \\ \underline{rain} \\ time \end{pmatrix}$

Wage income is a function of wage rate, GDP, and CPI and expressed as:

(12) $$I_{io} = f(GDP, Wage\ Rate, CPI)$$

Total income is expressed as:

(13) $$I_i = \sum_{i=1}^{K} P_{io} A_i y_i + I_{io}$$

2.5 From income estimates to total and food expenditures

The 'average propensity to consume' or APC is defined as the ratio of a household's spending or consumption to its disposable income. In turn, the 'average propensity to save' or APS is the ratio of the family's savings to its disposable income. The resulting sum of APC and APS is one; that is, one hundred percent of disposable income.

To pass the shocks to income and then to total household expenditure, the household APC was estimated for urban and rural populations in Pakistan by using Pakistan Social and Living Standards Measurement Survey (PSLM) data. The equation for total expenditure is specified as a function of household income, controlling for households social and demographic characteristics such as household size, location, and gender of household head, age of household head, and education of household head.

(14) $$Total\ expenditure = f\ (total\ income,\ hhsize,\ location,\ gender,\ age,\ education)$$

The elasticities derived are used for the shock model simulation.

Income group separation

Differences in income and household characteristics lead to different household behavior in the acquisition of goods. Food expenditures are almost completely explained by income levels for low income households, while for high income households food expenditures depend on other factors such as household demographic characteristics. The method for classifying households into income groups was based on an analysis of homogeneity of variances of residuals. Following Jensen and Manrique (1996), the procedure has two basic steps, estimation of Engel relations and tests for homoscedasticity of variances. Successive Goldfeld-Quandt tests using the residuals from the Engel estimation were performed in order to classify the household observations into groups with different variances. Classification of households into income groups was determined by setting income boundaries for groups of residuals. The idea is to test whether the variance of the disturbances of one part of the sample is the same as another part (homoscedasticity).

To do so, first the observations were ordered based on income level (or total food expenditure level) and equally separated in the number of groups desired (i, normally five groups); second, equally separate the sub-observations into three groups (j) within the group (i) and re-estimate independently for each sub-group of observations (j) based on the Engel estimation; third, test whether the variances of the three sub-groups are the same based on the estimation in step two and F-test. If the F-test indicates they are not in the same income group, those observations are moved to the next group i; forth, final income boundaries are determined by repeating the Goldfeld-Quandt tests. In the context of Pakistan, three income groups (low, middle and high) were identified.

2.5.1 First stage demand system (linear expenditure system): Total household expenditure

In this analysis, the first stage allocates total household expenditure to eight broad groups of goods: food, clothing, fuel, housing, durable goods, education, medical items, and other items. A non-Linear Seemingly Unrelated Regression was used to estimate a linear expenditure system (LES) of seven equations for the first-stage budget allocation (Box 1). The advantage of the LES is that it is simple and provides an intuitive economic interpretation, despite its strong separability assumption. The separability assumption is not overly restrictive for such commodities as food, housing, or clothing (Timmer and Aldermand, 1979).

Box 1. Linear expenditure system (LES) demand equations

In the LES, demand equations are assumed to be linear in all prices and incomes and the set of demand functions is expressed in expenditure form:

(1) $$P_I X_I = P_I R_I + \beta_I \left[Y - \sum_j P_I R_I \right]$$

with $0 < \beta I < 1$, $\sum_I \beta_I = 1$ and $Y > X_I$. Where $P_I X_I$ (P_I and X_I are aggregated price and quantity indices for commodities within group I) is expenditure, and R_I and β_I are parameters. Y is household total expenditure. The uncompensated own-price and cross-price elasticities associated with equation (1) are:

(2) $\eta_{II} = (1- \beta_I) P_J R_J/(P_I X_I)-1$ and

(3) $\eta_{IJ} = - \beta_I (P_J R_J)/(P_I X_I)$.

The expenditure elasticities are: (4) $\mu_I = \beta_I Y/(P_I X_I)$.

This study uses Pakistan Social and Living Standards Measurement Survey (PSLM) data of 2001/02, 2003/05, 2005/06, and 2007/08 which recorded all major economic activities in the survey year. Unlike aggregate time series, which are often not conducive to precise estimation of cross-price effects largely due to collinearity of prices, cross-sectional data offer an important advantage in deriving better elasticity estimates. Detailed demographic characteristics collected in cross sectional surveys allow accommodation of heterogeneous preferences, and the typically large sample also provides the degrees of freedom required to estimate a large and disaggregate demand system.

The sample contains variables on rural and urban household income, expenditure, production and consumption, as well as their demographic characteristics. The data used are the panel data of cross sector (by province and income group) and time series (four time periods). The data are derived from aggregated data from the Pakistan National Statistical Office. The aggregated prices for the grouped goods in the first stage are derived based on the Pakistan CPI database and are computed using the Stone aggregation with their expenditure shares as weights in each group.

Results of parameter estimates and elasticities

The estimation results for the first-stage demand for eight broad consumption groups are presented in Table 1. All parameters, from the regressions for each income group and entire sample, have the expected signs and appropriate magnitudes. Most parameters are significant at the 1 percent level.

The adjusted R-square is 0.93 for food expenditures for urban and 0.95 for rural, and are greater than 0.8 for all other expenditure groups in both urban and rural.

Table 1: Household demand in Pakistan: Estimated own price elasticities and expenditure elasticities by rural/urban for the first stage demand system, 2001-2007

	Food	Clothing	Fuel	Housing	Durables	Medical	Education
RURAL PARAMETERS							
Own price elasticities	-0.836	-0.820	-0.816	-1.003	-0.878	-0.856	-1.183
Expenditure elasticities	0.874	1.025	1.015	1.295	1.103	1.097	1.562
URBAN PARAMETERS							
Own price elasticities	-0.788	-0.797	-0.811	-1.159	-0.961	-0.801	-1.142
Expenditure elasticities	0.792	0.932	0.943	1.429	1.139	0.947	1.377

Source: Estimated by Joint FAO/WFP Household Modeling Project based on Pakistan HIES data 2005/06.
"Food" corresponds to "Food, beverages and tobacco".

Using the estimated coefficients, uncompensated price and expenditure elasticities are evaluated at the sample means. Own-price elasticity for food is -0.836 in rural and -0.788 in urban. Own-price elasticities for clothing, fuel, medical, and other group are similar to that of food group, ranging from -0.82 to -0.88 in rural and ranging from -0.80 to -0.96 in urban. Relatively, housing and education have more elasticity, with own-price elasticities greater than unity in both rural and urban areas.

Expenditure elasticity for food is 0.87 in rural and 0.79 in urban, the lowest in the broad consumption groups. Education and housing have the highest expenditure elasticities: 1.56 for education and 1.30 for housing in rural and 1.38 for education and 1.43 for housing in urban. These results indicate that the demand for food is less elastic than the demand for the other 6 groups with respect to expenditures. This implies that people would reduce expenditures much more on education and housing during a price shock than on food.

2.5.2 Second stage of food demand system

The synthetic food demand equation for each food item is defined in per-capita terms and is a function of real price of the commodity, real consumer expenditures per capita and real prices of other foods:

(15) $$d_i = f(P_i, P_j, Expi)$$

The real price of the commodity is expected to be negatively related to food demand. The signs of the other two variables are ambiguous because expenditure elasticities can be positive or negative, and other foods can be substitutes or complements.

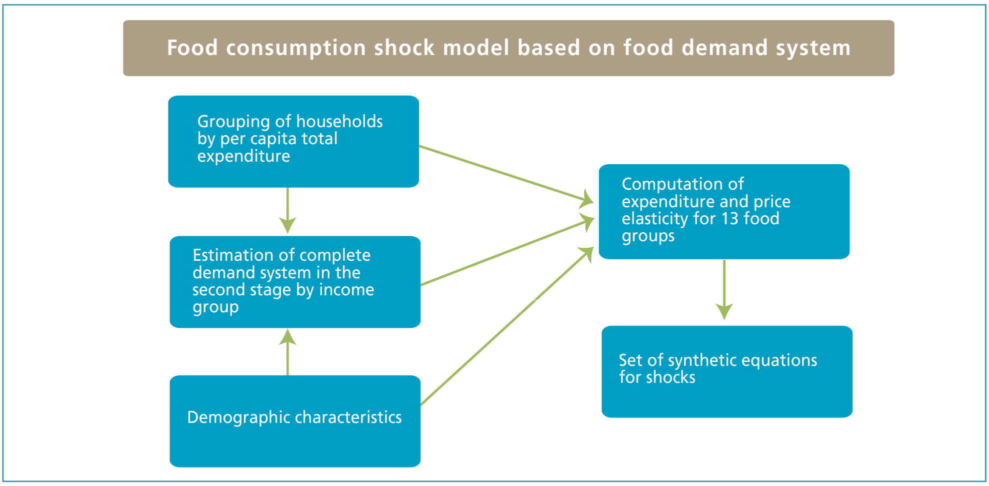
Given the income and price elasticities, the percentage change in each food item consumed will be determined by percentage of change in price (own and cross price) and percentage of change in income.

The framework of the second stage is summarized in Figure 2.

In this second stage, a Linear Almost Ideal Demand System (LAIDS) (Deaton and Muellbauer 1980) (see Box 2) was estimated for 13 food products: milk and milk products; meat and fish; fruits; potatoes; vegetables; tobacco; sugar; beverage and drinks; wheat; rice; other cereals; edible oils/fats; and spices. A censored linear almost ideal demand system is estimated with a Bayesian Markov chain Monte Carlo procedure (detailed can be found from Kasteridis, Yen, and Fang). The second stage estimates used the household level 2005/06 PSLM data of 15 400 households. Conducted by Pakistan's Federal Bureau of Statistics, The PSLM is one of the main mechanisms for monitoring the implementation of the Poverty Reduction Strategy Paper of the Government of Pakistan (2003).

Of the 13 equations estimated, statistical significance of demographic variables are most notable in the tobacco equation, with 14 of the 15 variables significant at

Figure 2. Second stage of food demand system: Deriving food consumption



Box 2. Model specification

Consider the Linear Almost Ideal Demand System (LAIDS) with L equations for latent share of each food group in total consumption (s^*_{hi} for household (Deaton and Muellbauer 1980):

(1) $$s^*_{hi} = \sum_{k=1}^{K} \alpha_{ik} x_k^h + \sum_{l=1}^{L} \gamma_{il} \ln p_l^h + \beta_i \ln\left(\frac{M_h}{P_h}\right) + \varepsilon_{hi}, i = 1, \dots, L$$

where $x_1^h = 1, x_2^h, \dots, x_k^h$ demographic variables, M_h is total expenditure, and P_h is the price index. The adding-up, homogeneity, and symmetry restrictions are in Equations (23), (24) and (2), respectively:

$$\sum_{i=1}^{L} \alpha_{i1} = 1, \sum_{i=1}^{L} \alpha_{ik} = 0 \text{ for } k \geq 2$$

(3) $$\sum_{i=1}^{L} \gamma_{ij} = 0 \text{ for all } j = 1, \dots, L, \sum_{i=1}^{L} \beta_i = 0, \sum_{i=1}^{L} \varepsilon_{ih} = 0 \text{ for all } h$$

(4) $$\sum_{j=1}^{L} \gamma_{ij} = 0 \text{ for all } i$$

(5) $$\gamma_{ij} = \gamma_{ji}, \text{ for } i \neq j.$$

the 10 percent significance level or lower, followed by sugar, wheat, and cereals (with nine variables significant), down to rice (three variables significant), and beverages (two variables significant). Of the 78 quadratic price coefficients (γ), over two-thirds (56 coefficients) are significant at the 10 percent level or lower. All but two (meat, fruits) of the coefficients of the expenditure variable (β), and all the error standard deviations, are significant at the 1 percent level. Over two thirds (or 46) of the 66 error correlation coefficients (ρ) are significant at the 10 percent level or lower.

The estimated compensated price and expenditure elasticities are summarized in Tables 2, 3 and 4. The own-price elasticities of beverages are slightly above unity for low, middle and high income groups. In addition, the own-price elasticities are above one for fruits and tobacco in the low income group; for meat in the middle income group, and for rice and oils in the high income group. All other own-price elasticities are below unity, suggesting that demand for food is predominantly inelastic in Pakistan. All expenditure elasticities are positive and significant at the 1 percent level. The largest expenditure elasticities are observed for milk (1.5), fruits (1.0), wheat (1.6) and rice (1.3) in low income groups; for tobacco (1.3) and fruits (1.1) in middle income groups, and for meat (1.0), fruits (1.1) and tobacco (1.3) in high income groups.

The cross-price elasticities show a mix of gross complements and substitutes. Wheat and rice are complements for low income groups while they are substitutes for middle and high income groups. Milk and oils are substitutes to cereals (rice, wheat) in all three income groups. However meat is a complement for wheat in low income groups. Sugar is a substitute to cereals in low and middle income groups.

2.6 Measuring undernourishment and food security indicators

2.6.1 Deriving per capita dietary energy consumption

The dietary energy consumption per person is the amount of food, in kilocalorie (kcal)[7] per day, for each individual in the total population (FAO, 2008). Food consumption in quantities is converted into dietary energy consumption (DEC) by using energy conversion factors for energy-yielding macronutrients (proteins, fats and carbohydrates). These energy conversion factors for Pakistan were extracted from the conversion factors in Nepal and Bangladesh, as well as by consultation with Pakistan.

Following the FAO method (FAO, 2010), the total dietary energy consumed by individuals depends on the quantity of food consumed and its caloric content:

[7] One kcal equals 1 000 calories and one kj equals 1 000 joules. In the International System of Units (ISU), the universal unit of dietary energy is the joule (J). One kcal = 4.184 kJ. The dietary protein consumption per person is the amount of protein in food, in grams per day, for each individual in the total population. The dietary fat consumption per person is the amount of fat in food, in grams per day, for each individual in the total population (Data source: FAO Statistics Division).

Table 2: Low income group in Pakistan: Compensated price elasticities and income elasticities

	Price elasticities												Expenditure
	Milk	Meat	Fruits	Potatoes	Veg.	Tobacco	Sugar	Bev.	Wheat	Rice	Cereals	Oils	Spices	
Milk	–0.793***	0.138***	0.066***	0.025***	0.071***	0.011***	0.107***	0.036***	0.118***	0.055***	0.081***	0.035***	0.051***	1.529***
Meat	0.205***	–0.082***	0.038***	–0.030***	–0.010	–0.010	0.009	0.002	–0.231***	0.017	0.053***	0.044***	–0.004	0.891***
Fruits	0.217***	0.085***	–1.015***	0.073***	0.055***	0.024***	0.064***	–0.028***	0.084***	0.129***	0.092***	0.179***	0.041***	1.023***
Pota-toes	0.124***	–0.091***	0.100***	–0.295***	0.078***	0.046***	0.048***	0.044***	–0.226***	–0.089***	0.013	0.228***	0.02	0.721***
Veg.	0.176***	–0.018	0.037***	0.040***	–0.501***	0.034***	0.031***	0.031***	–0.039	0.009	0.042***	0.134***	0.025**	0.769***
Tobac-co	0.215***	0.016	0.115***	0.137***	0.211***	–2.314***	0.034	0.118***	0.521***	0.366***	0.051**	0.415***	0.117***	0.663***
Sugar	0.184***	0.002	0.028***	0.016***	0.020**	–0.009*	–0.622***	0.085***	0.109***	0.015*	0.023***	0.139***	0.010*	0.584***
Bev.	0.150***	0.003	–0.040***	0.040***	0.053***	0.031***	0.202***	–1.404***	0.548***	0.124***	0.041***	0.214***	0.038***	0.696***
Wheat	0.143***	–0.189***	0.026**	–0.065***	–0.027*	0.052***	0.078***	0.170***	–0.210***	–0.061***	–0.054***	0.124***	0.012	1.574***
Rice	0.250***	0.058*	0.175***	–0.081***	0.021	0.139***	0.049**	0.137***	–0.188***	–0.831***	0.029*	0.126***	0.116***	1.256***
Cereals	0.312***	0.134***	0.110***	0.012	0.072***	0.006	0.060***	0.042***	–0.149***	0.024*	–0.754***	0.101***	0.030***	0.759***
Oils	0.064***	0.038***	0.087***	0.082***	0.092***	0.050***	0.133***	0.087***	0.166***	0.044***	0.039***	–0.966***	0.085***	0.612***
Spices	0.201***	-0.017	0.045***	0.017	0.041**	0.029**	0.027*	0.036***	0.048	0.104***	0.029***	0.207***	-0.767***	0.542***

Note: Asterisks indicate levels of statistical significance: *** 1%; ** 5%; * 10%.
Source: Estimated by Joint FAO/WFP Household Modeling Project based on Pakistan HIES data 2005/06.

Table 3: Middle income group in Pakistan: Compensated price elasticities and income elasticities

	Price elasticities													Expenditure
	Milk	Meat	Fruits	Potatoes	Veg.	Tobacco	Sugar	Bev.	Wheat	Rice	Cereals	Oils	Spices	
Milk	–0.686***	0.152***	–0.069***	0.056***	0.036***	0.177***	0.041***	0.037***	0.111***	0.060**	0.019**	0.050***	0.017***	0.828***
Meat	0.302***	–1.128***	0.048	0.090**	0.007	–0.095	0.053***	0.024	0.615***	0.109	–0.045*	0.029	–0.009**	0.930***
Fruits	–0.115***	0.022	0.090**	0.047***	0.036***	0.062	–0.022***	0.005	–0.136***	–0.003	0.017*	–0.003	–0.001	1.089***
Potatoes	0.288***	0.232**	0.156***	–0.930***	0.166**	0.097	0.046	0.02	–0.079	–0.056	–0.042	0.129**	–0.028***	0.783***
Veg.	0.156***	0.018	0.152***	0.182**	–0.954***	0.149*	0.031	–0.016	0.097	0.017	0.054	0.093	0.019*	0.849***
Tobacco	0.166***	–0.047**	0.038**	0.008	–0.001	–0.017	–0.046***	–0.006	–0.066**	0.026	–0.003	–0.039***	–0.013***	1.341***
Sugar	0.168***	0.168**	–0.082***	0.032	0.023	–0.236***	–0.724***	0.186***	0.375***	0.216***	–0.037	–0.081*	–0.008	0.879***
Bev.	0.223***	0.083	0.056	0.017	–0.014	0.101	0.166***	–1.291***	0.331**	0.122	0.007	0.167***	0.031***	0.867***
Wheat	0.138***	0.444***	–0.125***	–0.027	0.037	–0.195***	0.096***	0.079**	–0.820***	0.210***	0.053**	0.066**	0.045***	0.714***
Rice	0.125**	0.110*	0.006	–0.015	0.018	0.035	0.069***	0.039*	0.281***	–0.759***	0.039*	0.034	0.016***	0.828***
Cereals	0.099*	–0.149*	0.087**	–0.067	0.07	0.051	–0.012	0.008	0.233*	0.127	–0.536***	0.085**	0.004	0.833***
Oils	0.199***	0.067	0.007	0.130*	0.089	–0.164**	–0.045	0.143***	0.178	0.045	0.063*	–0.709***	–0.004	0.805***
Spices	0.273***	–0.169***	0.011	–0.225***	0.082	–0.239***	–0.014	0.125***	0.727***	0.141***	–0.007	–0.032	–0.673***	0.664***

Note: Asterisks indicate levels of statistical significance: *** 1%; ** 5%; * 10%.
Source: Estimated by Joint FAO/WFP Household Modeling Project based on Pakistan HIES data 2005/06.

Table 4: High income group in Pakistan: Compensated price elasticities and income elasticities

	Price elasticities													Expenditure
	Milk	Meat	Fruits	Potatoes	Veg.	Tobacco	Sugar	Bev.	Wheat	Rice	Cereals	Oils	Spices	
Milk	–0.876***	0.025	–0.090***	0.025**	–0.001	–0.084***	0.022***	0.008	0.02	0.013	–0.004	0.003	–0.002	0.941***
Meat	0.029	–0.873***	–0.085***	0.029	–0.031**	–0.251***	0.011	0.014	0.185***	0.015	–0.027	–0.025	–0.010**	1.017***
Fruits	–0.142***	–0.078***	–0.278***	0.007	–0.032***	–0.243***	–0.038***	–0.007	–0.184***	0.007	–0.004	–0.046***	–0.014***	1.052***
Potatoes	0.094**	0.078	0.034	–0.799***	–0.035	–0.117**	0.044	0.144***	–0.336***	0.061	–0.029	0.049	–0.017	0.828***
Veg.	–0.003	–0.084*	–0.099***	–0.077	–0.423***	–0.250***	0.019	–0.043	0.104	–0.067	–0.017	0.013	–0.012	0.938***
Tobacco	–0.093***	–0.149***	–0.149***	–0.032***	–0.060***	–0.245***	–0.081***	–0.039***	–0.204***	–0.078***	–0.033***	–0.086***	–0.026***	1.273***
Sugar	0.071***	0.04	–0.073***	0.029	0.007	–0.194***	–0.833***	0.013	–0.093	0.068	–0.052***	0.032	0.036***	0.949***
Bev.	0.044	0.067	0.004	0.196***	–0.024	–0.151***	0.037	–1.257***	0.269***	–0.060	–0.012	0.046	0.017	0.824***
Wheat	0.036	0.178***	–0.172***	–0.130***	0.033**	–0.266***	–0.013	0.075***	–0.865***	0.156***	0.025	0.129***	0.004	0.810***
Rice	0.03	0.025	0.033	0.035	–0.021	–0.160***	0.037*	–0.022	0.210***	–1.188***	0.022	0.03	0.003	0.967***
Cereals	–0.042	–0.079	0	–0.054	–0.016	–0.152***	–0.075**	–0.021	0.071	0.057	–0.611***	0.023	–0.029***	0.928***
Oils	0.002	–0.032	–0.114***	0.044	0.014	–0.279***	0.051*	0.03	0.358***	0.062	0.02	–1.005***	0.013	0.837***
Spices	–0.022	–0.034	–0.095***	–0.079	–0.015	–0.229***	0.166***	0.045	0.015	0.032	–0.068***	0.052	–0.548***	0.780***

Asterisks indicate levels of statistical significance: *** 1%; ** 5%; * 10%.
Source: Estimated by Joint FAO/WFP Household Modeling Project based on Pakistan HIES data 2005/06.

(16) Dietary Energy Consumption: $$TC = \sum_j c_j \cdot x_j(p, y).$$

Food consumption is usually measured at the household level, so we define x_j as the per-capita quantity of food j, c_j is the energy content of food j, and TC the total dietary energy intake, measured in kilocalories per capita. As the energy conversion factors are fixed and they depend on the energy contents of the various macronutrients), the changes in dietary energy consumption are given by the changes in food consumption.

2.6.2 Undernourishment and percentage of people consuming less than the DECR in total population

Undernourishment refers to the condition of people whose DEC is continuously below a minimum dietary energy requirement for maintaining a healthy life and carrying out light physical activity. In a specified age and sex group, the minimum energy requirement is the amount of dietary energy per person adequate to meet the energy needs for minimum acceptable weight for attained-height maintaining a healthy life and carrying out a light physical activity. For a population, the minimum energy requirement is the weighted average of the minimum energy requirements of the different age groups (male and female) in the population. Percentage of people consuming less than the DECR is defined as the proportion of the population in a condition of undernourishment. This study measures the prevalence of undernourishment as the percentage of people with daily kilocalorie (kcal) intake <2 350 kcal in adult equivalent (the recommended daily caloric intake for an adult) (Smith *et al.*, 2006). However, other definitions for undernourishment such as 2 100 kcal/day and 1 730 kcal/day were also applied to all categories of the simulation results (Appendices 2 and 3).

The following indices capture different aspects of hunger, presenting a comprehensive picture. The Headcount simply counts the number of the undernourished. The Hunger Gap contains a measure of the Depth of Hunger. The Severity of Hunger captures the degree of inequality among the undernourished. Only joint consideration of these three indices can give an adequate description of undernourishment.

The calculation of undernourishment indices computes the hunger value for each individual and then aggregates these values to obtain an index for all the population. Formulas are as follows:

Headcount (HC): $$H_{0i} = h_0(w_i) = \begin{cases} 1 & \text{if } w_i < z \\ 0 & \text{if } w_i \geq z \end{cases} \qquad HC = \frac{1}{N}\sum_{i=1}^{N} h_0(w_i)$$

Hunger Gap (HG): $$H_{1i} = h_1(w_i) = \begin{cases} \left(\frac{z - w_i}{z}\right) & \text{if } w_i < z \\ 0 & \text{if } w_i \geq z \end{cases} \qquad HG = \frac{1}{N}\sum_{i=1}^{N} h_1(w_i)$$

Severity of Hunger (SH): $$H_{2i} = h_2(w_i) = \begin{cases} \left(\frac{z - w_i}{z}\right)^2 & \text{if } w_i < z \\ 0 & \text{if } w_i \geq z \end{cases} \qquad SH = \frac{1}{N}\sum_{i=1}^{N} h_2(w_i)$$

Where z is the value of the undernourished line, w_i is the per adult equivalent consumption expenditure of the individual i, and N is the total population. For all the indices, when the individual values are summed up they are multiplied by the household size and properly weighted to represent the whole population.

2.6.3 Food gap in quantity of wheat equivalent

For a rapid food security assessment, one important indicator is the calculation of the food assistance needed. Food Gap (FG) in quantity of grain (such as wheat) equivalent is calculated for households with DEC below the requirement. **The formula for Pakistan is the following:**

(19) Food Gap in grain per household = (kcal consumed or available per capita – requirement) x HH size /conversion factor from kcal to kg of grain).

In conclusion, the methodological approach presented above provides two main intermediary outputs that can be used for early warning: the market price transmission effects and the production forecast. In addition, the SISMOD provides important outputs to the understanding of undernourishment status after a shock or in anticipation of a shock:

- the hunger head-count of the undernourishment, i.e. the percentage of undernourished population affected by a shock. This estimate can be presented by gender, geographic setting, income groups or livelihood groups;
- the hunger-gap and the severity of hunger can also be categorized by the different groups mentioned above;
- the food gap in cereal equivalent quantity.

3. Economic environment and vulnerability to food price shocks

The following chapter provides a summary of the current economic context in Pakistan and identifies the transmission channels of market shocks in the country. The first part of this chapter provides contextual information on the economic environment in Pakistan by reviewing the macroeconomic context, trade policies and regulations, and the characteristics of the agricultural sector. The core of this chapter provides a market integration analysis and price transmission analysis in Pakistan to determine the degree of wheat, IRRI rice, and basmati rice price transmission between domestic and international markets. The results highlight the markets that are most vulnerable to domestic and international price shocks.

3.1 Macroeconomic context

The global food, fuel, and financial crises in 2008 triggered the beginning of an economic slowdown that sent shockwaves around the world. The current global economic deceleration is the result of a variety of simultaneous bubbles or crises, which displayed the interconnection and undrawn boundaries between international and domestic markets. The shockwaves have resulted in tremendous economic challenges which have rippled through national to household economies.

Today, Pakistan's economy continues to face the combined residual effects of the global financial crisis, the food and fuel crises, the aftermath of various natural disasters, and the continuing volatile security situation. Prior to the 2008 fiscal year Pakistan was the 26th largest economy in the world in terms of purchasing power, and in 2005 Pakistan was the third fastest growing economy in Asia. During the five years prior to 2008, Pakistan's economy more than doubled in size with an annual GDP growth rate averaging nearly 7 percent. Pakistan, classified as a lower middle income country by the World Bank, had a 2009 GDP valued around USD166 billion using the official exchange rate. However, the economy has experienced a slowdown in growth. As a consequence of the effects of the above mentioned shocks, key macroeconomic indicators are signifying a weakened and unstable economy compared with previous years.

The nominal GDP growth rate dropped from 7.7 percent in 2005 to 2.0 percent in 2008 and 3.7 percent in 2009. In real terms, the GDP growth rate was estimated to be 2.7 percent in 2009 (World Bank, 2011). The largest contributor to Pakistan's national income is the state supported services sector (especially in transport, communications and life insurance), which accounts for just over half of the GDP and a considerable amount of employment (WTO, 2008). Agriculture is the second largest sector. Despite a 3 percent decline in its share of GDP in the last decade, it accounts for 21 percent. The manufacturing sector has an 18 percent share of GDP (Government of Pakistan, 2011).

Pakistan's fiscal balance and account balance have come under pressure over the last five years due to inflated oil and food prices. The fiscal deficit and account deficit have both followed similar trends. They have been steadily increasing since the Fiscal Year (FY) 2004-2005 and peaked in FY 2007-2008, but have begun decreasing in the last two years. The fiscal deficit has increased significantly from 2.4 percent of GDP in FY 2003-2004 to 7.6 percent of GDP in FY 2007-2008, and 5.2 percent in 2009. Similarly, in the FY 2003-2004, the account balance was classified as a surplus, but from this point forward the account deficit peaked at 8.5 percent of GDP in FY 2007-2008. The current account deficit is expected to contract around 2.8 percent in the outgoing year, a significant improvement from the 5.7 percent in FY 2009.

As shown in Table 5, Pakistan's trade deficit has increased more than ten-fold over the last six years. This increase is derived from the increasing total value of imports that resulted from higher costs of petroleum, raw materials and food imports. The total value of food imports climbed from USD 1.6 billion in FY2003-2004 to USD 3.5 billion in FY2007-2008. Wheat and edible oils accounted for more than 60 percent of the food import bill (FAO, UNDP, UNESCO *et al.*, 2008). Over the past year, the trade deficit has made improvements mainly due to the massive reduction in import expenditures, as a result of the decrease in international prices.

High food and utility (mainly fuel) prices, the depreciation of the Pakistani Rupee versus the USD, as well as higher international commodity prices have been the main drivers of the higher cost of imports and the amplified inflation in Pakistan. The Consumer Price Index (CPI) increased by 11.7 percent in 2009/2010, 20.8 percent

Table 5: Pakistan's trade balance (USD millions)

	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Exports (f.o.b.)	12 396	14 401	16 388	17 119	20 207	18 918
Imports (f.o.b.)	13 604	18 753	24 647	26 614	35 027	31 410
Trade balance	-1 208	-4 352	-8 259	-9 495	-14 820	-12 492

Source: Government of Pakistan, 2010. Pakistan Economic Survey 2009-2010. Finance Division. f.o.b: free on board.

in 2008/2009 and by 12 percent in 2007/2008. The CPI for June 2010 increased by about 12.7 percent over that for June 2009, and the food CPI increased by 14.5 percent over the same period. For the first 10 months of 2009/2010, food accounted for over 40 percent of the CPI inflation (Government of Pakistan, 2010).

Remittances in Pakistan serve as a safety-net to support households. Remittances in Pakistan have grown over the last decade to account for a sizable percentage of the national income. In 2009, remittances accounted for ~6 percent of the Pakistan's GDP, increasing steadily from USD 3.9 billion in 2004 to 9.4 billion (World Bank, 2010).

During this period of economic decline the unemployment rate has not increased. In fact, from FY 2002 to FY 2009 the unemployment rate has declined from 8.3 percent to 5.6 percent. The government has recently announced a 16 percent increase in the minimum wage (Government of Pakistan, 2010).

3.2 Trade policies and regulations

The year 1995 marked the formal economic structural transition from a protected closed economy to a free market approach, as Pakistan became a member of the World Trade Organization (WTO). The Comprehensive Economic Revival Program launched in 1999 was the first major liberalization initiative to restructure the economy and liberalize trade. Pakistan adopted the liberal economic framework of strengthening its comparative advantage to build an export-import based economy. This has been a central element in Pakistan's becoming a participant in the global economy and in developing a higher performing and more efficient economy. Therefore, Pakistan began implementing market-based reforms, a privatization program, and removing protectionist trade policies that protected domestic producers from foreign competition. The government adopted new policy measures that removed restrictions and bans on exports and imports, eliminating non-tariff barriers, and reducing tariff rates to engage markets in international competition (WTO, 2002).

Since then, trade restriction and tariff rates have dropped drastically, but Pakistan still maintains a level of protection of domestic entities in international trade. According to the World Bank's World Trade Indicators (2010), with a MFN[8] Tariff Trade Restrictiveness Index (TTRI) for overall trade of 12.2 percent, Pakistan's trade regime remains slightly more restrictive than the average South Asian nation (TTRI of 11.3 percent) and considerably more restrictive than the average lower-middle-income country (TTRI of 8.6 percent). The simple average of the MFN applied tariff

[8] MFN is the abbreviation for "most favoured nation", which is a status or level of treatment accorded by one state to another in international trade. All members of the WTO agree to accord this status to each other.

rate has decreased roughly by one-third over the last decade to 13.5 percent. Owing to Pakistan's dependency on food imports, the government has established much lower import barriers for agricultural goods than for non-agricultural goods.

Despite Pakistan's integration of free market reform into the economic framework, the Government of Pakistan still intervenes in wheat and rice trade policy at different levels. Owing to the importance of wheat in household consumption, the government intervenes heavily on wheat markets, with the dual objectives of maintaining adequate incentives for producers and ensuring the supply of wheat flour to consumers at affordable prices. The government purchases a large proportion of the crop available in the market and releases the wheat at subsidized consumer prices. The procurement price of wheat is fixed each year before the planting season. Prior to the market disruptions of 2008, the Government of Pakistan purchased on average 60 percent of the crop available in the market (FAO, UNDP, UNESCO *et al.*, 2008).

In 2008, wheat production reached approximately 22 million tonnes. As Pakistan experienced massive exports, the country had to import over 2 million tonnes of wheat at peak prices. Thus the government decided in autumn 2008 to increase the farm support price for wheat. This resulted in a bumper harvest of 24 million tonnes in spring 2009. In the meantime the international wheat price decreased below the farm support price in Pakistan. This price differential between domestic prices in Pakistan and the international price led to an important decrease in wheat exports from Pakistan to neighbouring countries and to a decline in domestic consumption. As a result, the government was left with large stocks.

In contrast, since rice trade was liberalized and the state run Rice Export Corporation of Pakistan was dismantled, government intervention in rice production has been limited. However in response to the rising food prices in 2008, the Pakistani government took a number of measures to protect the agricultural sector and to ensure national food security. In the rice market the government applied floor prices to rice exports, with the intention of ensuring a fair price. The measure was implemented for only a short time and has now been removed. In the wheat market the government has implemented a ban on wheat exports and imports (Raza and Carroll, 2010).

In the wake of the recent shocks to the economy, the Ministry of Commerce released a three year Strategic Trade Policy Framework 2009-2012 that aims to achieve sustainable economic growth through exports. The objective is to increase the growth of exports over the three year period from 6 percent to 13 percent by the final year. The major measures to achieve this objective in the agricultural sector are to improve rice production and develop the capacity for processed food exports which have an enticing profit potential. By emphasizing improved and more efficient rice production, the potential for directly increasing export growth can be achieved. The policy measures include introducing new varieties of rice, increasing the area under cultivation, a strict monitoring system of import seeds and investment in additional rice farm machinery (Government of Pakistan, 2010).

3.3 Characteristics of Pakistan's agricultural sector

The agricultural sector is the largest employer in Pakistan, absorbing 45 percent of the country's labor force. Growth in the agricultural sector has been in decline for the past three decades. Over the past six years, the sector has grown at an average rate of 3.7 percent per annum. However, volatility in the sector is high, with the range of growth varying from 1.0 percent to 6.5 percent. The fluctuations depend largely on the contribution of crop production, which is challenged by water availability and climate change.

The total value within the sector is composed of crops, which contribute ~43 percent, and livestock, which contributes ~54 percent. The most important crops are wheat, rice, cotton, sugarcane, fruit and vegetables, which together represent more than 75 percent of the value of the total crop output. However, it should be noted that despite intensive farming practices, Pakistan still remains a net food importer. Pakistan's exports include rice, fish, fruit, and vegetables, while its imports consist of vegetable oil, wheat, cotton (net importer), pulses and consumer foods.

Wheat plays an important role in sustaining livelihoods in Pakistan. Wheat is Pakistan's most important agricultural crop, as it is of importance on both production and consumption sides. It is a winter crop planted between October and December and harvested from April to June. Wheat is a staple food for most households in Pakistan; it supplies about 72 percent of caloric energy in Pakistan (Raza and Carroll, 2010). Per capita wheat consumption is estimated at around 124 kg/year, one of the highest in the world. Wheat is grown by 80 percent of farmers on about 40 percent of the total cultivated area. Over the last two years wheat production has ranged from 21.5 million metric tonnes (MMT) in 2008 to 24 MMT in 2009 (a record production level). Wheat production forecasts for 2010 are 22.5 MMT, down from the previous year. In 2008, 2009 and 2010, total production accounted for 79 percent, 91 percent and 88 percent respectively, of Pakistan's total wheat supply, with the remainder coming from imports and drawdown of government stocks (Raza and Carroll, 2010). The major production area is Punjab, which accounts for 80 percent of the total annual wheat production, followed by the Sindh province.

The majority of Pakistan's wheat production is used for domestic demand; however, Pakistan has fluctuated between being a net-exporter and net-importer of wheat. Since 2000 Pakistan has been a net-exporter of wheat. The main destination for formal and informal outflows has been Afghanistan. However, when supply is below demand levels due to harvest, economic, or informal export shocks, Pakistan is a net-importer. This was the case in 2007/2008, when international prices and Afghanistan's wheat prices were higher than domestic prices, which increased informal exports and decreased domestic supply.

Rice is one of the main export items of the country. It is the second most important cash crop in Pakistan, after cotton. Rice plays an important role in household food consumption, although to a much smaller extent than wheat. Rice accounts for 7 percent of total caloric consumption in Pakistan. There are two main rice varieties, Basmati and IRRI rice. Although the higher priced Basmati rice is preferred, IRRI rice is largely consumed by less affluent households because of its lower price. Rice is cultivated in diverse and different climate zones in Pakistan. For example, basmati rice is cultivated in the northern zone of Punjab whereas IRRI rice is grown in Sindh and Baluchistan provinces. Pakistan is the 12th largest rice producer in the world and was the third largest exporter in 2009. About 45 percent of rice produced is used for domestic consumption. After a decrease in 2001, the production of paddy rice has increased during the last years. Pakistan exports milled rice, and the volume of exports has increased since 2002. Over the last three years (2008-2010) rice production has been steady, ranging from 6.5 MMT to 6.7 MMT. The Marketing Year (MY) 2009/2010 production of basmati is estimated at 2.5 MMT and IRRI rice production at 4.0 MMT. Despite a good rice harvest in 2008-2009, massive rice exports from Pakistan at that time led to reduced in the country and high domestic prices. Moreover, the hoarding of rice by traders also contributed to the high prices. Rice exports have remained stable between 3.8 MMT and 4.0 MMT over the last three years (Raza and Carroll, 2010).

3.4 Market integration and food price transmission

The sharp increase in food prices over the past few years has raised serious concerns about the food and nutrition situation in Pakistan. The volatility of food prices is still an issue of concern, particularly after the recent price increases of wheat and coarse grains in international markets. To understand to what degree international prices influence domestic markets, as well as the price transmission among domestic markets within Pakistan, a market integration analysis was carried out focusing on wheat and rice, the main staples for Pakistani households.

The aim is to understand the degree of vulnerability of people to food market shocks in Pakistan. As rice varieties vary depending on the climate, both basmati rice, (which is cultivated in the northern zone of Punjab) and IRRI rice (grown in the southern provinces of Sindh and Baluchistan) are considered in the analysis.

The wheat and rice price data extracted from the Pakistani Federal Bureau of Statistics cover the period from January 1993 to March 2010. The degree of price transmission over this time period will be measured in two ways: (i) by assessing the distribution and trends between wholesale and retail prices with international prices of wheat and rice[9] ; (ii) by using time series econometrics to examine the relationship among domestics markets in Pakistan, and then assessing the price transmission from world prices to domestic prices.

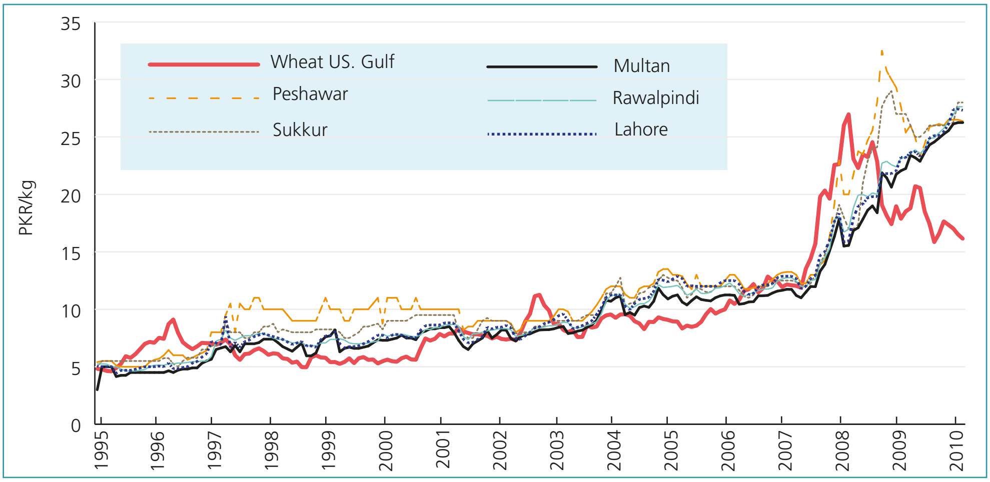
3.4.1 Trends in domestic and international prices of wheat and rice

Wheat

- From 1993 to 2010, wheat prices are characterized by five main trends. First, there are limited price differentials among domestic price averages during this time period. Retail prices among 11 analysed selected markets show that the price differential is not large over the period 1993-2009. On average, wheat price is lowest in Multan (9.7 rupees) and is highest in Peshawar (11.6 rupees). The wholesale wheat prices are almost the same in the five selected markets, with a price variation of 10.1 rupees in Hyderabad and 10.5 rupees in Peshawar.
- Second, domestic wheat prices show a pattern of a delayed response to international prices. Since 1993, retail wheat prices have followed the same pattern. Prices remained quite stable between 1994 and 2004. Domestic prices rose because of the relatively poor harvests in 2004 and 2005. Prices in Pakistan began to increase sharply from September 2007 as shown in Figure 3. During the price hike in 2008, prices in Peshawar, Karachi, Hyderabad and Sukkur increased more than in the other markets located in Punjab. The price in Peshawar reached a peak in November 2008, at Pakistan rupees 30.75/kg. The international price of wheat reached a peak a few months earlier in March 2008 at Pakistan rupees 27/kg. While the international price began to decrease from March 2008, retail and wholesale domestic prices continued to increase until March 2010.
- Third, the price of wholesale wheat is set by production levels in production markets. Wholesale prices started to increase in some Pakistani markets before the international price of wheat (Figure 4). It is particularly noticeable in Multan and Sukkur, which are located in two major wheat-producing areas. Despite the price stability policy, Pakistan experienced a sharp increase in wheat price in 2008. The main reasons for the price hike are the increase in

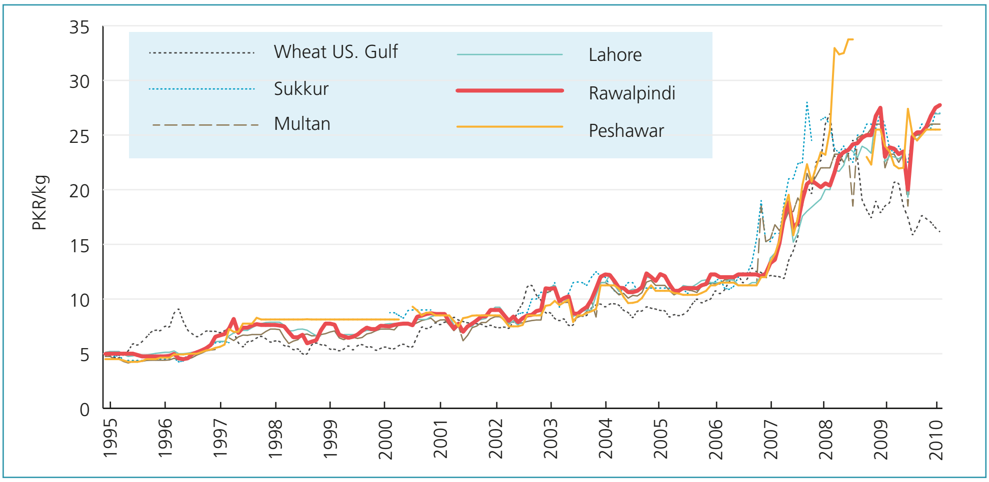
[9] Rice international price is that of Thai rice, 5 percent broken. Wheat international price is that of Wheat US. Gulf.

Figure 3: Comparing retail wheat prices in key domestic markets to the international price



PKR: Pakistan rupees

Figure 4: Comparing wholesale wheat prices in domestic markets to the international price



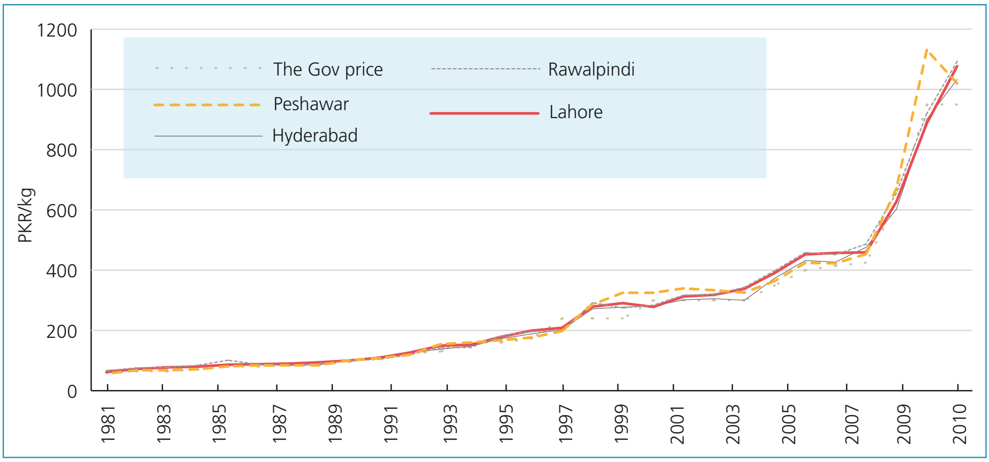
PKR: Pakistan rupees

the cost of production (increase in the energy costs), the price differentials with neighbouring countries that give a strong incentive for informal trade and the shortage of national wheat production.

- Fourth, as for retail prices, wholesale prices in Peshawar increased more than the other markets. Peshawar is located close to the border with Afghanistan and is the main grain market supplying the Federally Administered Tribal Areas (FATA) and KPK areas. KPK area has the largest wheat deficit and is one of the most vulnerable areas in Pakistan. While the western part of the country experienced wheat shortages in 2008 and the early months of 2009, the movements of wheat were banned from surplus areas to deficit areas, causing severe regional disparity and important price differentials.

- Finally, the wholesale prices of wheat follow closely the procurement price decided by the government (Figure 5). The procurement price appears as a major factor in price determination. Wholesale and retail prices followed the same pattern which can be explained by the government interventions on wheat markets.

Figure 5: Wheat wholesale price and procurement price

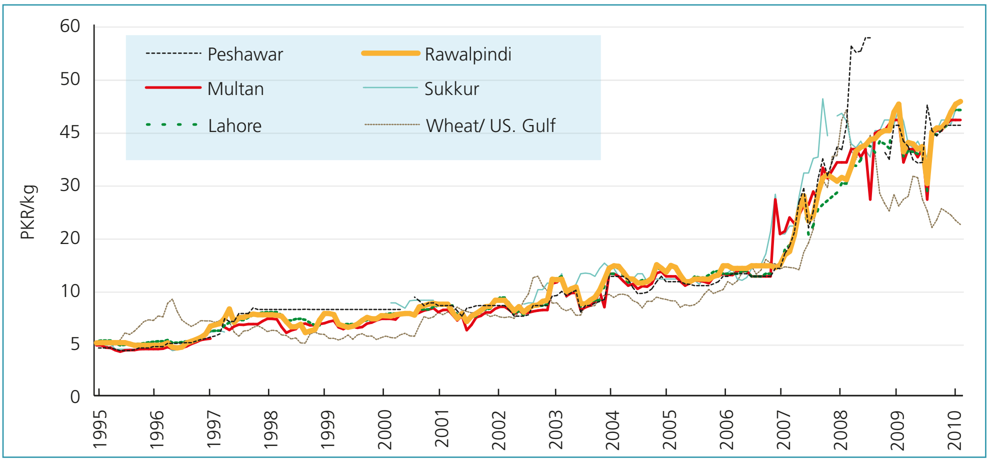


PKR: Pakistan rupees

IRRI rice

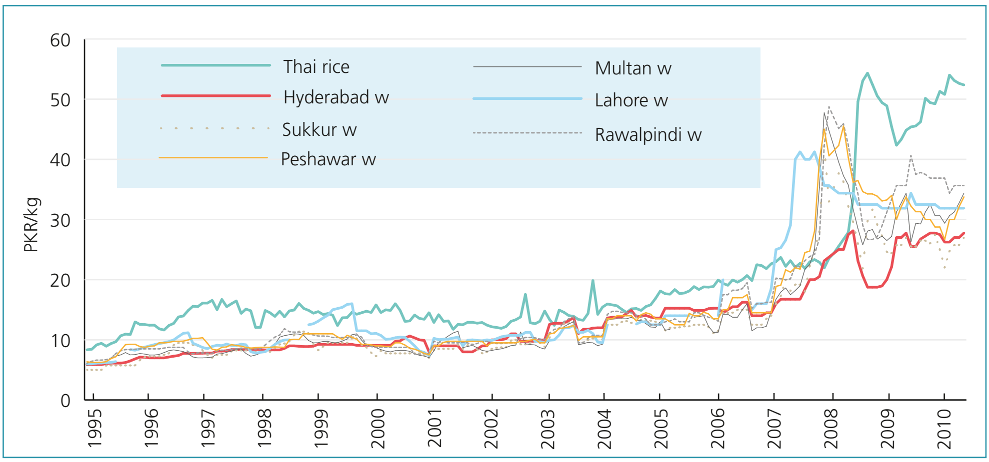
- IRRI rice prices were relatively stable until the end of 2006 (Figure 6). In December 2006, retail prices varied from 15 rupees in Gujranwala to 19 rupees in Peshawar. Prices then rose steadily and peaked in May and June 2008 at 43 rupees/kg in Gujranwala and at 57.5 rupees in Peshawar. While prices fell in 2009, they rose again in 2010 and have remained at high levels since then. As in the case of wheat prices, price differentials between markets were small before the price hike in 2008, suggesting low transaction costs and thus an efficient IRRI rice trade.
- Wholesale prices started to increase from March 2007 in Lahore (Figure 7), approximately 11 months before the rise in the international rice price. As Pakistan was the third largest rice exporter in 2009, price fluctuation in Pakistan

Figure 6: IRRI rice retail prices: Comparing key domestic markets to regional and the international price*



PKR: Pakistan rupees
* International prices refer to Thai Rice

Figure 7: IRRI Rice wholesale prices: Comparing domestic markets to regional and the international price



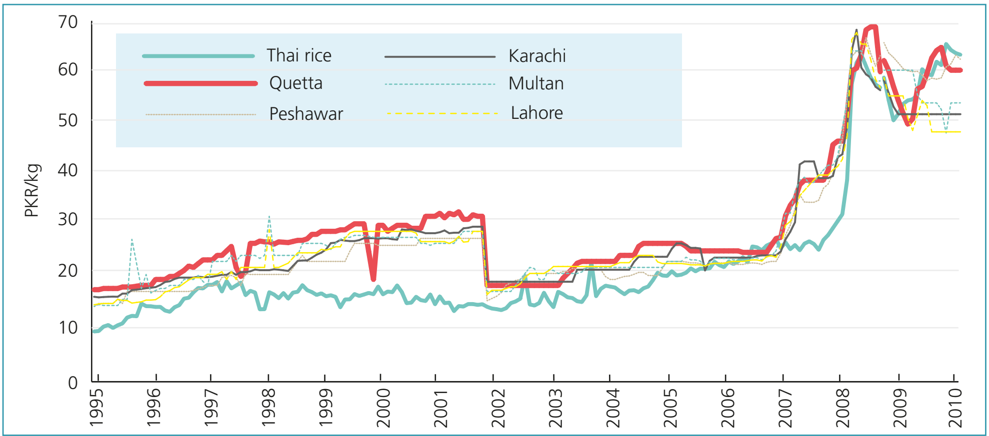
PKR: Pakistan rupees

may have had an impact on world rice price determination, and the early increase in rice price in Pakistan in 2007 may have contributed to the world rice price hike in 2008. The market price in Lahore increased faster than the other Pakistani markets. Price in Lahore increased from 16 rupees per kilo in October 2006 to 40 rupees a kilo in April 2007.

Basmati rice

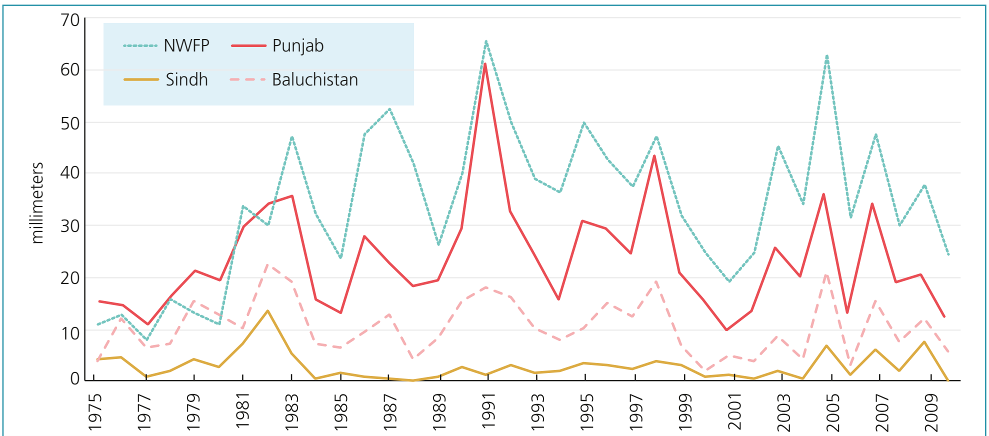
- Figures 8 and 9 show that the retail prices follow the same pattern as wholesale prices change. Prices increased slightly between 1994 and 1998. They remained stable between 1999 and 2001 and then decreased suddenly in December 2001. After a period of stability, prices increased again sharply in 2008.
- Wholesale prices increased slightly between 1994 and 2007. Wholesale prices in Pakistan began to increase in April 2007 in Rawalpindi, Lahore and Peshawar ten months before the rise in international price (Figure 9).

Figure 8: Basmati retail prices: Comparing domestic prices to regional and the international price



PKR: Pakistan rupees

Figure 9: Basmati wholesale prices: Comparing domestic prices to regional and the international price



PKR: Pakistan rupees

3.4.2 Domestic price transmission

Domestic wheat prices

The augmented Dickey-Fuller test, the Phillips-Perron test and KPSS tests suggest that there is insufficient evidence to reject the null hypothesis of non-stationarity for all price series. When applied to the differenced series, the tests reject the null, indicating that all price series are non-stationary I(1). A series is said to be integrated of order 1 (I (1)) if, the changes in this series form a stationary series. Therefore, the first differences are used to compute the coefficients of correlation.

The coefficients of correlation between prices are low, suggesting a situation of price discrimination. The results from the price correlations between both retail and wholesale wheat markets with the various domestic markets are presented in Table A1.2. Typically, this would suggest price dispersion, but due to the government's price procurement policy and the prices between markets showing limited variation, a situation of price discrimination is more likely to exist in some markets. The average coefficients between retail prices are around 0.5 and the average coefficients between wholesale prices are around 0.4.

The change in wholesale prices is not immediately transmitted to retail prices owing to the government subsidy policy. On an individual basis, there is strong correlation among four markets. The three highest coefficients of correlation are between Sarhodha-Faisalabad (0.81 based on retails price), Sialkot-Sarghoda (0.77 based on retails price), and Lahore-Rawalpindi wholesale price (0.77). The correlation between wholesale and retail markets was also found to be very low.

A Granger causality test was carried out to assess whether price movements follow well-defined patterns from production and supply areas to consumption and demand areas. The results suggest that the Karachi and Rawalpindi markets may play a role in retail wheat price formation, as they have the largest amount of significant causal relationships with other markets (Table 6). Karachi is located in the south of Pakistan, and Rawalpindi is located in northern Pakistan. It appears that both retail markets are central supply markets. Rawalpindi is located in the region of Pakistan that produces 80 percent of the domestic wheat, while Karachi is the main port where imports arrive and where urban households are among the biggest consumers of imported wheat. In addition, the results suggest that Rawalpindi is a major actor in the determination of price as it Granger causes four markets and shares a bi-directional relationship with Karachi (the other import source market).

As shown in Table 7, the Granger causality tests between wheat wholesale markets indicate the importance of Multan and Peshawar for wholesale market monitoring. Both Multan and Peshawar appear to be linked to the other wholesale markets. These findings highlight the importance in monitoring wholesale price

Table 6: Granger causality tests: Wheat retail prices (January 1993-March 2010)

Market X	Cause	Other markets	No. of other markets Granger-caused by X market (sig. at 5% Level)	No. of other markets Granger-causing market X (sig. at 5% Level)
Faisalabad	→	**Karachi**, Sukkur	2	1
Gujranwala	→	**Hyderabad*, Karachi**, Rawalpindi*	1	0
Hyderabad	→	**Gujranwala***, Karachi*, Sukkur	1	3
Karachi	→	**Faisalabad, Gujranwala*, Rawalpindi***, Lahore, **Multan***	2	3
Lahore	→	/	0	2
Multan	→	**Karachi***, Lahore	1	0
Peshawar	→	Hyderabad, Rawalpindi	2	1
Rawalpindi	→	Hyderabad, **Karachi**, Multan*, Sukkur	3	1
Sargodha	→	Multan*	0	0
Sialkot	→	Hyderabad, Peshawar*	1	0
Sukkur	→	Peshawar	1	3

A market in bold text indicates a bidirectional relationship
* indicates that the coefficient is significant at 10% level; otherwise at 5% level

Table 7: Granger causality tests: Wheat wholesale prices (January 1993-March 2010)

Market x	Cause	Other markets	No. of other markets Granger-caused by x market (sig. at 5% level)	No. of other markets Granger-causing market x (sig. at 5% level)
Hyderabad	→	**Peshawar**	1	2
Lahore	→	**Peshawar**	1	2
Multan	→	Hyderabad, Lahore, **Peshawar**, Rawalpindi	4	1
Peshawar	→	**Hyderabad**, **Lahore**, **Multan**, Rawalpindi	4	3
Rawalpindi	→	Hyderabad*	0	2

A market in bold text indicates a bidirectional relationship
* indicates that the coefficient is significant at 10% level; otherwise at 5% level

in these two markets, especially Multan, which influences four markets and is Granger-caused by only one market. Granger causality tests indicate that Peshawar is also important for monitoring and early warning, as it seems to forecast prices in the rest of the country. Peshawar, located along the border to Afghanistan and the crisis-affected areas of Pakistan, is the main cereal market which supplies the

FATA and KPK areas. Wheat comes from Multan and Lahore and then moves on to crisis-affected areas. An estimated 70 percent of the wheat flour coming from Lahore is exported to Afghanistan through informal cross-border trade (WFP, 2010), reflecting strong incentives due to the price difference.

Co-integration tests were carried out on wholesale wheat prices to explore the existence of a long term relationship between wholesale markets (Table 8). The elasticities of price transmission among these markets are the coefficients of the co-integration relationship, as prices are expressed in logarithm. In the long-run, all the pairs of price series move together with the exception of Peshawar and Hyderabad.

Table 8: Co-integration tests: Wheat wholesale prices

P1t	P2t	Long-run relationship?	Short-run adjustment from P2t to P1t
Hyderabad	Rawalpindi	Yes	0.53
Hyderabad	Lahore	Yes	0.63
Hyderabad	Peshawar	No	
Hyderabad	Multan	Yes	0.31
Rawalpindi	Hyderabad	Yes	0.70
Rawalpindi	Lahore	Yes	0.85
Rawalpindi	Peshawar	Yes	0.38
Rawalpindi	Multan	Yes	0.42
Lahore	Peshawar	Yes	0.43
Lahore	Multan	Yes	0.43
Lahore	Rawalpindi	Yes	0.74
Lahore	Hyderabad	Yes	0.70
Peshawar	Multan	Yes	0.19
Peshawar	Rawalpindi	Yes	0.36
Peshawar	Hyderabad	No	
Peshawar	Lahore	Yes	0.47
Multan	Hyderabad	Yes	0.78
Multan	Lahore	Yes	0.91
Multan	Peshawar	Yes	0.38
Multan	Rawalpindi	Yes	0.75

All the coefficients are significant at 5% level

Error correction model (ECM)

If two variables are co-integrated, the following error correction model can be estimated:

(17) $$\Delta y_t = a + \theta\left(y_{t-1} - \beta x_{t-1}\right) + \delta\Delta x_{t-1} + \rho\Delta y_{t-1} + \varepsilon_t$$

where y_t and x_t are the log of two different markets
Δ is the difference operator
α, θ, β, δ, and ρ are the estimated parameters, and
ε_t is the error term

The term $\theta(y_{t-1} - \beta x_{t-1})$ is called the error correction term. If $y_{t-1} > x_{t-1}$ that means that y_{t-1} is too high above its equilibrium value, then the negative value of θ corrects the error. θ reflects the speed of adjustment: the speed by which prices adjust to their long-run relationship

Changes in the price at one market may need some time to be transmitted to other markets for various reasons. That is why the distinction between short-term and long-term adjustment is important.

Since prices are expressed in logarithms, the coefficient of change in the market x_t (δ) is the short-run elasticity of the price in the market y relative to the price on the market x. It represents the percentage adjustment of price on market y after 1 percent shock in price on market x. The co-integration factor (β) is the long-run elasticity of price transmission or of market y in relation to market x.

The four Pakistani wheat markets considered appeared to be linked to wheat prices in Multan (Table 9). The elasticity of price transmission ranges from 0.87 to 0.97, suggesting that 87-97 percent of the changes in Multan wheat prices are transmitted to these four domestic markets.

The estimated ECM suggests that the adjustment process is faster for Peshawar and Quetta as about 16 percent of divergence from the long-run equilibrium is corrected each month.

The short-run adjustment coefficients indicate that changes in Multan wheat prices are transmitted to the other domestic markets contemporaneously but not fully.

Table 9: Market integration tests and adjustment for the domestic wheat markets (Multan to other markets)

	Unit root ?	Long-run relationship	Speed of adjustment	Short-term adjustment	Long-run adjustment
Hyderabad	Yes	Yes	-0.06	0.28	0.87
Lahore	Yes	Yes	-0.05	0.34	0.97
Peshawar	Yes	Yes	-0.16	0.48	0.97
Quetta	Yes	Yes	-0.16	0.30	0.94

Domestic IRRI rice markets

Based on the Augmented Dickey-Fuller tests, the Phillips-Perron tests and KPSS tests, there is insufficient evidence to reject the null hypothesis of non-stationarity for all price series. When applied to the differenced series, both tests reject the null, indicating that all price series are I(1).

The coefficients of correlation between market prices are relatively high, suggesting that prices are integrated in IRRI rice retail markets in general. Table A1.3 displays the coefficient of correlations of IRRI rice retail and wholesale prices in Pakistan's markets. The coefficients of correlation for retail prices range from 0.50 to 0.97. On average, prices in Hyderabad, Islamabad and Rawalpindi have the highest correlations with coefficients of 0.8. Retail prices portray a stronger correlation than those of wholesale prices. However, the coefficients are quite high between Multan and Peshawar (0.66) and between Multan and Rawalpindi (0.70). Between wholesale and retail prices, the coefficients of correlation are very low even when the wholesale and retail prices are related to the same market. This result confirms the lack of connectivity between wholesale and retail prices owing to policy interventions.

As shown in Table A1.4, the Granger Causality tests were applied to 12 markets. Islamabad, Karachi, Lahore, Quetta and Rawalpindi influence many other IRRI rice retail markets in Pakistan. Therefore, it is important to monitor these markets. There are many bidirectional causal relationships, suggesting efficient trade and information flows between IRRI markets. Lahore appears to have the least bidirectional relations and therefore plays a large role in influencing prices elsewhere.

Table A1.5 displays the results from the Granger causality tests applied to wholesale markets, and indicates that IRRI rice wholesale prices are well integrated. Similar to IRRI rice retail markets, there are many bidirectional causal relationships, suggesting efficient trade and information flows. It is not clear which market plays the leading role, but Multan and Quetta have less bidirectional relations and thus may have larger roles.

The results from the co-integration tests displayed in Table A1.6 show a long-run integration of wholesale prices between all markets except between Peshawar and Hyderabad. Again, this is the only pair of markets where a long-term relationship between prices does not exist. In the short run, the magnitude of price transmission from Multan and Rawalpindi to other wholesale markets is high, suggesting that these two markets are important for monitoring and early warning. A shock in these markets is likely to be transmitted to the other markets. The results of Market Integration Tests and Adjustment for the Domestic IRRI Rice Markets (Multan to other markets) are shown in Table 10.

Table 10: Market integration tests and adjustment for the domestic IRRI rice markets (Multan to other markets)

	Unit root ?	Long-run relationship	Speed of adjustment	Short-term adjustment	Long-run adjustment
Hyderabad	Yes	Yes	-0.06	0.28	0.87
Lahore	Yes	Yes	-0.05	0.34	0.97
Peshawar	Yes	Yes	-0.16	0.48	0.97
Quetta	Yes	Yes	-0.16	0.30	0.94
Rawalpindi	Yes	Yes	-0.27	0.56	1.02
Sukkur	Yes	Yes	-0.22	0.60	0.94

Domestic Basmati rice markets

The results indicate a moderate level of correlation between basmati rice retail prices, as well as among wholesale prices (Table A1.7). The level of correlation between retail prices varies according to the markets selected. On average, the two markets with the highest coefficients of correlation are Islamabad and Lahore (0.7). The markets with the lowest coefficients of correlation are Sukkur and Quetta. In contrast to retail prices, the coefficients of correlation are generally low between wholesale prices.

The results from the Granger causality tests show very limited integration for retail and wholesale markets in Pakistan (Table A1.8). In general, the causal relationships are not statistically significant. The only market that is influential in price transmission is the Peshawar retail market, with seven unidirectional relationships. The Peshawar market needs to be monitored as a price shock in Peshawar will likely be transmitted to almost all other markets. The Granger Causality tests suggest that the wholesale markets of basmati rice (Table A1.9) are not integrated in Pakistan. The weak integration (or lack of integration) of basmati rice markets is further confirmed by co-integration tests. Table A1.10 shows that there is no long-run linkage between markets.

3.4.3 Price transmission between world prices and domestic prices

Johansen co-integration tests were carried out on wheat and rice prices to assess the relationship between global food price shocks and domestic wholesale prices. The price series are non-stationary or I(1), according to the Augmented Dickey-Fuller, Phillips-Perron and KPSS tests.

Two of the six wheat markets have a long-run relationship with world wheat prices (Table 11). There is also evidence of unidirectional Granger causality. In particular, the international price of wheat Granger causes the prices on Hyderabad and Peshawar markets.

Table 11: Transmission of world wheat price to domestic prices (nominal prices in rupee)

Markets	Type of markets	Commodity	Unit root?	Long-run relationship?	Vector error correction model		
					Speed of adjustment	Short-run adjustment	Long-run adjustment
Hyderabad	Wholesale	Wheat	Yes	Yes	-0.0603 *	0.0032	-1.2109 *
Lahore	Wholesale	Wheat	Yes	No			
Multan	Wholesale	Wheat	Yes	No			
Peshawar	Wholesale	Wheat	Yes	Yes	-0.0490 *	-0.0398	-1.4902 *
Rawalpindi	Wholesale	Wheat	Yes	No			
Sukkur	Wholesale	Wheat	Yes	No			

* Indicates that the coefficient is significant at 10% level; otherwise at 5% level

However, when assessing the speed of transmission and the short-term convergence of international and domestic wheat prices through an error correction model (ECM), domestic prices appear to take a significant amount of time to adjust to international price fluctuations. The error correction coefficients (-0.06 for Hyderabad and -0.05 for Peshawar) indicate that the adjustment to the long-run relationship is relatively slow, with an adjustment speed of 5-6 percent to the long-run equilibrium. The short-run adjustment coefficients are not statistically significant, suggesting that Hyderabad and Peshawar are not well integrated in the short run with the international wheat market. This result implies that global wheat price hikes are transmitted with a long delay and domestic prices are sticky to international price declines.

Although Pakistan is probably more of a price maker than a price taker in rice markets, the world price can still affect domestic markets. The integration tests of IRRI rice prices show that five of the seven wholesale markets displayed a long-run relationship between domestic and international price (Table 12). Short-term adjustment coefficients are quite low and not significant, suggesting that domestic prices and international price are not well integrated in the short term.

The integration tests of the basmati rice markets yield the same conclusion (Table 13). The poor integration between basmati domestic rice and the world price of Thai rice can be due to the difference in quality between these types of rice that hinders the comparison.

3.4.4 Key markets exposed to price shocks

The findings suggest that the degree of market integration is stronger among domestic markets compared with international markets. The low integration of international to domestic price signals can be explained by various factors, such as government intervention in wheat markets and trading patterns in IRRI and

Table 12: Transmission of world IRRI rice price to domestic prices (nominal prices in rupee)

Markets	Type of markets	Commodity	Unit root?	Long-run relationship?	Vector error correction model		
					Speed of adjustment	Short-run adjustment	Long-run adjustment
Lahore	Wholesale	IRRI rice	Yes	No			
Quetta	Wholesale	IRRI rice	Yes	Yes	0.024	0.019	-1.172 *
Rawalpindi	Wholesale	IRRI rice	Yes	Yes	-0.015	-0.049	-1.044 *
Hyderabad	Wholesale	IRRI rice	Yes	No			
Peshawar	Wholesale	IRRI rice	Yes	Yes	-0.011	-0.009	-1.009 *
Multan	Wholesale	IRRI rice	Yes	Yes	-0.032	-0.094	-1.031 *
Sukkur	Wholesale	IRRI rice	Yes	Yes	-0.022	-0.136	-0.98 *

* indicates that the coefficient is significant at 10% level; otherwise at 5% level.

Table 13: Transmission of world Basmati rice price to domestic prices (nominal prices in rupee)

Markets	Type of markets	Commodity	Unit root?	Long-run relationship?	Vector error correction model		
					Speed of adjustment	Short-run adjustment	Long-run adjustment
Lahore	Wholesale	Basmati rice	Yes	No			
Rawalpindi	Wholesale	Basmati rice	Yes	No			
Hyderabad	Wholesale	Basmati rice	Yes	Yes	-0.005781	0.024684	-0.604 *
Peshawar	Wholesale	Basmati rice	Yes	No			

* indicates that the coefficient is significant at 10% level; otherwise at 5% level.

basmati rice markets. Informal trade flows with Afghanistan and India tend to affect integration patterns due to cross-border price differentials. The statistical significance of international price transmission was relaxed to 10 percent in order to select leading markets. The low integration of domestic markets to the international market could undermine market response to international price decreases. At the same time it could shelter households from being severely impacted by imported price volatility.

The results of the domestic market integration analysis show that price transmission is strongest in wheat and IRRI rice markets. The results of the price transmission in domestic wheat markets are also likely affected by government intervention, but the price signals are strong enough to draw conclusions on the price-setting markets. IRRI rice price is the most integrated among domestic markets and in international price transmission. Figure 10 summarizes the list of the main markets that are vulnerable to food price shocks and hence require close monitoring due to their leading role in the domestic economy and their integration to the international market.

Since wheat is the staple commodity in Pakistan, access and availability have direct linkages with ensuring household food security. Therefore, the Pakistani government's decision to intervene in wheat markets to keep wheat prices affordable in order to ensure food security has affected the level of price transmission and the ability to determine the price-setting markets. Despite these general findings, this study suggests that there are two wheat markets to monitor: Hyderabad and Peshawar which are the two markets that showed a long-term relationship with international prices. Hyderabad is located near the major port of Karachi, which is the entry point for wheat imports.

On the retail side, two markets appear important: Karachi and Rawalpindi. Karachi is the entry point for wheat imports and is also a major consumption center. Rawalpindi is a market which also serves Islamabad, the capital city of the country. These two markets are wheat deficit markets and are important to monitor as they are likely to be highly sensitive to a change in wheat supply. On the wholesale side, two important markets were identified for monitoring: Peshawar and Multan. Peshawar is a major trading point with Afghanistan and supplies areas in FATA and KPK. Multan is located in the center of the largest wheat producing province Punjab and can affect the variation in wheat supply.

Price transmission from international IRRI rice markets to domestic markets shows mixed results. The results show a marginal level of price transmission from international to domestic prices. Unlike wheat, domestic wholesale prices of IRRI rice tend to increase before the international price, suggesting that Pakistan plays a role in setting the price in the IRRI rice market. The results of the market integration analysis highlight five IRRI rice markets to monitor in case of an international price shock (Figure 10). Sukkur, which is located close to the border with India, has the highest response rate of short-term fluctuations in international prices. Multan also shows a higher level of short-term adjustment to international prices compared with the other markets. This suggests that IRRI rice prices in Sukkur and Multan are most responsive to shocks.

The domestic price integration analysis suggests that Islamabad, Karachi, Lahore, Quetta and Rawalpindi are important retail markets to monitor as prices in these markets play a role in price determination throughout Pakistan's IRRI rice markets. On the wholesale side, the analysis suggests monitoring of Multan and Rawalpindi markets. Rawalpindi is located just outside of Islamabad and is a major supply market for the capital city. Multan is a leading market on domestic price transmission and likely a price setter among domestic prices due to Multan's number of unidirectional relations in the Granger causality tests.

Figure 10: Markets that are most sensitive to price shocks

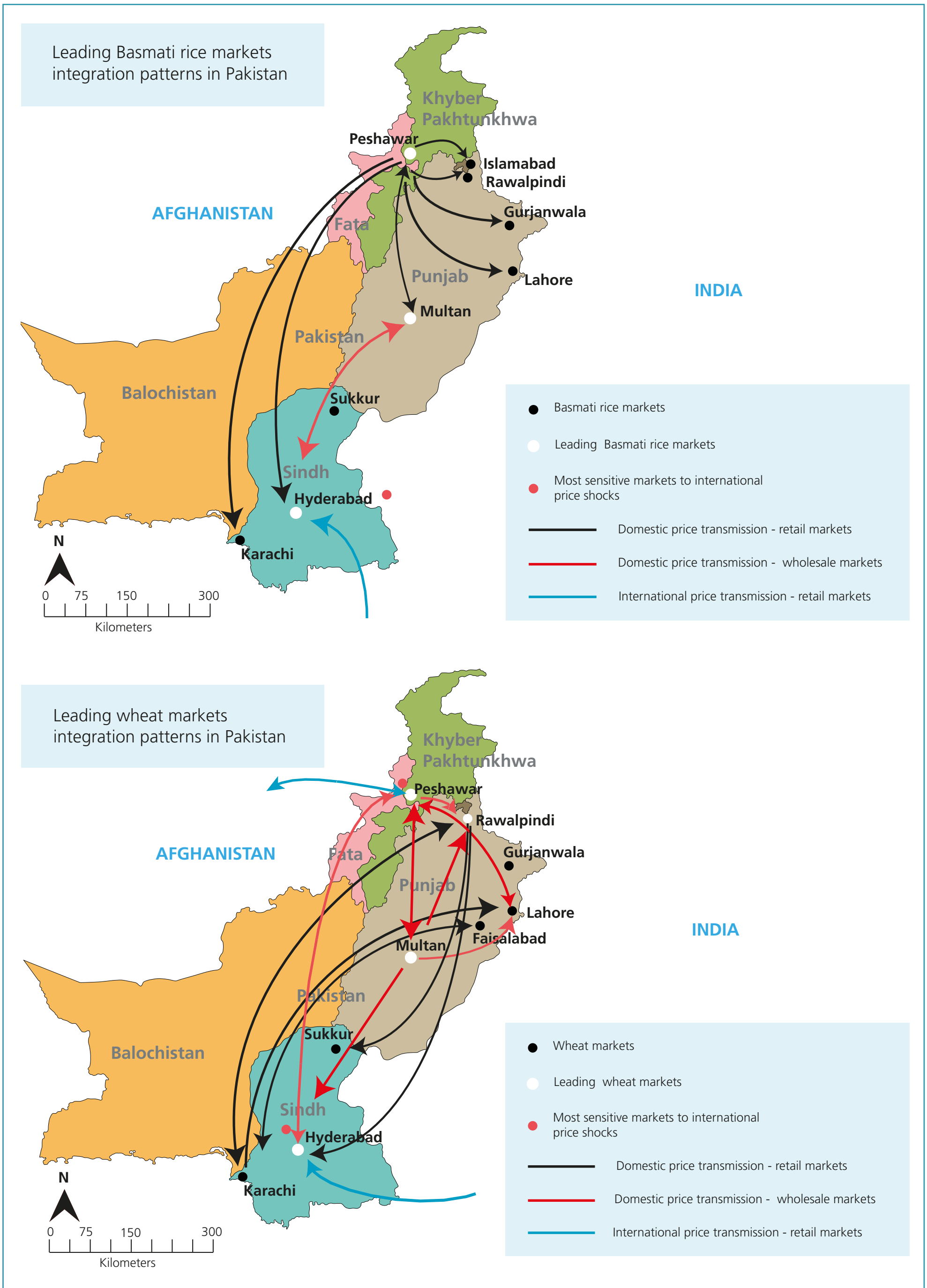


Figure 10: Markets that are most sensitive to price shocks (Cont.d)

Leading IRRI rice markets integration patterns in Pakistan

Retail markets

Markets (Leading markets)	Islamabad	Karachi	Lahore	Quetta	Rawalpindi	Gurjanwala	Multan	Peshawar	Faisalabad	Sialkot	Sukkur	Hyderabad
Islamabad	.	↕	↕	↕	↕	↕	↕	↕	↑	↕	↑	↕
Karachi	↕	.	↕	↕	↕	↕	↕	↕	↑	↑	↑	↕
Lahore	↕	↕	.	↑	↑	↕	↑	↕	No	↑	↑	↕
Quetta	↕	↕	↑	.	↕	↑	↕	↑	No	↕	↑	↕
Rawalpindi	↕	↕	↑	↕	.	↕	↕	↕	↑	↕	↑	↕

- ● IRRI rice markets
- ○ Leading rice markets
- ● Most sensitive markets to international price shocks
- ↑ Domestic price transmission - retail markets (unidirectional relationship)
- ↕ Domestic price transmission - retail markets (bidirectional relationship)
- — Domestic price transmission - wholesale markets
- — International price transmission - wholesale markets

The basmati rice market efficiency seems quite low. The trends of wholesale and retail prices in Hyderabad and Rawalpindi suggest that the government intervenes to keep retail prices affordable for consumers. The government indirectly influences prices by controlling exports in order to manipulate supply levels. Similar to wheat, government intervention prevents market efficiency and makes it difficult for price forecasting. The results indicate that basmati rice markets are weakly integrated between domestic markets and between international and domestic markets. In retail markets, Peshawar is the price setting market and should be monitored in case of a price shock. Such a shock would be transmitted to other markets.

4. Vulnerability to natural risks, shocks and hazards

The United Nations defines disaster as "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" (UNISDR, 2009). This chapter conducts a vulnerability analysis of natural disasters. After reviewing the frequency of climate shocks in Pakistan, floods and droughts are highlighted as the most common disasters. The impact of rainfall patterns on staple food production and yield is therefore assessed. The relationship between rainfall and wheat production in the four main provinces in Pakistan is analysed to provide a better understanding of the regions that are most vulnerable to the specified climate shocks.

4.1 Geographic features and climate

Pakistan is divided into three main agro-ecological zones: the northern highlands; the Indus River Plain, with two major subdivisions corresponding roughly to the Baluchistan Plateau and to the provinces of Punjab and Sindh. It is estimated that less than one-fifth of Pakistan's land area has the potential for intensive agricultural use. In fact, almost all of the arable land is actively cultivated. However, agricultural outputs are low in comparison to world standards. Due to Pakistan's geographic features, cultivation is sparse in the northern mountains, the southern deserts, and the western plateaus. The Indus River basin, situated in the provinces of Punjab and northern Sindh, has fertile soil that enables Pakistan to feed its population under usual climatic conditions. The Baluchistan plateau covers 347 192 km2 of Pakistani territory and represents 48 percent of the total land area of Pakistan. It is the largest of the four provinces in terms of geographical size. The population density is very low due to the mountainous terrain and scarcity of water.

Pakistan is located in the temperate zone, slightly above the Tropic of Cancer. The climate varies from tropical to temperate. In the coastal south, arid conditions prevail, characterized by a monsoon season with adequate rainfall and dry season with lower rainfall, while abundant rainfall is experienced in the Punjab province. The rainfall pattern can range from as little as 10 inches a year to over 150 inches a year in various parts of Pakistan. There are wide variations in terms of extremes in temperature across different locations.

Pakistan is marked by four seasons: a cool, dry winter characterized by mild temperatures from December through February; a hot, dry spring from March to May; the summer rainy season, or southwest monsoon period, from June to September; and the retreating monsoon period of October and November. Based on the location, the onset and duration of these seasons tend to vary.

4.2 Covariant risks: History of natural disasters in Pakistan

Natural disasters are classified into several categories based on their nature, i.e., whether their nature is biological, geophysical, hydrological, meteorological, etc. Figure 11 illustrates the classification of natural disasters according to the Centre for Research on the Epidemiology of Disasters (CRED).

According to Maplecroft (2010), a global risk assessment company, Pakistan ranks fourth among the top countries at risk from extreme weather. Pakistan is prone to various reoccurring natural hazards such as, floods, earthquakes, landslides, and cyclones. Among the two most severe natural disasters that occurred within the current decade in Pakistan were the October 2005 earthquake and the July 2010 floods. Both these disasters caused tremendous damage in terms of human and economic losses. Thousands of lives were lost; 5 128 000 people were affected by the earthquake that struck Pakistan and Azad Jammu and Kashmir (AJK) in October 2005 and 20 202 327 people were reportedly affected by the July 2010 floods (EM–DAT, 2010). Recently (18th of January 2011), Pakistan experienced a major earthquake of magnitude 7.2 in Kharan, Baluchistan, but no major damages were reported (CNN, 2011).

Figure 11: Classification of natural disasters

NATURAL DISASTERS

Biological	Geophysical	Hydrological	Meteorological	Climatological
• Epidemic • *Viral infectious disease* • *Bacterial infectious disease* • *Parasitic infectious disease* • *Prion infectious disease* • Insect infestation • Animal stampede	• Earthquake • Volcano • Mass movement (dry) • *Rockfall* • *Landslide* • *Avalanche* • *Subsidence*	• Flood • *General flood* • *Flash flood* • *Storm Surge/ coastal* • *Flood* • *Mass movement (wet)* • *Rockfall* • *Landslide* • *Avalanche* • *Subsidence*	• Storm • *Tropical cyclone* • *Extra-tropical cyclone* • *Local storm*	• Extreme temperature • *Heat wave* • *Cold wave* • *Extreme winter condition* • *Drought* • *Wildfire* • *Forest fire* • *Land fire*

Source: "EM-DAT: The OFDA/CRED International Disaster Database: www.emdat.be-Universit? Catholique de Louvain-Brussels-Belgium"

4.2.1 Floods

Floods are the most frequent natural disaster in Pakistan (Figure 12). Pakistan has been traditionally vulnerable to recurring floods, particularly in the alluvial plains of the Indus river system. Pakistan is also among the five South Asian countries with the highest annual average number of people physically exposed to floods. This normally occurs due to storm systems that originate from the Bay of Bengal during the monsoon season from July to September. At a provincial level, Punjab and Sindh are particularly prone to floods, while hill torrents tend to affect the more hilly provinces of KPK and Baluchistan. The major flood events of 1973, 1976, 1992, and 2005 caused many deaths and huge losses to the national economy. In addition, the recent flooding (July 2010) has also resulted in considerable damage to life and property, the damage caused being estimated at USD 9.5 billion (EM–DAT, 2010). According to official sources, over the period 1991-2001, floods in Pakistan caused an estimated damage of over Rs. 78 000 million to property. In addition to the riverine floods during the summer monsoon, flash floods and land slide hazards are also frequent events in the mountainous north along watersheds. Flash floods also occur in the upper plains adjacent to river catchment areas.

The increase in loss of life and property in recent years (see Figure 13) indicates the relative lack of preparedness to such hazards. This is in spite of the fact that an effective protection network of dykes and flood water regulatory infrastructure has been built over the years.

Figure 12: Frequency of natural disasters in Pakistan

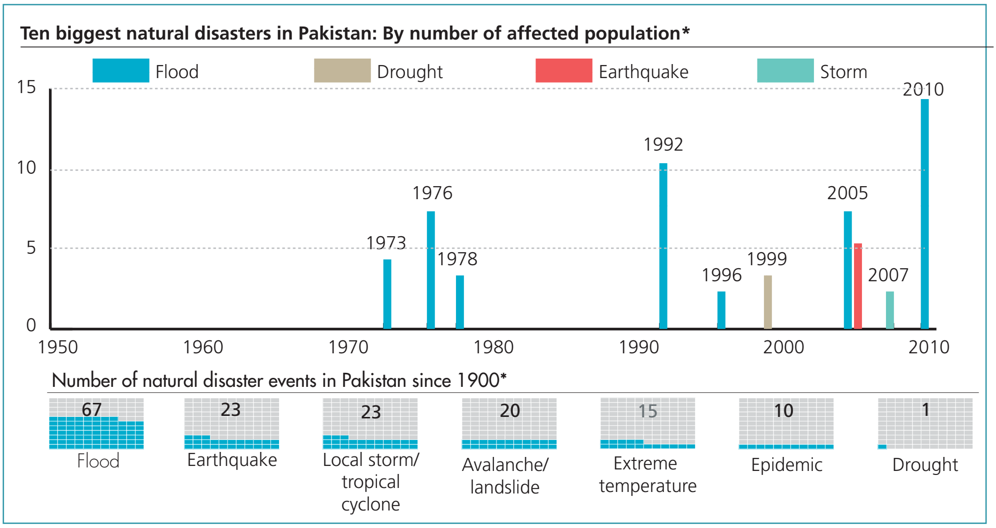
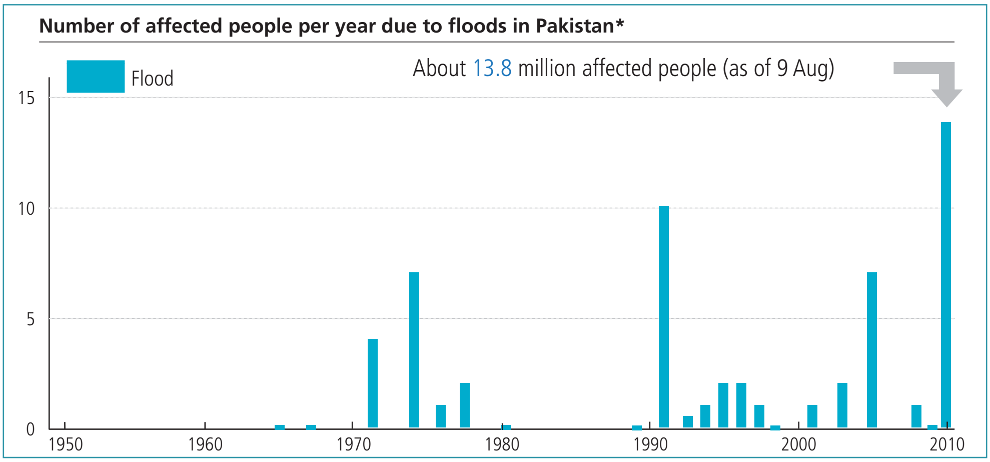


Figure 13: Number of people affected by floods in Pakistan



Source: http://www.reliefweb.int/rw/fullmaps_sa.nsf/luFullMap/8A7B7152D23697D0C125777B-00411D87/$File/FL-2010-000141- PAK_0809_graph.pdf?OpenElement, OCHA

* The information on natural disasters presented here is taken from EM-DAT: The OFDA/CRED International Disaster Database. In order for a disaster to be entered into the database, at least one of the following criteria has to be fulfilled: a) 10 or more people reported killed; b) 100 people reported affected; c) a call for international assistance; d) declaration of a state of emergency.

4.2.2 Drought

Drought is an irregular occurrence for Pakistan, but when it does take place, the aftermath is often devastating. In recent years, drought is reported to have brought extensive damages to Baluchistan, Sindh and Southern Punjab, where average rainfall is as low as 200-250 mm per year. In 2000 and 2002, severe droughts led to human deaths, affected livelihoods, forced tens of thousands to migrate and killed large numbers of cattle. Official estimates suggest that this drought period led to 120 deaths and affected 2 200 000 people. The impact of the drought was most pronounced during the 2000-2003 period, when it spread across 68 districts in four provinces.

The main arid rangelands that are affected by droughts are Thar, Cholistan, Dera Ghazi Khan (D.G.K.), Tharparkar, Kohistan and western Baluchistan. With the exception of Baluchistan, all of these areas are within the range of monsoon rainfall, which is erratic and scattered. As a consequence, in these areas two to three years in every decade are drought years. Moreover, there have been prolonged incidences of drought in the poverty-ridden arid regions of Pakistan and fewer occurrences of floods, linked to changing regional weather patterns.

4.2.3 Implications for agricultural production

Floods and droughts in Pakistan have caused tremendous damage to livelihoods and infrastructure, with severe implications for food security. As exemplified by the August 2010 flood, the largest losses and impact were suffered by the agriculture, livestock, and fisheries sectors. Damage to the already old irrigation infrastructure caused by the 2010 floods, combined with the increasing scarcity of water resources in Pakistan, pose serious risks to agricultural production. This is particularly alarming when a large portion of the national wheat output depends on irrigation.

4.3 Forecasting the impact of weather shocks on wheat production

As shown above, Pakistan has experienced several catastrophic floods over the past few decades, which often have substantial impacts. The following crop production model determines the depth of the relationship between rainfall and wheat production by province, and provides implications for household food security. This section first reviews the descriptive statistics on the trends in wheat and rainfall data among the four main wheat producing provinces. This analysis provides the parameters for crop production monitoring, taking into account the impacts of weather related variables such as rainfall. The estimated productions are then used in the SISMOD.

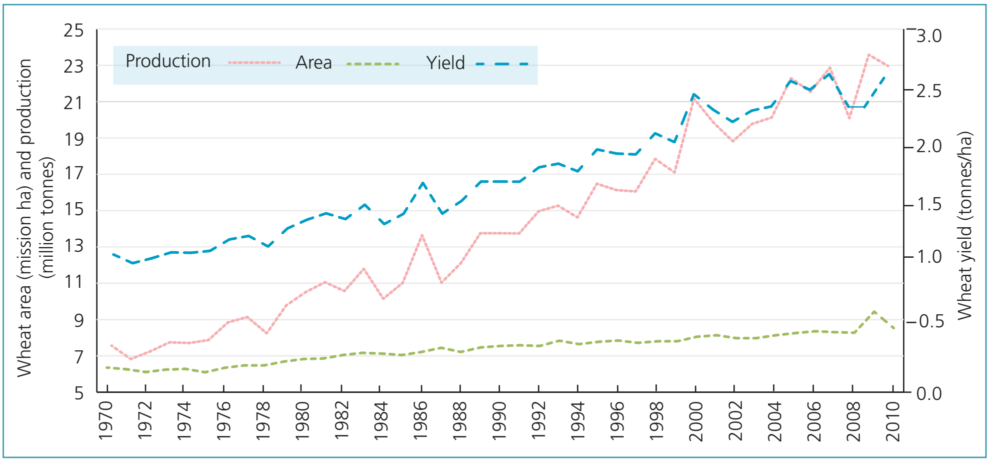
4.3.1 Trends in wheat production from 1970-2008

Figure 14 shows the general trend in wheat production and yield in Pakistan from 1970-2010. Both production and yield have more than doubled (increased by 2.32 times) within this time period. During these 40 years the national wheat production increased from an annual 6.85 million tonnes in 1970-72 to 22.77 million tonnes in 2008-10, an increase of 232 percent.

The main increase was the result of both a yield increase (by 120 percent) and an area increase (by 50 percent). The increase in productivity during this period was partially due to the agricultural policies and reforms implemented subsequent to the Green Revolution of the 1970s.

At a provincial level (see Figure A1.1), in Punjab production increased by 2.5 times, yield doubled, and cultivated area became 50 percent more than it used to be in 1970. There has been a steady pace in the increase in both wheat production and yield in Punjab, although a small decline was experienced from 2001 to 2003. In Sindh, from 1970 to 2000 production tripled and yield more than doubled, whereas cultivated area remained constant throughout this period. From 2000 to 2004, Sindh experienced a significant decline in both production and yield. From 2004 to 2008, production and yield went up by 60 percent and 40 percent respectively, whereas the cultivated area increased by 10 percent. Overall, wheat

Figure 14: General trend in wheat production and yield in Pakistan (1970-2010)



production exhibited the lowest standard deviation in KPK, suggesting that this province is less likely to suffer from erratic rainfall patterns and natural disasters. For KPK, production almost tripled and yield more than doubled, while cultivated area only rose slightly from 1970 to 2008. There was a steep decline in both production and yield from 1998 to 2001, followed by an increase.

Both production and yield in Baluchistan have gone up significantly, with production being 5 times higher and yield being 2.5 times higher in 2008 than in 1970, while the cultivated area doubled. There was a steep decline in both production and yield from 1997 to 2000 in Baluchistan, followed by an increase from 2000 to 2004, and a rapid increase from 2006 to 2008.

There are considerable differences in the area cultivated across the provinces (Table 14). Baluchistan has the lowest mean of area cultivated and Punjab has the highest. Out of the four provinces, Punjab is subject to the highest fluctuation in the area cultivated since the standard deviation is extremely high. The mean representing the cultivated area is the largest for Punjab among the provinces, totaling 5 440.17 hectares. This figure is more than double the mean of the combined cultivated areas of the other 3 provinces (Baluchistan, KPK and Sindh) (2 016.43 hectares).

The fact that the median values are almost always greater than the mean values for production, area and yield implies that the impact of weather shocks related to erratic annual rainfall could have led to a decline in wheat production and yield across the various provinces in recent years. This explanation is consistent with the increase in both frequency and scale of natural disasters that have struck Pakistan in recent years.

Table 14: Wheat area (000 ha), yield (tonnes/ha), and production (000 tonnes) by province (1970-2008)

	Mean	Standard deviation	Minimum	Maximum	Median
BALUCHISTAN					
Production	483.4	269.9	68.6	930.1	529.5
Area	272.2	86.1	134.5	430.5	293.7
Yield	1.63	0.59	0.40	2.41	1.86
KPK					
Production	921.9	248.3	331.2	1356.0	962.2
Area	767.8	75.3	589.6	918.1	781.9
Yield	1.18	0.25	0.56	1.54	1.20
PUNJAB					
Production	10575.1	3893.7	4948.2	17853.0	10513.8
Area	5440.2	707.3	4216.3	6483.4	5589.4
Yield	1.89	0.48	1.13	2.78	1.86
SINDH					
Production	2077.6	592.6	1081.1	3411.4	2130.9
Area	976.5	111.0	755.5	1144.2	1010.7
Yield	2.11	0.52	1.19	3.47	2.12

4.3.2 Trends in rainfall patterns from 1970-2010

From Table 15, Sindh and Baluchistan appear to be drier areas while KPK and Punjab are wetter areas, based on rainfall over a 35-year period. The data indicate there is a great deal of variation in the rainfall pattern between the four provinces as well as within a given province.

Sindh is the driest among the four provinces, while KPK province is the wettest province, receiving the highest average annual rainfall over a 35-year period. The mean, standard deviation, minimum, maximum and median values for Sindh are the lowest among the four provinces. The data highlight that Sindh is more vulnerable to droughts. On the other hand, KPK has the highest mean, standard deviation, minimum, maximum and median values of the four provinces, suggesting that the KPK is more prone to flooding.

The range in the monthly precipitation received within a province is also quite significant, especially in KPK in Punjab, as can be seen from the differences between the minimum and maximum values. It should also be noted that owing to the vast surface area of Punjab, it might be more useful to aggregate the data at a district level, in order to better account for the variation in the rainfall data at the provincial level.

Table 15: Cumulative rainfall (October-April in mm) by province (1975-2010)

Province	Baluchistan	KPK	Punjab	Sindh
Mean	105.23	341.91	218.63	29.36
Standard Deviation	55.10	145.94	107.02	27.03
Minimum	21.15	79.40	79.63	2.18
Maximum	224.87	657.00	600.26	134.24
Median	97.59	339.68	189.20	21.16

Rainfall pattern in four provinces at the start of the winter wheat harvest season in April, based on Pakistan's crop calendar (using cumulative rain (October- April)

Looking at the data showing the cumulative annual rainfall for the four provinces (1975-2010), Baluchistan and Sindh are still the drier areas whereas KPK and Punjab receive more rainfall (Figure 15).

4.3.3 Provinces vulnerable to weather shocks on wheat production

From this trend data, we were able to run regressions and derive the parameter estimations to link rainfall to crop yield. Detrended wheat yield and cumulative rainfall are plotted in Figure 16. The strength of the relationship between cumulative rainfall and annual wheat production is represented by the power of the regression, the R^2 value. The derived parameters are shown in Table 16 and the scatter plots are displayed in Figure A1.2.

The results show all four regions have a stronger correlation between estimated and observed yield when the weather shock data (droughts and floods) are

Figure 15: Cumulative rainfall (October-April) from 1975-2010 for four provinces

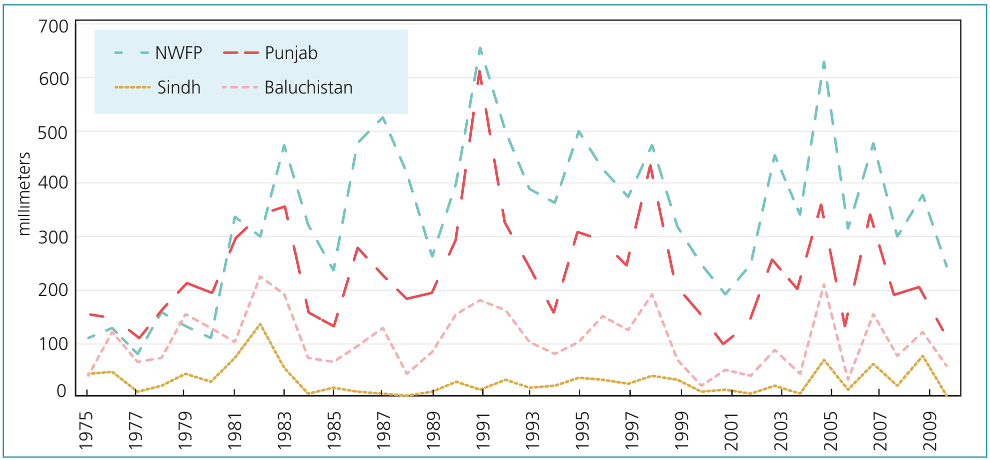


Figure 16: Detrended wheat yield and cumulative rainfall (October-April) from 1975-2010 for four provinces

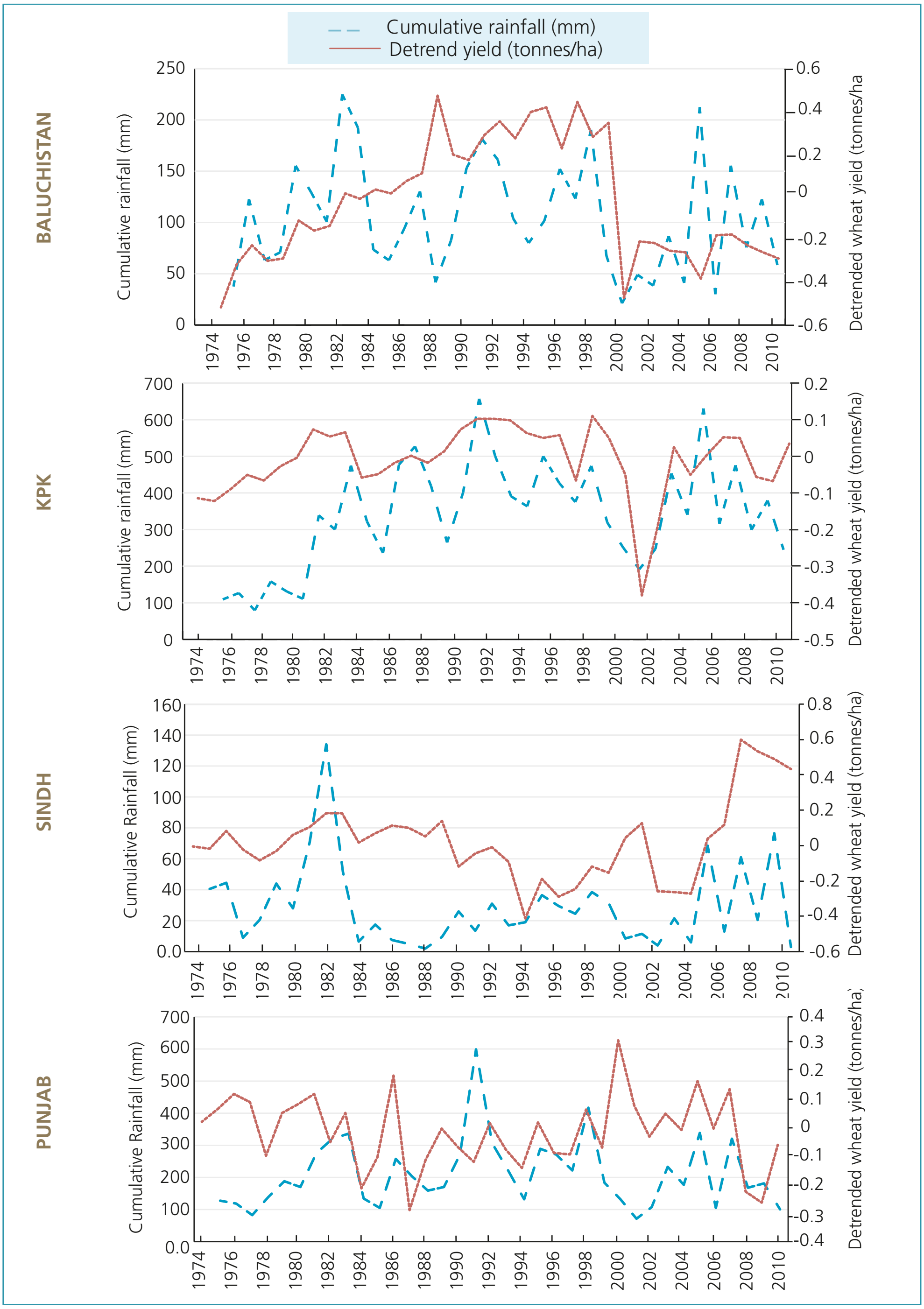


Table 16: Relationship between wheat yield and cumulative rainfall (October-April) with or without shocks (droughts/floods Pakistan)

Province	Estimated yield, y	Coefficient of observed yield, x	Constant	Power of regression, R^2
Punjab	w/ weather shocks	0.92	0.16	0.91
	w/o weather shocks	0.97	0.06	0.94
Sindh	w/ weather shocks	0.81	0.42	0.81
	w/o weather shocks	0.81	0.42	0.81
KPK	w/ weather shocks	0.64	0.45	0.66
	w/o weather shocks	0.71	0.36	0.80
Baluchistan	w/ weather shocks	0.59	0.73	0.64
	w/o weather shocks	0.58	0.74	0.66

excluded from the correlation. The overall trend displays a positive slope indicating that production and yield have both improved despite the frequent ups and downs caused by weather shocks. The strongest relationships were in Punjab and Sindh. Both provinces receive the largest amount of rainfall among the provinces. KPK produces the least amount of wheat, while Punjab is the largest wheat producer. The forecasting model is a good predictor of trends in crop production and yield, as is supported by the relatively high R^2 values. Once rainfall data that are categorized as "outliers" are removed (in order to isolate natural disaster events such as droughts or floods), the R^2 values increase significantly.

In conclusion, in all four provinces wheat production is vulnerable to both flood and drought shocks. The derived parameters will serve to estimate changes in wheat production in the SISMOD. The correlation between wheat production and cumulative rainfall is statistically significant, suggesting that cumulative rainfall is a good predictor of wheat production in Pakistan. This vulnerability to weather shocks has implications on household food insecurity and livelihoods in Pakistan. However, the magnitude of the impact transmitted to households largely depends on their livelihood and reliance on the agricultural sector. The next chapter provides further insights into livelihoods, incomes and consumption patterns and their vulnerability to both the market and weather shocks, identified in Chapters 3 and 4.

5. Household food security and vulnerability to shocks

The last aspect of the profiling analyses livelihood groups that are vulnerable to potential shocks. In order to provide such an assessment, this chapter presents a descriptive household analysis. The analysis groups the different profiles by province and by livelihood in rural and urban areas, including demographics, income sources, assets (land and livestock), expenditures and food energy consumption. These variables provide insight into sectors of the population in Pakistan that are more vulnerable to the impacts of market and climate shocks.

5.1 Demographics

5.1.1 Nationwide demographics

Pakistan is the sixth most populous country in the world, with an estimated population of about 170 million people. The population is still growing quite significantly, with a growth rate of 2.05 percent over the last four years. Pakistan is considered a "young" country, as there are currently 104 million Pakistanis below the age of thirty. Approximately 109.1 million people reside in rural areas and 60.9 million live in cities. Life expectancy in Pakistan is 64.1 years of age (GOP, 2010).

Pakistan is currently the most urbanized nation in South Asia. Urban dwellers make up 36 percent of the population. Since 1950, Pakistan's urban population has expanded seven-fold, while the total population increased four-fold. The urbanization growth rate is 3 percent (GOP, 2010).

Pakistan has the tenth largest labor force in the world. According the latest Labor Force Survey of 2008-2009, the labor force is estimated at about 54 million. The total working-age population is 121 million. Of the total labor force, about three million people are unemployed, which results in unemployment rate of 5.5 percent. The gender distribution of the labor force is 42 million men and 12 million women (GOP, 2010).

5.1.2 Demographics of the household survey sample

The descriptive analyses of demographics in different livelihood groups in Pakistan show many similarities between rural and urban areas (Table A1.11). The household sizes range between 7 and 15 persons in rural areas and 7 and 12 persons in urban areas. However, rural areas exhibit a relatively higher dependency ratio compared

Table 17: Distribution of households by livelihood group

Livelihood	Rural households	
	% of HH	No. of HH
RURAL LIVELIHOOD GROUPING		
Employer	16	1 224
Paid employee	43	3 322
Unpaid family worker	1	63
Owner cultivator	25	1 916
Share cropper	9	693
Contract cultivator	3	217
Livestock only	4	307
URBAN LIVELIHOOD GROUPING		
Agriculture	7	346
Traders	26	1 291
Social & personal service	29	1 463
Service sector	13	639
Industrial sector	25	1 221

with urban areas, 0.49 vs. 0.42, on average. The unpaid family worker type of household in the rural part of Baluchistan has the highest average dependency ratio of 0.78.

When assessing the size of each livelihood group in Table 17. In rural areas the largest livelihood groups are paid employee, owner cultivator and employer, while in urban households social and personal service, traders and the industrial sector make up the largest livelihoods. As expected, households that engage in agriculture (owner cultivator, sharecropper, contract cultivator, and livestock) reside mostly in rural areas, while in urban areas agriculture is the smallest livelihood activity.

5.2 Household wealth status

5.2.1 Income by source

Households in Pakistan engage in many income-generating activities for their livelihoods. Table 18 and Table 19 display households share of income sources by province and livelihoods in rural and urban Pakistan, respectively.

Rural households tend to have a more diversified income structure than urban households. Their income sources are spread among two to three sources. In general, households of employers and paid employees derive their incomes mainly from two sources in all four provinces (non-agricultural wage income and public wage income), with the exception of paid employees in Sindh and Baluchistan, who rely on three sources (agricultural wage income in addition to the two others mentioned above).

In rural Pakistan, the lowest earners are contract cultivators, earning 1 287.07 rupees per capita per month in KPK and unpaid family workers, earning 1 733.22 rupees per capita per month in Punjab. In Sindh, sharecroppers are the lowest earners with a per capita monthly income of 1 815.48 rupees, while pastoralists in Baluchistan earn the lowest income of 1 862.58 rupees. The unpaid family workers in Punjab earn most of their income from agricultural wage, non-agricultural wage,

Table 18: Per capita monthly income (Rs) and percentage share by source and by livelihood group in rural areas in Pakistan

Livelihood	Per capita income	Crop income	Livestock income	Agricultural wage income	Non agricultural wage	Public wage	Remittance income	Other income
	Rs	%						
PUNJAB								
Employer	2 475	2.5	5.8	4.7	57.4	22.8	2.8	4.1
Paid employee	2 024	2.2	6.6	11.3	50.5	23.5	3.2	2.8
Unpaid family worker	1 733	8.5	15.8	35.3	16.1	6.3	14.6	3.4
Owner cultivator	3 298	15.8	18.1	52.3	5.6	2.3	4.2	1.8
Sharecropper	1 946	11.0	21.1	50.4	8.7	1.3	6.0	1.4
Contract cultivator	2 996	22.5	17.3	48.6	6.0	1.2	3.5	0.8
Livestock only	2 357	0.1	37.2	30.8	9.6	1.8	9.2	11.3
SINDH								
Employer	2 604	3.0	8.8	8.7	62.9	11.5	0.1	5.0
Paid employee	2 017	3.8	3.0	29.8	39.9	20.0	0.1	3.5
Unpaid family worker	2 537	34.3	5.6	54.8	3.5	0.3	1.5	0.0
Owner cultivator	2 869	27.7	9.6	53.6	5.0	2.9	0.3	0.9
Sharecropper	1 815	27.4	10.0	51.2	8.1	2.8	0.4	0.2
Contract cultivator	3 004	27.4	2.9	59.7	5.0	4.9	0.0	0.0
Livestock only	3 149	0.7	13.6	20.9	2.4	1.3	0.4	60.7
KPK								
Employer	2 470	0.9	2.7	2.2	55.8	22.4	7.8	8.2
Paid employee	1 975	1.6	3.2	4.8	49.1	27.6	6.9	6.6
Unpaid family worker	1 443	-7.4	5.4	17.7	33.3	13.9	23.1	14.1
Owner cultivator	1 759	5.8	15.0	38.4	10.8	6.0	19.5	4.4
Sharecropper	1 521	6.3	19.8	37.1	16.0	3.8	14.9	2.0
Contract cultivator	1 287	3.6	14.3	45.1	12.2	6.4	15.2	3.2
Livestock only	2 211	1.1	39.0	34.0	7.9	3.2	12.6	2.2
BALOCHISTAN								
Employer	2 514	1.7	1.6	9.7	58.6	25.7	0.1	2.6
Paid employee	2 020	2.7	1.8	14.9	49.6	29.0	0.3	1.7
Owner cultivator	2 570	14.1	4.4	67.4	8.3	5.0	0.4	0.5
Sharecropper	2 165	17.5	9.6	67.4	2.3	2.2	0.0	0.9
Livestock only	1 863	0.7	31.3	40.5	8.8	4.6	2.2	11.9

Note: Livelihood Groups of Unpaid family worker and Contract Cultivator in Baluchistan are not shown since only very small samples were available

and livestock income; in Sindh most of the sharecroppers earn through both crop income and agricultural wage income; and in Khyber Pakhtunkhwa agricultural wage, remittance income, livestock and non-agricultural wage income prevails for contract cultivators.

Urban household income is generally distributed among one to three income sources. Among the urban livelihood groups, more than 80 percent of income share is derived from non-agricultural wages and public wages in all four provinces, with the exception of the agriculture-based households. The service sector captures the highest income levels in Punjab, Sindh, and KPK. Service sector based households in urban Punjab capture the highest per capita total monthly income of 4 866 rupees, with public and non-agricultural wages accounting for roughly 90 percent of the incomes. This is closely followed by agriculture-based households in Punjab, earning a per capita total monthly income of 4856.80 rupees. The per capita wages are generally lower in Baluchistan than in the other provinces for all sectors with the exception of agriculture-based households, which have the highest income levels in Baluchistan, at 3 256 rupees.

Similar to rural households, urban households classified as agriculturalists tend to have more diversified income structures than non-agricultural households. In urban agricultural households, the main share of income range from two to three sources, typically from agricultural wages, livestock, and non-agricultural wages, depending on the province. The agriculture livelihood groups in both Baluchistan and KPK have a well-distributed share of income across sources.

5.2.2 Income by crop

Table 20 and Table A1.12 provide more details in terms of crop income earned by province and by livelihoods in rural and urban areas, respectively. As previously stated, rural areas are mostly engaged in agricultural activities and hence earn the most crop income. Wheat is a very important crop in Pakistan and most livelihood groups in all provinces engage in wheat production. Punjab and Sindh earn crop income from the production of wheat, rice, cotton and sugar. The biggest earners from maize are contract cultivators in Punjab and owner cultivators in KPK, while it is sharecropper households in Punjab and Baluchistan for pulses. Earnings from fruit production come from urban farming in Baluchistan and Pujab, and owner cultivators in Baluchistan.

5.2.3 Asset ownership

Asset ownership is a good determinant of household wealth. Table A1.13 and Table A1.14 show livelihoods and assets by province in rural and urban households, respectively. As expected, owner cultivators own the most land in rural Pakistan.

Table 19: Per capita monthly income (Rs) and percentage share by source in urban areas in Pakistan

Livelihood	Per capita income	Crop income	Livestock income	Agricultural wage income	Non agricultural wage	Public wage	Remittance income	Other income
	Rs	………………	………………	………………	%	………………	………………	………………
PUNJAB								
Agriculture	4 857	4.8	16.4	55.6	7.9	4.7	3.3	7.2
Traders	3 913	0.4	2.4	0.7	85.2	5.4	1.8	4.2
Social & personal service	4 850	0.4	0.9	0.9	46.4	42.7	2.0	6.6
Service sector	4 866	0.6	0.2	0.2	18.9	70.5	3.8	5.7
Industrial sector	3 895	0.4	0.9	0.4	89.3	4.6	1.6	2.9
SINDH								
Agriculture	3 097	13.2	5.9	67.7	7.1	3.4	0.0	2.6
Traders	4 673	0.0	0.2	0.0	90.7	5.6	0.5	2.9
Social & personal service	4 064	0.1	0.2	0.2	51.3	45.4	0.2	2.6
Service sector	4 682	0.0	0.2	0.3	10.9	87.3	0.0	1.3
Industrial sector	4 414	0.0	0.1	0.2	90.7	5.1	0.1	3.7
KPK								
Agriculture	2 572	2.8	16.1	39.5	15.9	9.6	5.5	10.6
Traders	3 127	0.0	0.7	0.5	86.2	4.5	2.4	5.7
Social & personal service	3 661	0.0	0.4	1.2	46.6	42.1	2.8	6.8
Service sector	4 272	0.2	0.9	0.8	7.1	79.8	5.5	5.8
Industrial sector	3 348	0.0	0.8	0.3	79.4	8.0	1.8	9.6
BALUCHISTAN								
Agriculture	3 256	10.3	9.2	63.8	8.9	7.1	0.5	0.2
Traders	2 402	0.0	0.6	1.4	88.4	6.7	0.9	2.0
Social & personal service	2 975	0.0	0.2	1.0	49.0	48.2	0.0	1.7
Service sector	2 577	0.0	0.1	0.0	7.3	91.3	0.2	1.1
Industrial sector	2 894	0.0	0.1	0.3	89.0	6.7	0.0	3.9

Table 20: Per capita monthly crop income (Rs) by commodity and by livelihood group in rural areas of Pakistan

Livelihood	Wheat	Rice	Maize	Cotton	Sugar	Pulses	Fruits
PUNJAB							
Employer	84.43	28.82	1.33	30.57	0.00	0.00	0.00
Paid employee	49.04	12.78	7.51	29.64	9.89	0.26	0.01
Unpaid family worker	131.94	11.52	0.00	87.61	68.33	12.43	0.61
Owner cultivator	596.97	217.95	17.56	301.25	116.18	18.49	27.31
Sharecropper	282.61	91.39	14.27	80.35	54.49	32.42	0.00
Contract cultivator	671.88	238.03	110.57	354.92	137.12	5.02	7.23
Livestock only	8.09	0.50	0.99	9.48	0.00	0.00	0.00
SINDH							
Employer	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paid employee	50.62	40.21	0.00	22.61	2.82	0.00	7.43
Unpaid family worker	530.68	185.37	0.00	526.70	0.00	0.00	0.00
Owner cultivator	664.88	320.14	1.32	559.39	95.43	1.55	3.38
Sharecropper	333.45	153.76	4.05	309.52	57.20	2.22	5.47
Contract cultivator	529.81	20.13	0.00	582.02	272.25	0.00	0.00
Livestock only	20.91	32.86	0.00	6.35	0.00	0.00	0.00
KPK							
Employer	55.28	0.00	10.01	0.00	0.00	0.00	0.00
Paid employee	25.07	3.60	15.02	0.00	5.47	0.69	1.20
Unpaid family worker	36.68	9.90	15.54	0.00	42.15	0.00	0.67
Owner cultivator	115.63	8.06	51.92	0.07	43.37	2.76	11.15
Sharecropper	98.31	14.60	26.84	1.90	58.43	1.67	3.29
Contract cultivator	94.27	15.83	37.99	0.00	45.10	0.00	0.27
Livestock only	6.45	0.00	25.28	0.00	0.00	0.44	0.58
BALUCHISTAN							
Employer	0.00	0.00	12.67	0.00	0.00	0.00	0.00
Paid employee	14.46	8.52	1.35	0.45	0.00	0.86	57.37
Owner cultivator	331.28	120.47	5.68	6.93	0.00	8.62	353.96
Sharecropper	348.17	255.24	15.43	10.43	26.85	29.71	8.26
Livestock only	3.93	0.00	0.00	7.86	0.00	1.96	0.00

Note: Livelihood Groups of Unpaid family worker and Contract Cultivator in Baluchistan are not shown since only very small samples were available

Contract cultivators and sharecroppers rent the most land in rural Pakistan, while sharecroppers mostly dispose of shared land. In urban Pakistan, agriculture-based urban households mostly own land; they rent and share land to a minimal extent. In Baluchistan, there is no evidence of any land rental or shared land.

In terms of total annual per capita livestock owned, unpaid family workers in rural KPK account for the highest value of 51 827 rupees (Table A1.13); but most of this is not marketed (as they account for a low per capita monthly livestock income of 78 rupees, equivalent to 5 percent share of total income, see Table 18). Buffaloes account for most of this value.

Pastoralist-based households have total per capita value of livestock owned ranging between 10 738 rupees/year in rural KPK and 15 375 rupees/year in rural Sindh (Table A1.13). Comparing with incomes, we observe that earnings from livestock account for about 39 percent of the total income of Pastoralist-based households in KPK while they account for 13.6 percent in Sindh (Table 18).

In urban areas, agriculture-engaged households possess the highest per capita livestock value, as is to be expected: 13 909 rupees/year in Punjab; 5 562 rupees/year in Sindh; 3 782 rupees/year in KPK; and 1 884 rupees/year in Baluchistan (Table A1.14). Buffalo (70 percent) and cattle (21 percent) make up most of the livestock asset value.

5.3 Household food consumption

5.3.1 Expenditures

The analysis of expenditures is displayed in Table A1.15 for rural households and in Table A1.16 for urban households. Employers are among those having the highest expenditure levels in all rural regions, as expected, since employers are among the highest income earners. Owner cultivators in Punjab, pastoralists in Sindh, and unpaid family workers in KPK also have high per capita expenditure levels, which correlate to their high income levels.

In general, for the average household, 60 percent of expenditures are allocated to non-food items and 40 percent to food items. Employers spend the most on food items (on average 471 rupees per month), but have an average distribution of expenditures between food (40 percent) and non-food items (60 percent). In urban areas, agricultural households spend the least on food items and allocate slightly less of their expenditures to food (on average 38 percent). However, the percentage of food expenditures varies quite significantly by livelihood group and by province. For example, while contract cultivators in Sindh spend 42 percent of their total income on food, those in KPK spend 47 percent on food items.

5.3.2 Food calorie intake

Table A1.17 and Table A1.18 display livelihoods and food calorie intake by province in rural and urban areas, respectively. The top 5 livelihoods in terms of total per capita calorie intake are agricultural households in urban Punjab and KPK (2 930 kcal and 2 697 kcal), owner cultivators in rural Punjab (2 925 kcal), pastoralists in rural KPK (2 808 kcal), and contract cultivators in rural Punjab (2 690 kcal).

The bottom 5 livelihoods in terms of total per capita calorie intake are mostly in urban Baluchistan: agricultural households (1 879 kcal), traders (1 792 kcal), service sector (2 007 kcal) and social and personal service (2 016 kcal). For rural areas, paid employees in rural Sindh have the lowest caloric intake of 1 984 kcal per capita.

The food items that make up most of the calorie intake in Pakistan are wheat, milk and rice, which account for 55 percent of caloric intake for the average rural household and 49 percent among urban dwellers. High-income groups tend to consume different food items compared with medium and low-income groups. In rural areas in Pakistan, high-income groups consume more milk, sugar, fats and oils, and fruit than medium- and low-income groups. The main difference in urban areas is that there are more equal consumption patterns of sugar between low- and high-income groups.

5.3.3 Undernourishment

The Percentage of people consuming less than the DECR is measured by comparing the usual food consumption expressed in terms of dietary energy (kcal) with the energy requirement norm of 2 350 kcal, which is the adult calorie requirement. The part of the population with food consumption below the energy requirement norm is considered undernourished.

Table 21 summarizes the undernourishment status in Pakistan. Rural Punjab has the highest average per capita total food calorie intake of 2 571.27 kcal, while, urban Baluchistan the smallest, of 2 019.63 kcal, with an estimated 67 percent of its population undernourished. Overall, the Pakistan average is satisfactory at 2 372.10 kcal, although about 45 percent of the population is undernourished in the baseline survey data.

Tables 22 and 23 display undernourishment among livelihood groups in rural and urban areas in Pakistan. Employers comprise a relatively low proportion of undernourished households as they are the highest income earners as well as spenders on food. The lowest levels of undernourishment (i.e. below 2 350 kcal) are encountered in households involved in the agricultural sectors. This is with the exception of owner cultivators, sharecroppers, pastoralists in rural Baluchistan (50 percent, 53 percent, and 60 percent of undernourished, respectively), and sharecroppers in rural Sindh (48 percent of undernourished, below 2 350 kcal), and

Table 21: Per capita total calorie intake and percentage of people consuming less than the DECR by province and by rural/urban

Category	Per capita total calorie intake	Percentage of people consuming less than the DECR (<2 350 kcal)
	(kcal)	......................%......................
PUNJAB		
Rural	2 571	35.8
Urban	2 475	44.4
SINDH		
Rural	2 167	50.9
Urban	2 144	59.9
KPK		
Rural	2 490	29.3
Urban	2 491	38.7
BALUCHISTAN		
Rural	2 114	56.4
Urban	2 020	66.7
Rural average	**2 397**	**41.0**
Urban average	**2 335**	**50.6**
Pakistan average	**2 372**	**44.8**

agricultural households in urban Sindh and Baluchistan (53 percent and 71 percent of undernourished below 2 350 kcal). In general, the province of Baluchistan suffers from the highest proportion of undernourishment in both rural and urban areas. The province of KPK seems to suffer the least from undernourishment, overall.

Staple foods (mainly wheat, rice and pulses) make up close to half of the calorie intake of most rural household groups and close to 40 percent for urban dwellers, ranging between 35 percent for social and personal service in urban Punjab and 44 percent for agricultural households in urban Sindh. In rural areas, the variance of the share of staples in calorie intake is lower, ranging from 40 percent for owner cultivators in Punjab to 51 percent for contract cultivators in Sindh.

5.4 Vulnerable livelihood groups

Based on the above household profile, the most vulnerable and at risk livelihood groups in Pakistan's four main provinces are highlighted in this section. The vulnerability of the livelihood groups varies between provinces, so it is best to review and highlight these groups accordingly. Vulnerability to shocks is defined according to the share of the income sources that a livelihood group is dependent on.

Table 22: Percentage of people consuming less than the DECR and share of staple food consumption in rural Pakistan by livelihood group and province

Livelihood	Percentage of people consuming less than the DECR (<2,350 Kcal)	Share of staple food consumption in calorie intake
	....................................%....................................	
PUNJAB		
Employer	41.4	42.8
Paid employee	47.9	44.2
Unpaid family worker	40.6	46.1
Owner cultivator	23.2	40.1
Sharecropper	19.6	43.3
Contract cultivator	24.9	41.6
Livestock only	28.5	41.7
SINDH		
Employer	32.9	45.3
Paid employee	57.1	46.5
Unpaid family worker	41.8	44.1
Owner cultivator	35.8	45.5
Sharecropper	47.9	49.8
Contract cultivator	41.8	50.5
Livestock only	34.0	44.4
KPK		
Employer	23.8	44.8
Paid employee	35.1	45.1
Unpaid family worker	27.0	40.6
Owner cultivator	20.1	45.8
Sharecropper	28.6	44.2
Contract cultivator	38.9	48.2
Livestock only	18.0	40.7
BALUCHISTAN		
Employer	63.7	46.1
Paid employee	58.3	47.8
Owner cultivator	49.6	45.7
Sharecropper	53.1	48.3
Livestock only	60.1	47.5

Note: Livelihood Groups of Unpaid family worker and Contract Cultivator in Baluchistan are not shown since only very small samples were available

Table 23: Percentage of people consuming less than the DECR and share of staple food consumption in urban Pakistan by livelihood group and province

Livelihood	Percentage of people consuming less than the DECR (<2 350 kcal)	Share of staple food consumption in calorie intake
	....................................%	....
PUNJAB		
Agriculture	23.0	36.9
Traders	51.4	36.6
Social & personal service	42.5	35.0
Service sector	47.1	36.8
Industrial sector	51.2	38.7
SINDH		
Agriculture	53.0	43.6
Traders	59.1	37.6
Social & personal service	61.1	38.2
Service sector	58.2	37.3
Industrial sector	58.8	38.5
KPK		
Agriculture	34.2	42.3
Traders	43.8	40.6
Social & personal service	32.0	36.4
Service sector	31.2	40.6
Industrial sector	38.9	41.4
BALUCHISTAN		
Agriculture	70.9	42.7
Traders	70.6	43.3
Social & personal service	63.1	41.9
Service sector	61.9	43.0
Industrial sector	59.4	42.5

There are three main income sources: crop and livestock income, agricultural wage income and non-agricultural wage income. Livelihood groups (owner cultivator, sharecropper, contract cultivator and pastoralists) whose major income source (at least 1/3) is crop and livestock income would be vulnerable to both market and climate shocks. Those that receive a significant portion of their income (at least 1/3) from agricultural wage income are at risk of both market and climatic shocks, as they would be dependent on the market for food expenditures and their agricultural wage labor could be affected in the case of a climate shock (flood,

Table 24: Vulnerability of rural livelihood groups to shocks

Livelihood	Market shocks	Climate shocks
PUNJAB		
Employer	XXX	X
Paid employee	XXX	XX
Unpaid family worker	XXX	XXX
Owner cultivator	XX	XXX
Sharecropper	XX	XXX
Contract cultivator	XX	XXX
Livestock only	XX	XXX
SINDH		
Employer	XXX	X
Paid employee	XXX	XX
Unpaid family worker	X	XXX
Owner cultivator	X	XXX
Sharecropper	XX	XXX
Contract cultivator	XX	XXX
Livestock only	X	XX
KPK		
Employer	XXX	X
Paid employee	XXX	X
Unpaid family worker	XXX	XX
Owner cultivator	XXX	XX
Sharecropper	XXX	XXX
Contract cultivator	XXX	XXX
Livestock only	XX	XXX
BALOCHISTAN		
Employer	XXX	X
Paid employee	XXX	XX
Unpaid family worker	X	XXX
Owner cultivator	XX	XXX
Sharecropper	X	XXX
Contract cultivator	X	XXX
Livestock only	XX	XXX

Level of Vulnerability to Shocks - XXX: High (> 1/3 of incomes); XX: Moderate (10-33% of incomes); X: Low (<10% of incomes

Table 25: Vulnerability of urban livelihood groups to shocks

Livelihood	Market shocks	Climate shocks
PUNJAB		
Agriculture	XX	XXX
Traders	XXX	X
Social & Personal service	XXX	X
Service sector	XXX	X
Industrial sector	XXX	X
SINDH		
Agriculture	XX	XXX
Traders	XXX	X
Social & personal service	XXX	X
Service sector	XXX	X
Industrial sector	XXX	X
KPK		
Agriculture	XXX	XXX
Traders	XXX	X
Social & personal service	XXX	X
Service sector	XXX	X
Industrial sector	XXX	X
BALUCHISTAN		
Agriculture	XX	XXX
Traders	XXX	X
Social & personal service	XXX	X
Service sector	XXX	X
Industrial sector	XXX	X

Level of Vulnerability to Shocks - XXX: High (> 1/3 of incomes); XX: Moderate (10-33% of incomes);
X: Low (<10% of incomes

drought). Non-agricultural wage income, public wage income, and remittances would be the most vulnerable to a market shock, as their livelihoods are dependent on both domestic and international markets.

In general, employers and paid employees in rural areas (Table 24) and traders, social and personal service, service sector, and industrial workers in urban areas (Table 25) receive the majority (close to 80 percent) of their income from non-agricultural income sources as mentioned above. These livelihood groups are likely to be more vulnerable to market shocks. Unpaid family worker, owner cultivator, sharecropper, contract cultivator and livestock livelihood groups have more distributed incomes sources between crop and livestock income, agricultural wage income, and non-agricultural wage income. These groups are likely to be more vulnerable to both climate and markets shocks.

6. Simulating the impacts of market and climate shocks on household food consumption

This chapter builds on the baseline profiles of Chapters 3, 4 and 5 to simulate the impacts of price increases and floods on caloric intake. The chapter begins by reviewing the main findings from the vulnerability profiling in order to depict its relation to SISMOD. This section is followed by a review of the main aspects of the methodology. The last section provides the results from SISMOD, which is organized by the Percentage of people consuming less than the DECR (categorized by rural/urban, main provinces, livelihood groups, and income groups), the number of undernourished people, and the food needs to meet the caloric requirement of the undernourished.

6.1 Overview of SISMOD: Interaction between vulnerability profiling and parameter estimations

In the case of Pakistan, the application of the SISMOD will focus on examining the impact of previous shocks on household income, expenditure and food consumption.

6.1.1 Review of main findings from vulnerability profiling

The key findings of the vulnerability profiling portray the trajectory of market and climate shocks by exposing the key markers to these crises: changes in price and production. These pathways of the two different shock factors will determine the magnitude of the impacts on households, simulated by the SISMOD.

The results of the price transmission analysis (Chapter 3) suggests that international cereal price shocks are transmitted to the Pakistani domestic markets through Hyderabad and Peshawar for wheat, and Multan, Sukkur, Peshawar, Rawalpindi and Quetta for IRRI rice and Hyderabad for Basmatti rice. However, due to policy interventions, the speed of transmission is delayed and domestic prices are sticky to international price declines. The above leading markets also play an important role in domestic price transmission between markets.

The relationship between crop production and natural disasters also suggests that all the main wheat production areas in Pakistan are significantly vulnerable to climate shocks. The most vulnerable wheat producing areas to weather shocks are Punjab and KPK (Chapter 4).

The household profiling reveals that a household's relationship with the agricultural sector in sustaining its livelihood plays a large role in the type of shock and the extent to which it is likely to be affected (Chapter 5). Livelihood groups that depend on the agricultural sector (crop and livestock income; agricultural wage income) have a more distributed share of income sources among crop income, agricultural wage income and non-agricultural income, and are likely to be impacted by both market and climate shocks. Livelihoods groups that are less directly dependent on the agricultural sector and whose main incomes are sourced from non-agricultural wage are likely to be most impacted by market shocks.

6.1.2 Shock scenarios

The shock model simulates two different scenarios to provide the most likely situations of market and climate shocks. The first scenario (market shock) is based on actual changes in real wholesale prices, retail prices and wage rates between 2005/06 and 2010/11. These changes were estimated for 20 commodity prices and wage rates in each province.

The second scenario combines scenario one and the impact of the flooding in August 2010. The impact of flooding is captured by the actual losses in crop and livestock production. These losses were estimated through assessments in more than 120 districts in Pakistan.

6.2 Impact of shocks on household food security

Please note that the following sections present the simulation results for the percentage of people with daily intake <2 350 kcal/day in adult equivalents; other definitions for undernourishment such as 2 100 kcal/day and 1 730 kcal/day were also applied to all categories of the simulation results and the results are provided in Appendices 2 and 3.

6.2.1 Impacts on percentage of people consuming less than the threshold (DECR)

Table 26 shows the results of the simulation applied to rural and urban areas, four provinces, seven livelihood groups, and three income groups. These results are articulated in terms of proportion of population with calorie intake below the adult equivalent for daily required kilocalories (<2 350 kcal.)[10]. The simulation results of scenario one (market shocks) show that price increases had a substantial impact on the Percentage of people consuming less than the DECR in both rural and urban areas (7.5 percentage points increase), but rural areas were impacted more (9.3 percentage points increase) than urban areas (4.8 percentage points increase). In

[10] Other definitions for undernourishment such as, 2 100 kcal and 1 730 kcal are applied to all categories of the simulation results and provided in Appendix 2 and Appendix 3.

Table 26: Simulated impact of flood and price increases on percentage of people consuming less than the threshold (caloric intake: % of adults <2 350 kcal/per day)

Category	Baseline (2005/2006)	POST-SHOCK (2010)				
	% population <2 350 kcal/ day	Scenario 1 % population <2 350 kcal/ day	Scenario 2 % population <2 350 kcal/ day	% Point change due to market shock	% Point change due to flood shock	% Point change due to combined Shock
Rural	41.0	50.3	55.4	9.3	5.1	14.4
Urban	50.6	55.4	55.2	4.8	-0.2	4.6
Total	44.8	52.3	55.3	7.5	3.0	10.5
MAIN PROVINCES						
Punjab	39.4	46.7	48.3	7.3	1.7	8.9
Sindh	54.7	64.5	70.9	9.8	6.5	16.2
KPK	32.5	34.2	35.8	1.7	1.6	3.4
Baluchistan	60.4	73.0	75.7	12.7	2.6	15.3
RURAL LIVELIHOOD GROUPING						
Employer *	40.8	50.7	55.1	9.9	4.4	14.3
Paid employee	50.3	62.7	67.7	12.4	5.0	17.4
Unpaid family worker	36.8	36.6	37.8	-0.1	1.1	1.0
Owner cultivator	28.4	33.0	40.5	4.5	7.6	12.1
Sharecropper	41.3	49.6	63.2	8.3	13.6	21.9
Contract cultivator	29.6	34.7	38.9	5.2	4.2	9.4
Livestock only	33.6	46.0	46.8	12.4	0.8	13.2
URBAN LIVELIHOOD GROUPING						
Agriculture	41.5	44.8	47.3	3.3	2.5	5.8
Traders	54.1	58.8	59.9	4.7	1.1	5.8
Social & personal service	49.5	53.5	53.9	4	0.4	4.4
Service sector **	49.9	56.4	56.3	6.5	-0.1	6.4
Industrial sector ***	53.1	60.0	60.2	6.9	0.2	7.1
INCOME GROUPING-RURAL						
Low	49.1	61.6	68.0	12.5	6.5	19.0
Middle	24.2	23.8	25.0	-0.4	1.2	0.8
High	11.4	13.2	14.8	1.8	1.6	3.4
INCOME GROUPING-URBAN						
Low	74.2	83.2	83.4	9.0	0.2	9.2
Middle	51.2	50.6	49.5	-0.6	-1.1	-1.7
High	24.9	28.6	28.6	3.7	0.0	3.7

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

* Employers is a livelihood group composed of mainly large employers (≥ 10 employees), small employers (<10 employees) and self employed non-agricultural businesses.

** Service sector is an urban livelihood group composed of transport, storage, real estate, & insurance sectors.

*** Industrial sector is an urban livelihood group composed of manufacturing, mining, construction, and electricity.

scenario two (combined market and flood shocks), the level of undernourishment in urban areas remained almost unchanged compared with scenario one, suggesting that urban households are less vulnerable to floods.

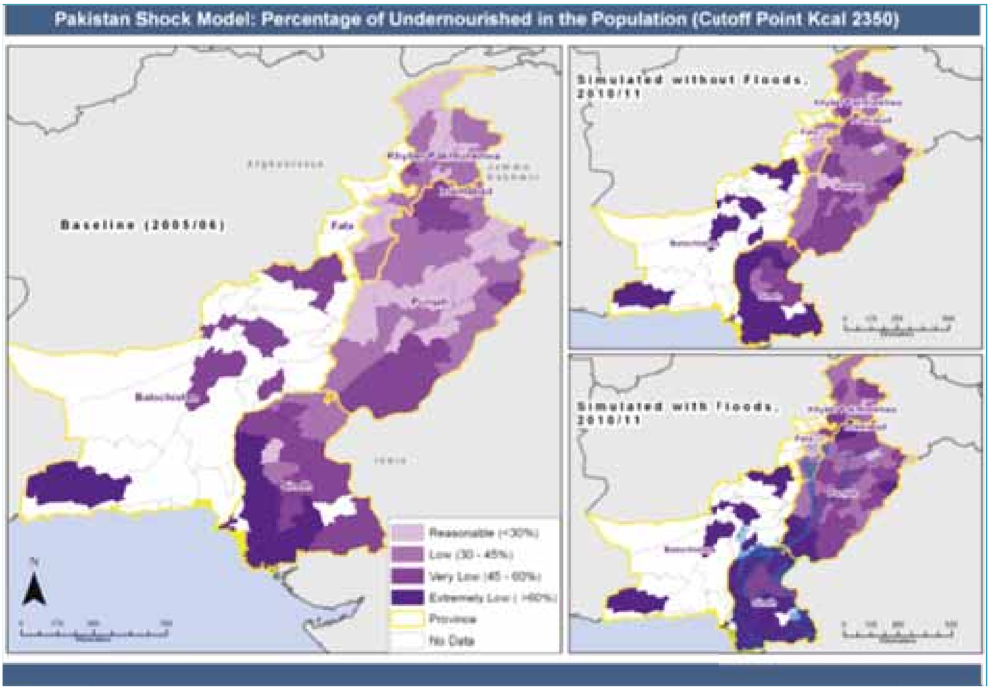
When categorizing the impacts by province, the results show that price increases had the largest impact in Baluchistan with a 13 percent percentage point increase. The market shock also substantially affected both Punjab and Sindh, which are the two largest wheat producing regions in Pakistan. The floods in 2010 had a significant impact only on the province of Sindh, with a 6.5 percentage point increase of undernourishment from the 2005/06 baseline scenario. The combined market and flood shocks had the highest incidence on undernourishment in Sindh (16.2 percentage points increase). KPK proved to be the most resilient to both price increases and floods. Figure 17 displays these provincial trends spatially for identifying the impacts of price increases and flooding on the Percentage of people consuming less than the DECR by district.

The results categorized by livelihood groups show similar findings from the baseline situation. Unsurprisingly, the livelihood groups that are less dependent on the agricultural sector as their main source of income are most affected by price increases in rural areas (first two rural livelihood groups in Table 26). Paid employees and pastoralists are the worst affected livelihoods, as the percentage of those having an inadequate food intake increased in both groups by 12.4 percentage points to 62.7 percent and 46.0 percent, respectively. Price increases also seem to have resulted in a substantial increase of undernourishment figures among employer-based households. The income source of employers is derived mainly from non-agricultural wages and public wages, which explains their vulnerability. Overall, household groups with agricultural production face relatively smaller impacts of price increases on the Percentage of people consuming less than the DECR. Rural non-farming households are worst hit by price increases because they cannot rely on own production for food consumption.

When applying the flood shock impact, the livelihood groups whose main income sources are derived from the agricultural sector were most affected. Sharecroppers suffered the most among the livelihood groups, having the highest percentage increase of undernourishment of 13.6 percentage points due to flooding. On average among the four provinces, sharecroppers earn over 80 percent of their income from the agricultural sector. In Baluchistan and Sindh sharecroppers have the highest shares of agriculture-based income of 94 percent and 88 percent. Owner cultivators also faced a relatively high percentage increase of undernourishment of 7.6 percentage points. Overall, rural farming households were worst hit by the August 2010 floods because they rely on production as their source of food and income.

The combined impacts of market and climate shocks seem to push households

Figure 17: Percentage of people consuming less than the threshold due to simulated market and flood shocks by district (% of population below 2 350 kcal/day)



which already had high-levels of food insecurity pre-crises into further destitution. When applying scenario two of the combined impact of price increases and floods, sharecroppers have the highest increase of undernourishment of 21.9 percentage points from the baseline year, with 63.2 percent of the population being undernourished in scenario 2. This is the second highest total inadequate food intake among livelihoods groups. Sharecroppers have quite a diverse income structure: their income comes from two to five sources in the four main provinces. Sharecroppers in KPK derive their income from five different sources. These balanced sources of income can explain this combined impact for sharecroppers. Also in scenario two, paid employees have the second highest increase in inadequate food intake of 17.4 percentage points, and the highest undernourished overall population among the livelihood groups of 67.7 percent.

Among urban livelihood groups, price increases had a larger impact on households' undernourishment than floods, as income sources were generally derived from non-agricultural income with the exception of agricultural-based urban households. Service sector and manufacturing sector based households were the worst affected urban livelihoods, as inadequate food intake increased by 6.5 percentage points to 56.4 percent and by 6.9 percentage points to 60 percent respectively. The simulation results found the situation of flooding to only affect agricultural based households among the urban livelihood grouping (2.5 percentage point increase).

Looking at the income groups, the shock impact simulation shows that a larger proportion of low-income households became undernourished as a result of price increases in both rural (12.5 percentage points) and urban (9.0 percentage points) areas. In the case of flooding, only low income households in rural areas are affected (6.5 percentage points increase in rural). Middle and high income groups did not suffer much from either price increases or flooding. As the average income increases, the impact of price increases and flooding on households' food consumption becomes less.

6.2.2 Quantifying the shock impacts in terms of the number of undernourished people, depth of hunger and food needs

As shown in Table 27, when applying the minimum requirement of 2 350 kcal/adult/day, the number of severely food insecure people nationwide increased from 77.6 million in the baseline situation to 95.7 million due to price increases (+12.9 million people) and flooding in August 2010 (+5.2 million people). The increase in the number of undernourished people was largest in rural areas, as an additional 9.9 million people became undernourished due to the market shock, and an additional 5.3 million people due to the climate shock from the baseline value of 45.7 million people. The increase of undernourishment in urban areas was small compared with rural areas, as urban areas were only impacted by the market shock by an increase of 3.0 million people from the baseline value of 31.9 million people.

The two indicators Depth of Hunger and Wheat Gap, quantify the food in kilocalories and kilograms required to mitigate the impacts of price and flood shocks on household undernourishment. Depth of Hunger calculates in kilocalories the gap between the estimated food consumption and the minimum requirement for the households with inadequate food calorie intake. As shown in Table 28, when consuming less than 2 350 kcal per day, the average number of kilocalories needed to close the gap among the undernourished nationwide increased from 475 kcal per day in the baseline situation to 603 kcal per day in a combined scenario of price increases (+78 kcal/day) and flooding (+50 kcal/day).

Depth of Hunger results show similar tends to the Percentage of people consuming less than the DECR. On the provincial level, the most severe Depth of Hunger was found in Sindh and Baluchistan (Figure 18). Both price increases and flooding led to steady increases (+66 kcal and +94 kcal respectively) to the amount

Table 27 Simulated shock impacts on the number of undernourished people (caloric intake: 000 adults <2 350 kcal/per day)

Category		POST-SHOCK (2010)		
	Baseline (2005/2006) (A)	Scenario 1	Scenario 2 (B)	Total (A+B)
Rural	45 665	9 991	15 273	60 938
Urban	31 899	3 004	2 899	34 798
Total	77 564	12 995	18 172	95 736

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase

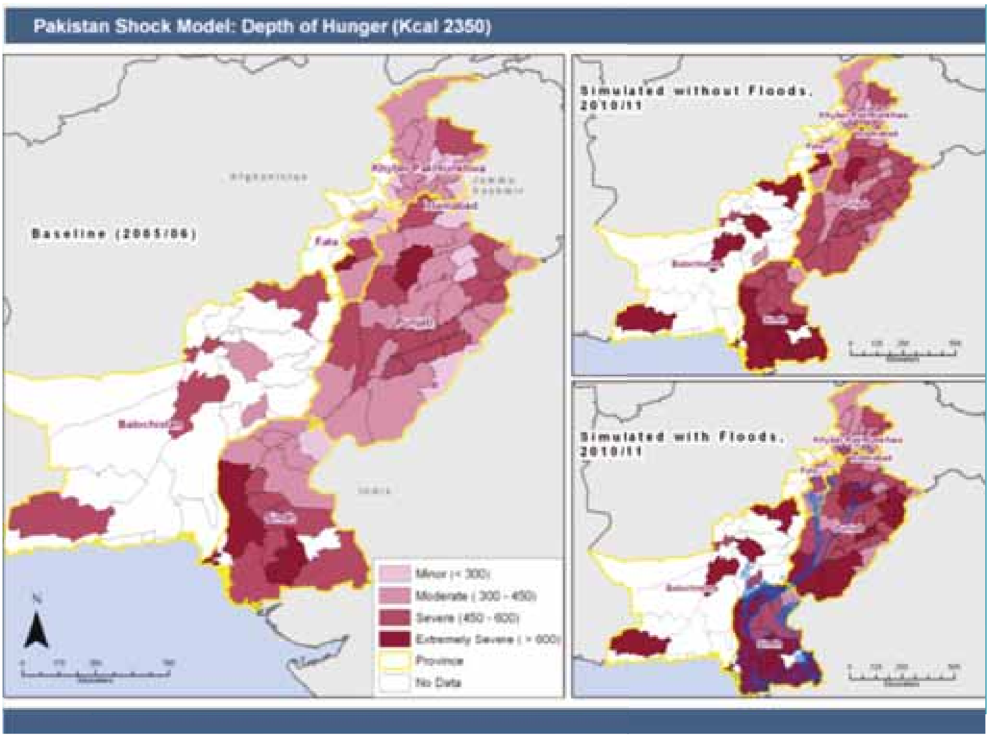
of kilocalories required to reached minimum caloric requirement of 2 350 kcal/day. With a combined impact, on average for an adult 699 kcal are needed per day to close the hunger gap. Prices increases in Baluchistan led to a significant increase in the Depth of Hunger (+120 kcal.) and to combat the combined impacts of a market shock and flood shock 657 kcal/day are needed per adult. Figure 17 displays these provincial impacts spatially to highlight the most severe depths of hunger on the district level for future mitigation.

On the household level, price increases most severely impacted the Depth of Hunger of paid employees (+106 kcal/day) among rural livelihood groups. Paid employees already had the highest baseline Depth of Hunger of 490 kcal/adult/day. This livelihood group also had one of the highest depths of hunger (+650 kcal/day) in a combined scenario (with floods). Floods had the most severe impact on sharecroppers as their average daily caloric intake decreased 200 kcal below 2 350 kcal. Like paid employees, sharecroppers had the highest Depth of Hunger (of 657 kcal/adult/day) among rural livelihood groups in a combined scenario.

When assessing the Depth of Hunger among urban households, there is small variation between livelihood groups. The increase in the Depth of Hunger from price increases ranged from 70 kcal/day for industrial-based households to 83 kcal/day for social and personal service households. Since the impacts of flooding were minor among urban households, the variation of the Depth of Hunger was small in the combined shock scenario, which ranged from 560 kcal/adult/day for industrial workers to 626 kcal/adult/day for agriculture-based households.

To quantify the hunger gap in terms of wheat in Pakistan, the Wheat Gap is calculated by converting the Depth of Hunger calculations from calories to the equivalent quantity of wheat in kilogram terms. As shown in Table 29, pre-crisis, the total food needs in 2005/06 to fill the Wheat Gap was 2.24 million tonnes of wheat in rural areas and 1.71 million tonnes in urban areas. An additional 978 126 tonnes of wheat is needed in rural areas and 446 242 tonnes in urban areas in 2010/11

Figure 18: Per capita severity of undernourishment due to simulated market and flood shocks by district (required kilocalories/day to reach minimum requirement of 1 730 kcal/person/day)



to fill the gap created by price increases. Nationwide, to cover the gap caused by flood, an additional 817 119 tonnes of wheat is required compared with the additional amount necessary if only price increases occur.

Estimated food needs per adult by district as a result of price increases and floods are reported in Table A1.19 and displayed spatially in Figure 19. The case of Sindh is illustrated in Figure 20. Due to the importance of various crops to household income and the degree of damage to crops in different districts, the impact on food needs varies significantly. In Sindh, Jacobabad has the highest increase in needs per capita (8.40 kg/person/month of wheat) due to floods and price increases, followed by Shikarpur (7.83 kg/person/month) and Dadu (7.76 kg/person/month of wheat).

Food need calculations allow for an assessment of the equivalent amount of wheat needed to meet requirements of the undernourished, but do not intend to overlook the issue of access. Food needs do not necessarily mean that the required

Table 28: Quantifying the shock impacts in terms of depth of hunger (no of Kkcal below 2 350 kcal/person/day)

Category		POST-SHOCK (2010)	
	Baseline (2005/2006)	Scenario 1	Scenario 2
Rural	455	537	608
Urban	500	576	596
Total	475	553	603
MAIN PROVINCES			
Punjab	439	520	551
Sindh	539	605	699
KPK	356	375	389
Baluchistan	532	652	685
RURAL LIVELIHOOD GROUPING			
Employer	421	510	560
Paid employee	490	596	650
Unpaid family worker	302	440	534
Owner cultivator	389	448	535
Sharecropper	425	457	657
Contract cultivator	403	415	464
Livestock only	409	451	540
URBAN LIVELIHOOD GROUPING			
Agriculture	493	573	626
Traders	502	577	588
Social & personal service	498	581	596
Service sector	476	552	579
Industrial sector	467	537	560
INCOME GROUPING-RURAL			
Low	472	559	636
Middle	331	338	348
High	328	355	367
INCOME GROUPING-URBAN			
Low	572	686	717
Middle	417	426	429
High	378	401	405

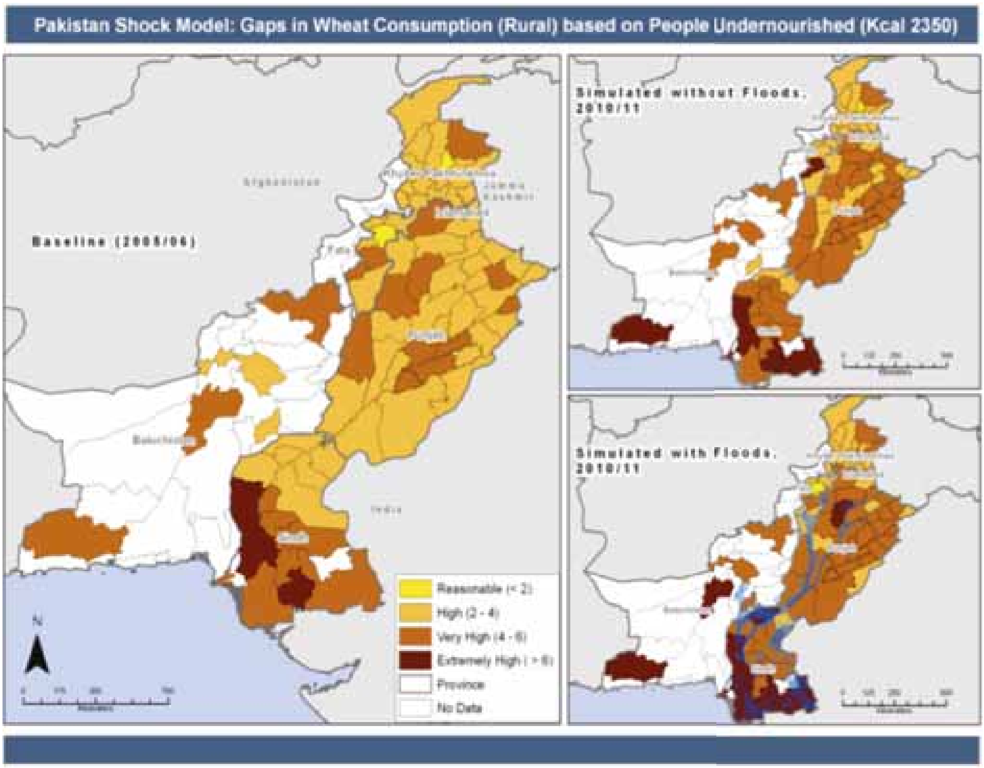
Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase

Table 29: Quantifying shock impacts in terms of food needed (tonnes of wheat per year) to meet requirements of the undernourished population

Category		POST-SHOCK (2010)		
	Baseline (2005/2006) (A)	Scenario 1	Scenario 2 (B)	Total (A+B)
Rural	2 244 263	978 126	1 725 946	3 970 209
Urban	1 711 257	446 242	515 541	2 226 797
Nationwide	3 955 520	1 424 368	2 241 487	6 197 006

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

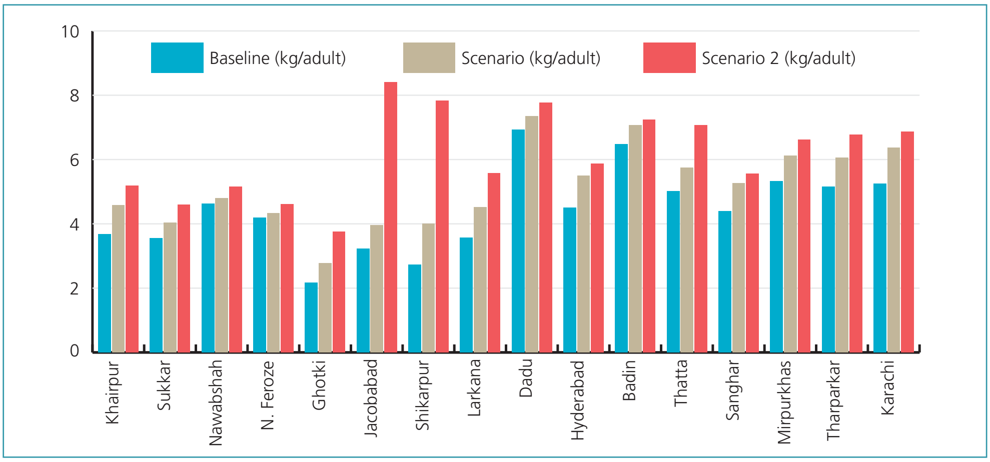
Figure 19: Wheat needed (kilograms/person/month) to meet threshold requirements of the undernourished population (2 350 kcal/person/day) by district



wheat did not exist. Lack of purchasing power and access played a major role in the hunger gap as households lost the ability to access wheat due to price increases, income loss, and crop loss. Ensuring sufficient-levels of purchasing power is essential for closing the gap.

In addition, the total combined effects of price increases and flood resulted in an increase of the food gap from 3.96 million to 6.20 million tonnes of wheat nationwide, when using the minimum requirement of 2 350 kcal/adult/day. As a result of high prices and falling incomes, Pakistan's per capita wheat consumption has been declining and led to the rising wheat stocks before floods in recent years. In 2010/11 (May/April) Pakistan is expected to be balanced in wheat at national level as a result of the reduced demand for wheat and by making use of stocks. Pakistan will continue to be a net exporter in rice because of favourable world rice prices and government rice policy.

Figure 20: District food needs (kilograms of wheat/adult/month) in Sindh



Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase

7. Conclusions

The Pakistan case study shows that price increases and floods had a negative impact on household food security. This assessment report provides valuable information for monitoring, preparing and responding to future shocks, in order to minimize the impacts on undernourishment. The price transmission and crop production analyses highlighted the trajectory of market and climate shocks by exposing the key markers to price and production changes.

In order to estimate the impacts of a market shock in the simulation model, the price transmission relationships where estimated for wheat and rice prices. The key wheat markets that are most sensitive to international price shocks and are therefore important for monitoring are Hyderabad and Peshawar. In the case of domestic price shocks, Karachi, Rawalpindi, Multan and Peshawar are the leading wheat markets that need monitoring. The IRRI rice markets that are key for monitoring domestic price changes are Islamabad, Karachi, Lahore, Quetta, Rawalpindi, and Multan. Multan, Sukkur, Peshawar, Rawalpindi, and Quetta are the leading IRRI rice markets for international price shocks. Among the basmati rice markets, the Peshawar, Hyderabad and Multan are domestic price-setting markets, while Hyderabad is the only market to monitor for international price shocks. Monitoring of the identified leading markets can provide early warning information on the first signs of a price shock.

Likewise, the results of the relationships between baseline wheat production and natural disasters (floods and droughts) can provide early warning information on production areas most likely to show the first signs of a climate shock in the Pakistan context. Wheat yield in the four main provinces in Pakistan are receptive to weather shocks, but the most at risk wheat producing areas for monitoring weather shocks are Punjab and KPK.

The results of the Household vulnerability and food security module show that a household's relationship with the agricultural sector in sustaining its livelihood plays a large role in the type of shock and the extent to which it is affected. Livelihood groups who depend on the agricultural sector have a more distributed share of income sources among crop income, agricultural wage income and non-agricultural income, and would be impacted by both market and climate shocks. Livelihoods groups that are less directly dependent on the agricultural sector and whose main incomes are sourced from non-agricultural wage income, are likely to be most impacted by market shocks. These assumptions are further supported by the results of the simulation model.

In the case of price increases, on the provincial level Sindh and Baluchistan were the two most affected provinces. Households of employers, paid employees and pastoralists in rural areas and service sector and industrial based households in urban areas were the most affected livelihood groups. The main income source of employers, paid employees, service sector and industrial sector livelihoods is non-agricultural wage income, which accounts for over 80 percent of income on average in all four of the main provinces in Pakistan. Among the various livelihood groups, paid employees and pastoralists are most sensitive to the impact of market shocks on undernourishment.

In the case of floods, the households that are most affected are sharecroppers and owner cultivators. Among the livelihood groups, the share of income sources is well distributed among the three income sources mentioned above, for all groups except paid employees. Sharecroppers are the most at risk to increased undernourishment during the occurrence of flood shocks. Among the four provinces, over 80 percent of sharecroppers' income is derived from the agricultural sector. Among the provinces Sindh was most affected by floods in the simulation model and sharecroppers in Sindh derive roughly 88 percent of their income from the agricultural sector. Furthermore, in the situation of the combined impacts of market and flood shocks, the most affected livelihood groups are sharecroppers and paid employees.

In total, it is estimated that an additional 18 million people became undernourished because of price increases and the severe flood of August 2010, increasing the total number of undernourished population from the baseline situation of 77.6 million people in 2005/2006 to 95.7 million people. On average, the undernourished population is about 603 kcal per day below the minimum requirement of 2 350 kcal/adult/day and about 6 million tonnes per annum of wheat is necessary to meet their requirements. Increasing purchasing power is essential for the undernourished to obtain access to wheat. However, based on the wheat balance, it is apparent that both national reserves and private imports alone are insufficient to meet the gap.

In conclusion, the findings of the Pakistan case study identified the transmission channels of market and climate shocks to household food security. The impacts of the shocks were measured through the Percentage of people consuming less than the DECR, the number of people affected, the Depth of Hunger, and the food needs to meet their post-crisis food requirements. As such, the simulation results can be used for shock impact mitigation responses. Further research can be carried out to simulate the potential impacts of crop forecast and future international price changes on household food security in Pakistan, building on the relationships established in this case study between international prices and domestic prices and between rainfall and production.

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Appendix 1:
Tables and figures on market integration analysis (Chapter 3), vulnerability analysis (Chapter 4) and household food security profiling (Chapter 5)

Table A1.1: Example tables of income sources and disaggregated crop Income

RURAL PAKISTAN: PER CAPITA MONTHLY INCOME (%) BY SOURCE AND LIVELIHOOD

	Crop	Livestock	Wage ag.	Wage no ag.	Wage pup	Remit	Other
	By source and livelihood ....(%)						
Employer (<10 empl.)	1.8	2.9	3.7	53.3	25.9	5.8	6.6
Employer (>10 empl.)	1.1	0.5	0.9	79.9	8.2	4.9	4.4
Self-employed	4.1	5.2	5.3	56.0	21.0	3.3	5.1
Paid employee	4.7	3.8	16.1	45.8	23.7	2.3	3.5
Unpaid family worker	18.0	10.0	29.6	17.0	6.7	13.2	5.4
Owner cultivator	30.7	11.8	43.3	5.5	2.8	4.4	1.5
Share cropper	32.2	11.1	43.8	7.3	2.2	2.8	0.6
Contract cultivator	37.1	12.5	39.3	5.2	1.6	3.5	0.7
Livestock only	1.1	30.6	29.7	7.5	2.2	6.4	22.4

Emp = employees;
Wage ag = agricultural wages
Wage no ag = non-agricultural wages
Wage pub = public wages

Source: Compiled by the authors

RURAL PAKISTAN: % OF PER CAPITA CROP INCOME

	Wheat	Rice	Maize	Cotton	Sugarcane	Pulse	Fruits
	By crop ....(%)						
Employer (<10 empl.)	69.9	9.7	10.2	10.3	0.0	0.0	0.0
Employer (>10 empl.)	94.2	0.0	3.3	0.0	0.0	0.0	2.5
Self-employed	46.4	13.0	2.3	29.4	2.3	1.5	5.0
Paid employee	39.3	19.1	5.6	16.6	5.1	0.4	13.9
Unpaid family worker	41.6	9.2	1.7	31.1	14.4	1.8	0.2
Owner cultivator	44.1	16.5	2.1	21.9	7.6	1.0	6.8
Share cropper	41.8	19.3	1.6	27.5	7.8	1.4	0.7
Contract cultivator	43.8	14.3	7.1	23.9	10.2	0.3	0.4
Livestock only	35.2	23.5	12.0	27.7	0.0	1.4	0.2

Source: Compiled by the authors

Table A1.2: Coefficients of correlation between wheat prices (January 1993-March 2009)

	Faisalabad	Gujranwala	Hyderabad	Hyderabad W	Karachi	Lahore W	Lahore	Multan W	Multan	Peshawar W	Peshawar	Rawalpindi	Rawalpindi W	Sarghoda	Sialkot	Sukkur W	Sukkur
Faisalabad	1.00																
Gujranwala	0.43	1.00															
Hyderabad	0.20	0.24	1.00														
Hyderabad W	0.31	0.24	0.20	1.00													
Karachi	0.31	0.47	0.16	0.16	1.00												
Lahore W	0.24	0.26	0.24	0.65	0.06	1.00											
Lahore	0.63	0.63	0.23	0.29	0.42	0.23	1.00										
Multan W	0.10	0.07	0.10	0.26	0.09	0.25	0.13	1.00									
Multan	0.71	0.61	0.22	0.35	0.37	0.31	0.68	0.06	1.00								
Peshawar W	0.31	0.10	0.25	0.58	-0.01	0.70	0.29	0.30	0.24	1.00							
Peshawar	0.48	0.27	0.13	0.27	0.50	0.09	0.46	0.13	0.44	0.18	1.00						
Rawalpindi	0.64	0.49	0.24	0.28	0.42	0.18	0.69	0.08	0.61	0.28	0.49	1.00					
Rawalpindi W	0.17	0.20	0.23	0.57	0.03	0.77	0.23	0.21	0.27	0.57	0.11	0.20	1.00				
Sarghoda	0.81	0.59	0.23	0.33	0.39	0.27	0.70	0.09	0.73	0.30	0.55	0.61	0.14	1.00			
Sialkot	0.64	0.66	0.33	0.24	0.48	0.23	0.74	0.05	0.62	0.19	0.49	0.66	0.21	0.77	1.00		
Sukkur W	-0.01	0.01	0.07	0.03	0.03	0.06	-0.05	0.54	-0.02	0.06	-0.08	-0.05	0.18	-0.01	0.06	1.00	
Sukkur	0.50	0.57	0.30	0.24	0.64	0.14	0.56	0.00	0.53	0.02	0.49	0.48	0.12	0.62	0.72	0.05	1.00

"W" indicates wholesale; for example, Lahore = Lahore retail price; Lahore W = Lahore wholesale price.
The 10% highest coefficients are shown in red and the lowest 10% coefficients in green.

Table A1.3: Coefficients of correlation between IRRI rice prices (January 1993-March 2009)

	Faisalabad	Gujranwala	Hyderabad	Hyderabad W	Islamabad	Karachi	Lahore	Lahore W	Multan	Multan W	Peshawar	Peshawar W	Quetta	Quetta W	Rawalpindi	Rawalpindi W	Sialkot	Sukkur	Sukkur W
Faisalabad	1																		
Gujranwala	0.69	1.00																	
Hyderabad	0.79	0.73	1.00																
Hyderabad W	-0.23	-0.35	-0.31	1.00															
Islamabad	0.76	0.79	0.84	-0.39	1.00														
Karachi	0.69	0.74	0.87	-0.49	0.84	1.00													
Lahore	0.65	0.73	0.79	-0.35	0.84	0.80	1.00												
Lahore W	-0.10	-0.02	-0.08	0.09	-0.09	-0.03	-0.10	1.00											
Multan	0.73	0.62	0.87	-0.30	0.76	0.77	0.69	-0.05	1.00										
Multan W	-0.02	-0.19	-0.20	0.41	-0.23	-0.25	-0.19	0.03	-0.21	1.00									
Peshawar	0.77	0.66	0.79	-0.21	0.80	0.69	0.72	-0.09	0.78	-0.18	1.00								
Peshawar W	0.07	0.03	-0.04	0.11	-0.07	0.02	-0.02	0.05	-0.10	0.66	-0.08	1.00							
Quetta	0.69	0.79	0.78	-0.37	0.84	0.78	0.78	-0.05	0.66	-0.19	0.70	-0.05	1.00						
Quetta W	0.12	0.20	0.18	0.21	0.09	0.11	0.01	0.22	0.25	0.11	0.13	0.20	0.06	1.00					
Rawalpindi	0.78	0.78	0.86	-0.36	0.97	0.84	0.85	-0.09	0.77	-0.24	0.82	-0.09	0.83	0.08	1.00				
Rawalpindi W	-0.24	-0.21	-0.22	0.47	-0.26	-0.22	-0.18	0.13	-0.26	0.70	-0.18	0.43	-0.24	0.15	-0.28	1.00			
Sialkot	0.61	0.74	0.76	-0.37	0.72	0.75	0.72	0.09	0.71	-0.13	0.56	0.00	0.76	0.23	0.72	-0.18	1.00		
Sukkur	0.58	0.50	0.65	-0.25	0.61	0.59	0.56	-0.07	0.59	-0.04	0.52	0.06	0.58	0.11	0.64	-0.16	0.57	1.00	
Sukkur W	-0.11	-0.10	-0.23	0.26	-0.16	-0.26	-0.17	0.04	-0.18	0.71	-0.14	0.52	-0.15	0.22	-0.17	0.48	-0.10	-0.03	1.00
International price	0.43	0.33	0.49	0.17	0.37	0.22	0.31	-0.01	0.52	-0.12	0.52	-0.19	0.42	0.18	0.45	-0.15	0.30	0.41	-0.05

The 10% highest coefficients are shown in red and the lowest 10% coefficients in green.
"W" indicates wholesale; for example, Lahore = Lahore retail price; Lahore W = Lahore wholesale price.

Table A1.4: Granger causality tests IRRI rice retail prices (January 1993-March 2010)

Market x	Cause	Other Markets	No of other markets caused by x market (sig. at 5% level)	No of other markets causing market x (sig. at 5% level)
Faisalabad	→	**Gujranwala**, Quetta, Sialkot, Sukkur	4	4
Gujranwala	→	**Faisalabad**, Hyderabad, **Islamabad**, **Karachi**, **Lahore**, **Multan**, **Peshawar**, **Rawalpindi**, Sukkur	9	8
Hyderabad	→	Faisalabad*, **Islamabad**, **Karachi**, **Lahore**, **Multan**, Peshawar, **Quetta**, **Rawalpindi**, Sialkot*	7	7
Islamabad	→	Faisalabad, **Gujranwala**, **Hyderabad**, **Karachi**, **Lahore**, **Multan**, **Peshawar**, **Quetta**, **Rawalpindi**, **Sialkot**, Sukkur	11	9
Karachi	→	Faisalabad, **Gujranwala**, **Hyderabad**, **Islamabad**, **Lahore**, **Multan**, **Peshawar**, **Quetta**, **Rawalpindi**, Sialkot, Sukkur	11	8
Lahore	→	Faisalabad*, **Gujranwala**, **Hyderabad**, **Islamabad**, **Karachi**, Multan, **Peshawar**, Quetta, Rawalpindi, Sialkot, Sukkur	10	7
Multan	→	**Gujranwala**, **Hyderabad**, **Islamabad**, **Karachi**, **Quetta**, **Rawalpindi**, **Sialkot**	7	9
Peshawar	→	**Gujranwala**, **Islamabad**, **Karachi**, **Lahore**, Multan, **Rawalpindi**, Sialkot, Sukkur	8	6
Quetta	→	Gujranwala, **Hyderabad**, **Islamabad**, **Karachi**, Lahore, **Multan**, Peshawar, **Rawalpindi**, **Sialkot**, Sukkur	10	7
Rawalpindi	→	Faisalabad, **Gujranwala**, **Hyderabad**, **Islamabad**, **Karachi**, Lahore, **Multan**, **Peshawar**, **Quetta**, **Sialkot**, Sukkur	11	8
Sialkot	→	Gujranwala, **Islamabad**, Lahore*, **Multan**, **Quetta**, **Rawalpindi**	5	8
Sukkur	→	Karachi*, Peshawar*	0	8

A market in bold text indicates a bidirectional relationship
* indicates that the coefficient is significant at 10% level; otherwise at 5% level

Table A1.5: Granger causality tests (IRRI rice wholesale prices (January 1993-March 2010)

Markets	Cause		#of times that a market x causes another market	# of times that a market x is caused by another market
Hyderabad	→	Lahore, Quetta*, **Sukkur**	2	4
Lahore	→	Multan, **Peshawar, Quetta, Rawalpindi, Sukkur**	5	4
Multan	→	Hyderabad, Lahore*, **Peshawar, Quetta, Rawalpindi, Sukkur**	5	4
Peshawar	→	Hyderabad*, **Lahore, Multan, Quetta, Rawalpindi, Sukkur**	5	5
Quetta	→	Hyderabad, **Lahore, Multan, Peshawar,** Rawalpindi	5	3
Rawalpindi	→	Hyderabad, **Lahore, Multan, Peshawar, Sukkur**	5	5
Sukkur	→	**Hyderabad, Lahore, Multan, Peshawar, Rawalpindi**	5	5

A market in bold text indicates a bidirectional relationship
* indicates that the coefficient is significant at 10% level; otherwise at 5% level

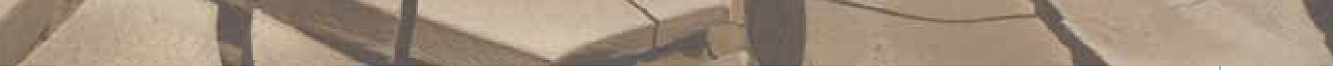


Table A1.6: Co-integration and error correction model IRRI Rice

P1t	P2t	Long-run relationship?	Short-run adjustment	P1t	P2t	Long-run relationship?	Short-run adjustment
Lahore	Hyderabad	Yes	0.35	Rawalpindi	Hyderabad	Yes	0.68
Lahore	Multan	Yes	0.34	Rawalpindi	Lahore	Yes	0.44
Lahore	Peshawar	Yes	0.4	Rawalpindi	Multan	Yes	0.56
Lahore	Rawalpindi	Yes	0.46	Rawalpindi	Peshawar	Yes	0.59
Lahore	Quetta	Yes	0.46	Rawalpindi	Quetta	Yes	0.64
Lahore	Sukkur	Yes	0.31	Rawalpindi	Sukkur	Yes	0.48
Multan	Hyderabad	Yes	0.77	Quetta	Hyderabad	Yes	0.38
Multan	Lahore	Yes	0.41	Quetta	Lahore	Yes	0.27
Multan	Peshawar	Yes	0.82	Quetta	Multan	Yes	0.29
Multan	Rawalpindi	Yes	0.81	Quetta	Peshawar	Yes	0.34
Multan	Quetta	Yes	0.73	Quetta	Rawalpindi	Yes	0.32
Multan	Sukkur	Yes	0.69	Quetta	Sukkur	Yes	0.3
Peshawar	Hyderabad	No		Sukkur	Hyderabad	Yes	0.6
Peshawar	Lahore	Yes	0.28	Sukkur	Lahore	Yes	0.35
Peshawar	Multan	Yes	0.48	Sukkur	Multan	Yes	0.6
Peshawar	Rawalpindi	Yes	0.5	Sukkur	Peshawar	Yes	0.64
Peshawar	Quetta	Yes	0.48	Sukkur	Rawalpindi	Yes	0.59
Peshawar	Sukkur	Yes	0.43				
Hyderabad	Lahore	Yes	0.17				
Hyderabad	Multan	Yes	0.28				
Hyderabad	Peshawar	No					
Hyderabad	Rawalpindi	yes	0.33				
Hyderabad	Quetta	Yes	0.3				
Hyderabad	Sukkur	Yes	0.24				

All the coefficients are significant at 5% level

Table A1.7: Coefficients of correlation between Basmati rice prices (January 1993-March 2009)

	Faisalabad	Gujranwala	Hyderabad	Hyderabad W	Islamabad	Karachi	Lahore	Lahore W	Multan	Multan W	Peshawar	Peshawar W	World price	Quetta	Rawalpindi	Rawalpindi W	Sialkot	Sukkur
Faisalabad	1																	
Gujranwala	0.62	1.00																
Hyderabad	0.68	0.57	1.00															
Hyderabad W	0.01	0.07	0.06	1.00														
Islamabad	0.71	0.69	0.71	0.03	1.00													
Karachi	0.59	0.57	0.76	-0.08	0.71	1.00												
Lahore	0.69	0.73	0.74	-0.05	0.79	0.73	1.00											
Lahore W	0.06	-0.03	-0.01	0.06	-0.04	-0.04	-0.02	1.00										
Multan	0.57	0.56	0.53	0.05	0.68	0.50	0.62	-0.02	1.00									
Multan W	0.05	0.04	0.00	0.47	0.00	0.03	0.03	0.33	-0.01	1.00								
Peshawar	0.64	0.58	0.77	0.11	0.77	0.69	0.68	0.04	0.55	0.02	1.00							
Peshawar W	0.17	0.15	0.02	-0.02	0.06	0.04	0.04	0.22	0.00	0.12	0.14	1.00						
World price	0.14	0.31	0.19	0.06	0.25	0.20	0.23	-0.12	0.26	-0.02	0.39	-0.11	1.00					
Quetta	0.36	0.48	0.59	0.05	0.56	0.48	0.51	0.08	0.34	-0.02	0.53	-0.15	0.24	1.00				
Rawalpindi	0.60	0.60	0.60	0.00	0.78	0.57	0.67	-0.02	0.56	0.01	0.63	0.09	0.17	0.44	1.00			
Rwalpindi W	0.04	0.04	-0.03	0.02	0.07	0.09	0.02	0.31	0.04	0.41	0.06	0.35	-0.04	0.05	0.05	1.00		
Sialkot	0.70	0.79	0.70	-0.05	0.74	0.65	0.79	0.02	0.57	0.04	0.64	0.23	0.15	0.49	0.67	0.05	1.00	
Sukkur	0.40	0.38	0.53	0.05	0.56	0.38	0.49	-0.03	0.42	0.00	0.49	0.01	0.20	0.47	0.42	-0.02	0.44	1.00

The 10% highest coefficients are shown in red and the lowest 10% coefficients in green.
"W" indicates wholesale; for example, Lahore = Lahore retail price; Lahore W = Lahore wholesale price.

Table A1.8: Granger causality tests - Basmati rice retail prices (January 1993-March 2010)

Markets	Cause		No. of times that a market x Granger-causes another market	No. of times that a market x is Granger-caused by another market
Faisalabad	→	Multan	1	1
Gujranwala	→	Hyderabad, Karachi, **Lahore**	3	3
Hyderabad	→	/	0	2
Islamabad	→	/	0	1
Karachi	→	Faisalabad	1	4
Lahore	→	**Gujranwala**	1	2
Multan	→	Karachi, **Peshawar**	2	2
Peshawar	→	Gujranwala, Hyderabad, Islamabad, Karachi, Lahore, **Multan**, Rawalpindi	7	1
Quetta	→	Gujranwala, Sialkot	2	0
Rawalpindi	→	/	0	1
Sialkot	→	Karachi	1	1
Sukkur	→	/	0	0

A market in bold text indicates a bidirectional relationship
All the coefficients are significant at 5% level

Table A1.9 Basmati rice granger causality tests - wholesale prices (January 1993-March 2010)

Markets	Cause		No. of times that a market x Granger-causes another market	No. of times that a market x is Granger-caused by another market
Hyderabad	→	Multan	1	1
Lahore	→		0	0
Multan	→	Hyderabad	1	1
Peshawar	→		0	0
Rawalpindi	→		0	0

All the coefficients are significant at 5% level

Table A1.10: Basmati rice co-integration and error correction model

P1t	P2t	Long-run relationship?	Short-run adjustment
Hyderabad	Lahore	Yes	0.16**
Hyderabad	Multan	Yes	0.46**
Hyderabad	Peshawar	No	
Hyderabad	Rawalpindi	Yes	0.08
Lahore	Hyderabad	Yes	0.33**
Lahore	Multan	Yes	0.63**
Lahore	Peshawar	Yes	0.33**
Lahore	Rawalpindi	Yes	0.18
Multan	Hyderabad	Yes	0.61**
Multan	Lahore	Yes	0.18
Multan	Peshawar	Yes	0.10*
Multan	Rawalpindi	Yes	0.49**
Peshawar	Hyderabad	No	
Peshawar	Lahore	Yes	0.22**
Peshawar	Multan	Yes	0.20*
Peshawar	Rawalpindi	Yes	0.54**
Rawalpindi	Hyderabad	Yes	0.066
Rawalpindi	Lahore	Yes	0.06
Rawalpindi	Peshawar	Yes	0.35**
Rawalpindi	Multan	Yes	0.33**

* indicates that the coefficient is significant at 10% level
** indicates that the coefficient is significant at 5% level

Table A1.11: Household vulnerability profiling: Urban and rural demographics

Livelihood	No. of households	Age of HH head	% Female headed HHs	HH size	% HH dependency ratio	No. age 14 or under	No. age 15-64 yr	No. age 65 or over
LIVELIHOODS AND DEMOGRAPHICS IN RURAL AREAS BY PROVINCE IN PAKISTAN								
PUNJAB								
Employer	620	44	1.1	8	46.60	0.00	0.00	0.00
Paid employee	1 147	43	2.8	7	48.43	0.00	0.00	0.00
Unpaid family worker	35	56	31.2	8	47.35	0.00	0.00	0.00
Owner cultivator	951	50	1.6	9	42.92	0.00	0.00	0.00
Sharecropper	105	51	1.9	9	43.97	0.00	0.00	0.00
Contract cultivator	165	46	0.0	8	46.33	0.00	0.00	0.00
Livestock only	178	48	12.5	8	49.52	0.00	0.00	0.00
SINDH								
Employer	159	43	1.3	9	46.37	0.00	0.00	0.00
Paid employee	1 003	40	0.4	8	45.95	0.00	0.00	0.00
Unpaid family worker	6	30	9.4	15	53.79	0.00	0.00	0.00
Owner cultivator	279	45	0.0	10	46.13	0.00	0.00	0.00
Sharecropper	400	44	0.0	9	50.19	0.00	0.00	0.00
Contract cultivator	14	40	0.0	8	48.51	0.00	0.00	0.00
Livestock only	49	44	1.1	9	48.77	0.00	0.00	0.00
KPK								
Employer	328	45	1.1	11	47.48	0.00	0.00	0.00
Paid employee	562	43	1.4	10	49.25	0.00	0.00	0.00
Unpaid family worker	21	55	21.8	11	51.10	0.00	0.00	0.00
Owner cultivator	408	50	6.2	12	48.17	0.00	0.00	0.00
Sharecropper	100	50	1.6	11	48.15	0.00	0.00	0.00
Contract cultivator	35	52	11.1	11	51.14	0.00	0.00	0.00
Livestock only	33	46	9.4	8	52.51	0.00	0.00	0.00
BALUCHISTAN								
Employer	117	45	0.3	9	50.64	0.00	0.00	0.00
Paid employee	610	42	0.0	9	48.68	0.00	0.00	0.00
Unpaid family worker	1	48	0.0	9	77.78	0.00	0.00	0.00
Owner cultivator	278	48	0.0	9	43.49	0.00	0.00	0.00
Sharecropper	88	45	0.0	9	47.53	0.00	0.00	0.00
Contract cultivator	3	41	0.0	8	41.31	0.00	0.00	0.00
Livestock only	47	50	0.0	8	49.96	0.00	0.00	0.00
LIVELIHOODS AND DEMOGRAPHICS IN URBAN AREAS BY PROVINCE IN PAKISTAN								
PUNJAB								
Agriculture	157	51	2.4	8	39.84	0.00	0.00	0.00
Traders	604	46	0.8	8	38.80	0.00	0.00	0.00
Social & personal service	606	45	3.9	7	39.18	0.00	0.00	0.00
Service sector	277	44	0.0	7	38.69	0.00	0.00	0.00
Industrial sector	537	43	1.7	8	41.19	0.00	0.00	0.00

Table A1.11: Household vulnerability profiling: Urban and rural demographics (cont.)

Livelihood	No. of households	Age of HH head	% Female headed HHs	HH size	% HH dependency ratio	No. age 14 or under	No. age 15-64 yr	No. age 65 or over
SINDH								
Agriculture	83	46	0.0	10	45.29	0.00	0.00	0.00
Traders	358	47	0.0	8	38.36	0.00	0.00	0.00
Social & personal service	376	44	1.9	9	38.56	0.00	0.00	0.00
Service sector	158	43	0.0	8	38.38	0.00	0.00	0.00
Industrial sector	434	44	0.7	8	39.36	0.00	0.00	0.00
KPK								
Agriculture	52	52	0.0	10	39.57	0.00	0.00	0.00
Traders	216	46	0.3	11	45.53	0.00	0.00	0.00
Social & personal service	243	46	1.8	8	40.42	0.00	0.00	0.00
Service sector	103	43	0.0	9	45.70	0.00	0.00	0.00
Industrial sector	150	44	0.0	8	39.75	0.00	0.00	0.00
BALUCHISTAN								
Agriculture	54	46	0.0	12	46.14	0.00	0.00	0.00
Traders	113	47	0.0	11	46.11	0.00	0.00	0.00
Social & personal service	238	44	0.0	9	46.02	0.00	0.00	0.00
Service sector	101	45	0.0	10	46.88	0.00	0.00	0.00
Industrial sector	100	45	0.0	10	44.17	0.00	0.00	0.00

Note: Livelihood groups of unpaid family worker and contract cultivator in rural Baluchistan are not shown since only very small samples were available.

Table A.12: Livelihoods and per capita monthly crop income (Rs) by commodity in urban areas of Pakistan

	Wheat	Rice	Maize	Cotton	Sugar cane	Pulses	Fruits
PUNJAB							
Agriculture	556.00	126.73	402.47	546.59	57.60	14.03	340.14
Traders	10.11	0.43	0.00	22.03	0.00	0.10	0.00
Social & personal service	13.31	3.24	0.31	23.71	3.31	0.00	0.00
Service sector	30.66	42.23	0.00	0.80	0.00	0.00	0.00
Industrial sector	27.79	14.63	0.00	13.62	6.56	0.00	0.00
SINDH							
Agriculture	218.06	86.58	0.00	202.65	54.68	0.00	84.67
Traders	0.29	0.00	0.00	0.29	0.00	0.00	0.00
Social & personal service	2.87	0.68	0.00	0.00	1.30	0.00	2.27
Service sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial sector	1.25	0.36	0.00	1.64	0.00	0.00	0.00
KPK							
Agriculture	95.65	14.06	18.15	0.00	18.82	0.00	0.29
Traders	3.18	0.50	0.39	0.00	0.00	0.06	0.00
Social & personal service	2.77	0.89	1.02	0.00	0.00	0.30	0.25
Service sector	9.99	0.38	1.30	0.00	0.00	0.00	0.00
Industrial sector	2.02	0.00	0.83	0.00	0.00	0.00	0.00
BALUCHISTAN							
Agriculture	57.67	39.78	0.00	11.16	0.00	0.80	487.24
Traders	0.35	1.04	0.00	0.00	0.00	0.00	0.00
Social & personal service	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Service sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial sector	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TableA 1.13: Livelihoods and per capita assets (land in hectare and annual value of livestock in Rs) in rural areas by province in Pakistan

	Land Owned	Land Rented	Land Shared	Livestock Owned	Cattle Owned	Buffalo Owned	Camel Owned	Sheep Owned	Goat Owned	Horses Owned	Asses Owned	Mules Owned	Poultry Owned	Other Livestock Owned
PUNJAB														
Employer	0.03	0.01	0.00	3 196	799	2 008	18	21	182	39	28	14	86	0
Paid employee	0.03	0.01	0.00	3 068	898	1 848	18	15	231	6	35	12	5	0
Unpaid family worker	0.14	0.02	0.03	7 907	2 529	4 288	0	88	758	0	111	0	17	117
Owner cultivator	0.43	0.09	0.02	17 573	4 284	11 131	154	211	922	673	122	1	73	2
Sharecropper	0.11	0.07	0.35	11 485	4 154	6 014	167	235	731	0	99	63	21	0
Contract cultivator	0.07	0.26	0.01	13 194	3 825	8 557	0	60	584	32	115	0	21	0
Livestock only	0.02	0.01	0.00	14 119	3 467	8 043	0	902	1 538	0	151	0	19	0
SINDH														
Employer	0.05	0.00	0.02	3 379	1 503	1 131	48	14	577	0	108	0	0	0
Paid employee	0.05	0.00	0.02	1 797	311	1 316	5	17	138	0	8	0	2	0
Unpaid family worker	0.17	0.00	0.08	5 465	401	4 874	0	0	180	0	0	0	9	0
Owner cultivator	0.44	0.00	0.02	7 301	1 568	5 119	0	51	507	0	31	0	11	14
Sharecropper	0.02	0.03	0.28	5 472	1 437	3 489	0	66	429	1	45	0	5	0
Contract cultivator	0.05	0.29	0.03	2 847	327	2 218	0	0	301	0	0	0	0	0
Livestock only	0.00	0.00	0.03	15 375	2 535	10 517	0	171	1 127	810	3	0	212	0
KPK														
Employer	0.09	0.00	0.00	1 083	511	330	19	13	190	0	4	0	15	0
Paid employee	0.06	0.00	0.00	1 361	724	343	0	36	188	21	26	0	23	1
Unpaid family worker	0.11	0.04	0.00	51 827	483	50 972	0	40	190	128	0	0	15	0
Owner cultivator	0.16	0.00	0.01	5 006	2 541	1 553	50	95	581	34	81	0	68	3
Sharecropper	0.06	0.13	0.06	4 898	2 658	1 431	189	40	416	0	79	0	55	30
Contract cultivator	0.05	0.07	0.01	5 301	2 224	2 337	0	98	552	0	48	0	42	0
Livestock only	0.03	0.00	0.00	10 738	2 845	5 471	0	225	1 753	45	204	0	106	89

TableA 1.13: Livelihoods and per capita assets (land in hectare and annual value of livestock in Rs) in rural areas by province in Pakistan - Cont.

	Land Owned	Land Rented	Land Shared	Livestock Owned	Cattle Owned	Buffalo Owned	Camel Owned	Sheep Owned	Goat Owned	Horses Owned	Asses Owned	Mules Owned	Poultry Owned	Other Livestock Owned
BALOCHISTAN														
Employer	0,02	0,01	0,02	633	295	100	61	47	129	0	0	0	0	0
Paid employee	0,04	0,00	0,00	887	129	124	60	94	466	0	10	0	5	0
Unpaid family worker	0,00	0,00	0,00	1.111	0	0	0	0	1.111	0	0	0	0	0
Owner cultivator	0,57	0,00	0,00	2 711	397	271	435	589	930	0	68	0	20	0
Sharecropper	0,10	0,01	0,42	4 502	1 573	1 993	0	170	705	25	30	0	6	0
Contract cultivator	0,00	0,00	0,27	0 288	0	0	0	0	288	0	0	0	0	0
Livestock only	0,02	0,00	0,00	11 101	501	289	569	5 581	4 023	56	68	0	13	0

Note: Livelihood groups of unpaid family worker and contract cultivator in Baluchistan are not shown since only very small samples were available

Table A1.14: Livelihoods and per capita assets (land in hectare and annual value of livestock in Rs) in Urban areas by province in Pakistan

	Land Owned	Land Rented	Land Shared	Livestock Owned	Cattle Owned	Buffalo Owned	Camel Owned	Sheep Owned	Goat Owned	Horses Owned	Asses Owned	Mules Owned	Poultry Owned	Other Livestock Owned
PUNJAB														
Agriculture	0.24	0.09	0.01	13 909	3 399	9 738	56	3	447	136	73	36	21	0
Traders	0.00	0.01	0.00	440	68	344	0	0	21	4	2	0	1	0
Social & personal service	0.01	0.00	0.00	605	76	459	24	1	18	0	1	0	26	0
Service sector	0.01	0.00	0.00	176	37	129	0	0	7	0	3	0	0	0
Industrial sector	0.01	0.01	0.00	647	147	464	0	9	22	0	2	0	3	0
SINDH														
Agriculture	0.17	0.01	0.02	5 562	358	4 616	0	22	440	0	44	0	82	0
Traders	0.00	0.00	0.00	228	24	201	0	0	2	0	0	0	0	0
Social & personal service	0.00	0.00	0.00	116	30	69	0	0	17	0	0	0	0	0
Service sector	0.00	0.00	0.00	81	0	60	0	0	0	0	0	0	21	0
Industrial sector	0.00	0.00	0.00	135	20	112	0	0	3	0	0	0	0	0
KPK														
Agriculture	0.31	0.01	0.01	3 782	1 245	1 554	39	25	639	0	43	0	237	0
Traders	0.00	0.00	0.00	356	121	218	0	0	14	0	1	0	2	0
Social & personal service	0.00	0.00	0.00	198	141	54	0	0	0	0	0	0	3	0
Service sector	0.08	0.00	0.00	374	35	319	0	0	16	0	0	0	3	0
Industrial sector	0.01	0.00	0.00	288	129	132	0	0	22	0	1	0	4	0
BALOCHISTAN														
Agriculture	0.07	0.00	0.00	1 884	178	1 577	0	5	120	0	1	0	3	0
Traders	0.00	0.00	0.00	148	0	147	0	0	0	0	0	0	1	0
Social & personal service	0.00	0.00	0.00	42	16	0	0	0	25	0	0	0	1	0
Service sector	0.00	0.00	0.00	70	62	0	0	0	8	0	0	0	1	0
Industrial sector	0.00	0.00	0.00	58	0	58	0	0	0	0	0	0	0	0

Table A1.15: Livelihoods and per capita monthly expenditures (Rs) in rural areas by province in Pakistan

Livelihood	Total	Recreation	Transport	Apperal	Housing	Medical	Education	Fuel	Food
PUNJAB									
Employer	1 193.0	2.4	63.6	97.4	133.1	69.5	34.9	60.7	435.8
Paid employee	1 074.4	1.3	61.3	83.9	125.7	54.4	32.7	59.7	410.3
Unpaid family worker	1 049.4	2.6	75.2	96.0	105.0	33.8	18.8	69.0	326.6
Owner cultivator	1 199.7	1.2	70.5	108.3	132.7	77.0	40.4	67.2	341.1
Sharecropper	951.0	1.0	47.0	86.4	85.4	98.0	28.3	57.7	297.5
Contract cultivator	992.7	0.7	51.2	93.0	110.9	61.8	22.8	56.5	310.1
Livestock only	1 052.4	0.2	46.5	81.7	125.3	47.9	22.0	60.1	401.7
SINDH									
Employer	1 179.2	5.6	79.8	82.9	167.5	57.9	26.2	43.4	452.8
Paid employee	962.4	1.5	79.5	69.1	114.2	44.6	15.1	41.8	412.3
Unpaid family worker	669.9	0.0	64.9	58.3	88.9	24.8	4.6	42.5	283.0
Owner cultivator	889.6	1.0	75.7	75.0	99.2	61.4	13.0	39.6	316.8
Sharecropper	665.6	0.2	41.3	58.9	76.6	40.7	6.1	37.3	263.0
Contract cultivator	966.1	0.0	102.9	69.8	88.8	51.8	10.8	37.8	411.7
Livestock only	1 180.4	2.0	89.8	89.9	109.1	64.0	17.2	41.4	353.3
KPK									
Employer	1 270.6	1.6	60.2	87.3	107.5	93.6	52.4	76.2	481.3
Paid employee	1 148.7	1.4	57.5	75.7	97.5	69.6	56.3	89.2	466.1
Unpaid family worker	1 270.5	3.8	49.6	86.6	122.9	92.7	48.6	96.8	514.5
Owner cultivator	1 090.0	0.9	56.4	84.1	87.2	89.2	37.4	92.6	407.6
Sharecropper	838.8	0.1	32.6	72.0	62.7	80.8	23.0	63.7	326.1
Contract cultivator	739.2	0.0	26.7	66.8	50.2	42.8	16.9	70.8	348.6
Livestock only	986.9	0.0	34.4	69.0	85.4	69.0	18.5	89.4	431.2
BALOCHISTAN									
Employer	1 085.3	2.4	87.9	55.1	153.2	23.2	16.5	57.1	517.1
Paid employee	943.5	2.4	73.4	52.4	109.1	20.5	12.9	55.2	480.4
Unpaid family worker	502.1	0.0	33.3	47.2	23.1	3.7	7.4	28.3	290.6
Owner cultivator	908.0	2.2	83.2	61.0	101.1	29.0	9.2	63.2	393.0
Sharecropper	716.2	1.1	68.2	59.3	75.6	32.1	4.1	46.3	302.5
Contract cultivator	934.7	0.0	93.7	46.7	133.1	18.3	6.6	40.8	420.2
Livestock only	762.3	1.4	65.7	49.2	66.3	21.2	4.4	53.7	384.3

Note: Livelihood groups of unpaid family worker and contract cultivator in Baluchistan are not shown since only very small samples were available.

Table A1.16 Livelihoods and per capita monthly expenditures (Rs) in urban areas by province in Pakistan

Livelihood	Total	Recreation	Transport	Apperal	Housing	Medical	Education	Fuel	Food
PUNJAB									
Agriculture	2 142.8	10.8	119.7	134.1	365.6	132.6	116.5	71.5	518,4
Traders	2 034.0	13.7	113.8	129.7	438.3	87.9	95.2	54.4	619,5
Social & personal service	2 617.7	24.9	165.3	142.2	640.0	87.8	174.4	63.1	703,5
Service sector	2 322.8	14.1	150.3	128.8	490.5	84.2	155.1	59.9	661,2
Industrial sector	1 905.6	14.6	116.2	116.8	410.5	58.9	96.5	57.2	615,3
SINDH									
Agriculture	1 325.1	9.3	91.7	84.8	218.8	42.2	28.6	40.2	422,0
Traders	2 218.7	25.7	182.8	107.2	562.0	56.4	127.9	47.2	629,4
Social & personal service	2 007.2	25.7	190.5	104.5	430.8	59.1	83.9	46.4	636,8
Service sector	2 518.6	31.7	187.3	114.3	638.6	63.8	196.7	44.3	703,4
Industrial sector	2 200.6	27.1	175.5	103.7	517.3	65.1	127.0	44.7	640,0
KPK									
Agriculture	1 347.9	9.8	76.9	86.6	165.0	85.0	28.4	71.3	450,6
Traders	1 564.5	3.2	74.5	82.1	207.3	160.2	74.3	57.7	542,0
Social & personal service	1 903.3	9.7	102.7	102.6	320.2	80.7	176.9	63.3	647,1
Service sector	1 870.0	7.8	94.1	92.6	323.2	88.3	148.0	61.9	607,4
Industrial sector	1 728.1	8.3	93.4	91.1	303.2	63.3	78.6	59.7	586,1
BALOCHISTAN									
Agriculture	1 114.7	6.2	77.0	63.9	199.7	23.2	18.9	56.0	455,5
Traders	1 270.9	7.9	97.2	60.4	259.7	25.3	44.8	58.4	506,1
Social & personal service	1 429.1	13.4	122.3	70.0	286.3	26.2	51.2	64.6	560,4
Service sector	1 340.7	7.9	85.9	64.1	283.4	27.8	44.8	68.6	548,2
Industrial sector	1 413.2	11.7	145.1	80.6	255.5	32.0	29.4	57.8	557,4

Table A1.17: Household vulnerability profiling: Rural caloric intake (kcal/person/day)

Livelihood	Total food	Milk	Meat	Eggs	Fish	Fresh Fruits	Dry Fruits	Potatoes	Vegetable
PUNJAB									
Employer	2 318	355.5	15.8	8.4	0.8	37.6	0.7	30.9	40.6
Paid employee	2 215	322.5	13.5	7.2	0.5	29.6	0.5	30.5	42.4
Unpaid family worker	2 501	471.6	12.1	9.3	0.5	25.2	0.3	27.5	32.8
Owner cultivator	2 925	751.8	17.1	11.0	0.8	41.9	1.1	32.5	36.6
Sharecropper	2 650	492.8	13.1	7.5	0.2	27.7	1.2	31.6	32.5
Contract cultivator	2 690	568.2	15.1	10.4	0.6	34.6	0.9	31.0	39.5
Livestock only	2 625	544.9	13.3	9.3	0.1	30.3	0.7	33.5	36.2
SINDH									
Employer	2 094	192.1	16.0	6.5	13.5	46.2	1.0	43.8	36.2
Paid employee	1 984	181.2	13.9	3.7	8.6	37.0	0.0	31.7	33.1
Unpaid family worker	2 145	279.7	16.3	3.5	5.3	11.5	0.0	47.4	29.7
Owner cultivator	2 380	381.2	16.0	4.6	12.7	36.6	0.0	42.1	32.0
Sharecropper	2 117	263.9	9.5	2.2	6.7	27.5	0.1	40.8	29.6
Contract cultivator	2 274	174.5	15.1	2.3	8.5	54.5	0.0	28.3	31.0
Livestock only	2 384	427.7	16.3	4.6	9.0	36.1	0.0	34.2	30.3
KPK									
Employer	2 509	262.0	26.8	10.2	0.7	40.6	1.8	33.2	47.2
Paid employee	2 374	221.6	21.3	12.5	1.0	33.4	1.8	29.8	36.3
Unpaid family worker	2 598	308.4	36.8	15.2	0.0	40.8	0.0	30.8	31.6
Owner cultivator	2 685	341.6	18.7	12.7	0.2	30.0	2.4	32.0	34.7
Sharecropper	2 454	330.7	17.0	13.5	0.2	27.0	1.2	24.3	30.7
Contract cultivator	2 222	164.4	15.6	9.6	0.0	11.5	1.2	33.4	33.0
Livestock only	2 808	413.0	14.8	17.2	0.4	40.6	4.5	27.9	38.3
BALUCHISTAN									
Employer	2 067	144.8	20.3	3.8	15.8	19.4	6.5	37.8	32.3
Paid employee	2 033	95.6	19.2	5.5	9.5	19.7	1.4	33.0	31.9
Unpaid family worker	1 517	78.2	0.0	8.2	0.0	32.8	0.0	53.9	28.3
Owner cultivator	2 192	164.6	22.0	6.4	9.2	22.4	3.3	34.2	40.8
Sharecropper	2 172	170.9	14.9	3.5	2.9	12.2	1.5	48.5	35.5
Contract cultivator	1 544	93.6	21.4	9.2	6.4	29.3	0.0	17.2	20.3
Livestock only	2 019	131.7	20.9	4.8	7.4	12.6	0.2	29.6	25.9

Note: Livelihood groups of unpaid family worker and contract cultivator in Baluchistan are not shown since only very small samples were available.

Table A1.17: Household vulnerability profiling: Rural caloric intake (kcal/person/day) - Cont'd

Condiments and Spices	Sugar	Non-alcoholic beverage	Wheat	Rice	Other cereals	Pulses	Oils and fats	Tea and coffee	Baked and fried products
PUNJAB									
48.1	194.1	0.5	855.4	80.3	6.9	9.8	254.9	6.6	6.4
46.2	194.3	0.4	848.8	75.0	4.8	10.6	250.5	6.6	2.5
40.5	169.4	0.3	1.002.3	70.2	4.3	8.5	265.2	7.6	0.7
267.5	222.5	0.7	986.1	93.0	8.4	11.3	266.2	7.6	1.4
41.4	232.1	0.4	1.008.0	80.7	6.2	11.4	259.9	8.0	0.8
48.8	222.8	0.4	959.1	88.0	7.7	9.9	254.0	6.8	0.6
49.9	774.6	0.5	937.0	81.4	10.4	11.4	254.6	7.1	2.7
SINDH									
52.5	142.3	0.3	644.1	287.5	5.0	8.0	254.1	10.6	3.3
53.3	159.9	0.3	698.2	215.3	4.5	7.6	211.8	12.0	2.6
54.5	172.2	0.2	668.3	254.8	2.0	5.8	240.5	11.3	0.5
54.5	160.4	0.2	714.0	334.7	5.4	7.5	231.8	11.1	1.5
50.2	157.7	0.1	722.6	300.5	3.0	6.8	197.4	10.1	1.1
48.4	190.0	18.6	953.8	183.2	9.0	9.6	200.3	12.8	0.6
51.7	160.4	0.4	742.6	271.7	15.7	7.9	229.4	12.1	2.1
KPK									
52.2	246.6	0.2	938.2	82.9	69.9	11.1	257.4	13.6	3.5
87.2	251.2	0.2	884.6	90.5	63.4	10.4	241.0	13.7	12.3
61.5	299.1	0.4	872.2	104.8	60.1	12.0	256.7	13.4	3.3
53.9	275.7	0.1	976.1	106.5	105.5	11.4	243.2	15.1	2.7
49.2	255.9	0.2	891.3	49.2	107.8	8.4	231.7	13.0	4.9
37.5	263.5	0.1	845.3	110.8	97.0	10.6	205.9	13.9	1.2
62.7	305.3	0.1	939.1	83.1	75.3	10.5	268.0	15.6	14.2
BALUCHISTAN									
50.5	186.5	0.2	838.0	88.5	3.4	11.2	244.2	11.7	2.4
53.2	195.8	0.1	858.5	86.1	2.8	11.0	240.2	11.2	2.3
44.0	79.0	0.0	538.2	128.1	6.4	4.7	245.0	7.3	0.0
51.8	210.4	0.3	874.4	102.5	6.8	11.5	240.7	11.4	3.2
60.5	193.0	0.0	794.9	190.2	45.9	6.8	231.6	9.6	0.7
53.0	82.6	0.0	562.5	19.3	0.0	11.8	293.9	13.6	0.0
53.5	192.2	0.0	823.1	101.1	2.2	11.7	239.5	10.9	1.7

Table A1.18: Household vulnerability profiling: Urban caloric intake (kcal/person/day)

Livelihood	Total food	Milk	Meat	Eggs	Fish	Fresh fruits	Dry fruits	Potatoes	Vegetable
PUNJAB									
Agriculture	2 930	684.7	24.8	13.1	3.6	62.3	2.4	32.8	60.0
Traders	2 243	407.1	23.2	11.6	2.3	53.7	2.1	30.9	33.5
Social & personal service	2 437	432.3	27.1	15.8	2.5	60.4	2.7	33.7	38.4
Service sector	2 311	358.5	26.1	13.5	1.4	53.6	2.4	31.2	36.8
Industrial sector	2 269	365.7	23.1	11.3	2.5	48.1	1.9	31.7	38.2
SINDH									
Agriculture	2 111	190.2	15.1	6.8	9.5	31.6	0.0	37.5	30.2
Traders	2 051	205.9	26.4	12.7	8.8	58.1	0.9	29.8	31.1
Social & personal service	2 073	211.5	23.8	14.1	9.8	59.4	0.9	29.9	30.1
Service sector	2 115	225.2	30.1	16.3	8.0	60.2	0.5	30.1	33.7
Industrial sector	2 063	190.6	24.4	15.7	7.5	58.3	1.1	29.8	33.3
KPK									
Agriculture	2 697	368.0	24.3	13.4	2.5	39.9	3.6	32.2	38.7
Traders	2 309	255.4	25.0	9.5	1.6	40.2	1.0	27.1	34.2
Social & personal service	2 668	310.9	33.5	20.5	4.2	60.9	3.2	31.8	41.8
Service sector	2 376	212.3	30.9	13.4	1.4	55.3	3.9	28.1	39.3
Industrial sector	2 491	240.0	26.3	10.7	1.3	45.2	1.3	32.5	44.5
BALUCHISTAN									
Agriculture	1 879	126.3	20.7	8.3	18.3	27.3	0.0	31.5	30.2
Traders	1 792	97.8	20.3	5.8	13.8	23.9	0.7	30.1	29.1
Social & personal service	2 016	107.1	23.5	5.5	6.9	25.7	2.0	29.5	34.8
Service sector	2 007	112.0	24.1	6.7	5.6	24.8	6.7	31.1	29.4
Industrial sector	2 039	109.0	21.1	5.4	9.6	28.9	2.6	32.1	31.7

Note: Livelihood groups of unpaid family worker and contract cultivator in Baluchistan are not shown since only very small samples were available.

Table A1.18: Household vulnerability profiling: Urban caloric intake (kcal/person/day) - Cont'd

Condiments and spices	Sugar	Non-alcoholic beverage	Wheat	Rice	Other cereals	Pulses	Oils and fats	Tea and coffee	Baked and fried products
PUNJAB									
52.7	219.6	1.5	879.8	98.3	8.9	12.7	303.7	7.5	10.6
47.7	166.8	2.4	678.6	83.6	7.6	11.1	267.1	6.2	19.6
51.2	218.0	1.6	696.5	90.8	7.4	11.7	299.0	7.5	31.8
50.8	177.0	4.1	697.8	92.2	8.2	12.4	289.8	7.6	27.6
47.5	176.6	1.1	716.3	91.1	6.9	11.2	278.5	6.8	17.9
SINDH									
83.3	153.2	0.4	660.3	234.7	10.2	7.4	249.0	11.0	4.3
58.2	152.0	0.9	574.2	171.7	7.2	9.3	271.2	13.0	30.9
55.9	155.2	1.0	576.5	177.0	7.7	9.2	274.4	13.5	31.3
54.6	159.3	1.1	562.3	182.9	7.3	9.2	276.1	14.0	38.0
60.3	160.7	1.2	588.2	171.5	7.1	9.7	268.7	14.2	27.0
KPK									
54.6	226.6	0.1	978.6	69.9	33.2	13.4	285.8	13.6	37.8
42.7	215.1	0.5	832.0	52.3	12.9	12.2	250.7	13.0	55.9
54.0	260.7	3.4	816.0	57.0	18.1	14.7	282.9	14.2	116.1
46.6	226.3	0.6	842.5	62.6	21.8	13.5	265.2	13.5	51.9
50.3	237.0	0.5	896.5	69.3	20.4	12.5	267.0	13.5	60.2
BALUCHISTAN									
49.3	167.4	0.0	658.4	132.6	4.2	9.1	229.4	10.7	2.9
47.9	168.5	0.3	666.9	99.0	2.7	8.2	222.8	10.2	5.4
51.9	201.9	0.4	738.5	88.1	2.6	10.5	255.1	11.4	25.3
50.5	234.6	0.5	750.0	81.8	3.8	9.4	245.1	9.6	21.6
50.7	196.4	0.3	721.9	131.4	3.2	9.6	267.8	11.0	14.3

Table A1.19: Estimated food needs: Kilograms of wheat per month/adult by district

District	Baseline	Scenario 1	Scenario 2
PUNJAB			
Islamabad	3.32	3.97	4.33
Attock	4.04	4.76	4.92
Rawalpindi	2.44	2.80	2.89
Jhelum	3.58	4.09	4.43
Chakwal	3.32	4.20	4.34
Sargoda	3.74	4.93	5.29
Bhakkar	4.05	4.42	4.79
Khushab	5.29	5.91	6.18
Mianwali	2.69	3.59	4.00
Faisalabad	3.46	4.16	4.63
T.T.Singh	3.03	4.15	4.37
Jhang	3.22	3.71	4.07
Gujranwala	4.54	5.02	5.49
Gujrat	3.95	4.32	4.80
Sialkot	3.08	3.91	4.40
Hafizabad	2.44	3.49	4.06
Mandi Bahaud Din	2.09	3.11	3.90
Narowal	2.77	3.58	3.42
Lahore	4.51	5.07	5.40
Kasur	3.83	4.88	5.40
Okara	3.25	4.54	4.68
Sheikhupura	3.97	5.10	5.32
Vehari	4.43	4.49	4.75
Sahiwal	4.45	5.19	5.68
Multan	3.23	4.28	4.29
D.G Khan	4.21	4.98	5.15
Pakpattan	3.99	4.69	4.95
Lodhran	4.08	4.64	5.06
Khanewal	4.41	5.13	5.20
Rajanpur	3.83	4.41	5.20
Layyah	2.99	2.99	3.40
Muzaffargarh	3.93	3.83	4.52
Bahawalpur	3.77	4.60	5.25
Bahawalnagar	2.57	3.36	3.66
Rahim Yar Khan	3.63	4.68	5.29
SINDH			
Shikarpur	2.72	4.01	7.83
Larkana	3.57	4.51	5.58
Dadu	6.92	7.35	7.76
Hyderabad	4.50	5.49	5.87
Badin	6.48	7.06	7.23
Thatta	5.01	5.74	7.07
Sanghar	4.39	5.27	5.56
Mirpurkhas	5.32	6.12	6.62
Tharparkar	5.15	6.05	6.77
Karachi	5.24	6.36	6.86
KPK			
Swat	2.93	2.64	2.95
Dir Upper	3.55	3.59	3.85
Dir Lower	2.97	3.04	3.19
Chitral	2.67	3.12	2.95
Shangla	1.46	1.92	2.71
Malakand	3.04	2.87	3.51
Bonair/Buner	2.08	2.70	2.75
Charsadda	2.12	2.52	3.01
Nowshera	3.40	3.73	4.25
Peshawar	2.36	2.54	2.67
Kohat	2.08	2.54	2.40
Karak	1.34	2.13	1.99
Hangu	3.49	3.51	3.73
Tank	5.83	6.16	3.39
D.I.Khan	3.38	3.50	3.63
Mansehra	3.33	3.56	4.22
Abbottabad	2.33	2.74	2.90
Haripur	3.20	3.78	3.45
Battagram	2.50	2.88	3.42
Kohistan	4.03	4.08	4.33
Mardan	2.65	2.95	3.22
Swabi	2.90	3.16	2.46
Bannu	2.52	2.49	2.70
Lakki	4.27	6.31	4.10
BALUCHISTAN			
Quetta	3.91	4.73	5.08
Sibi	3.83	5.55	5.64
Kalat	4.51	5.64	6.08
Makran/Turbat	4.96	6.20	6.56
Zhob	4.48	5.68	5.95
Nasirabad	2.82	3.59	4.22

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

Figure A1.1: Wheat area, yield, and production 1974-2010

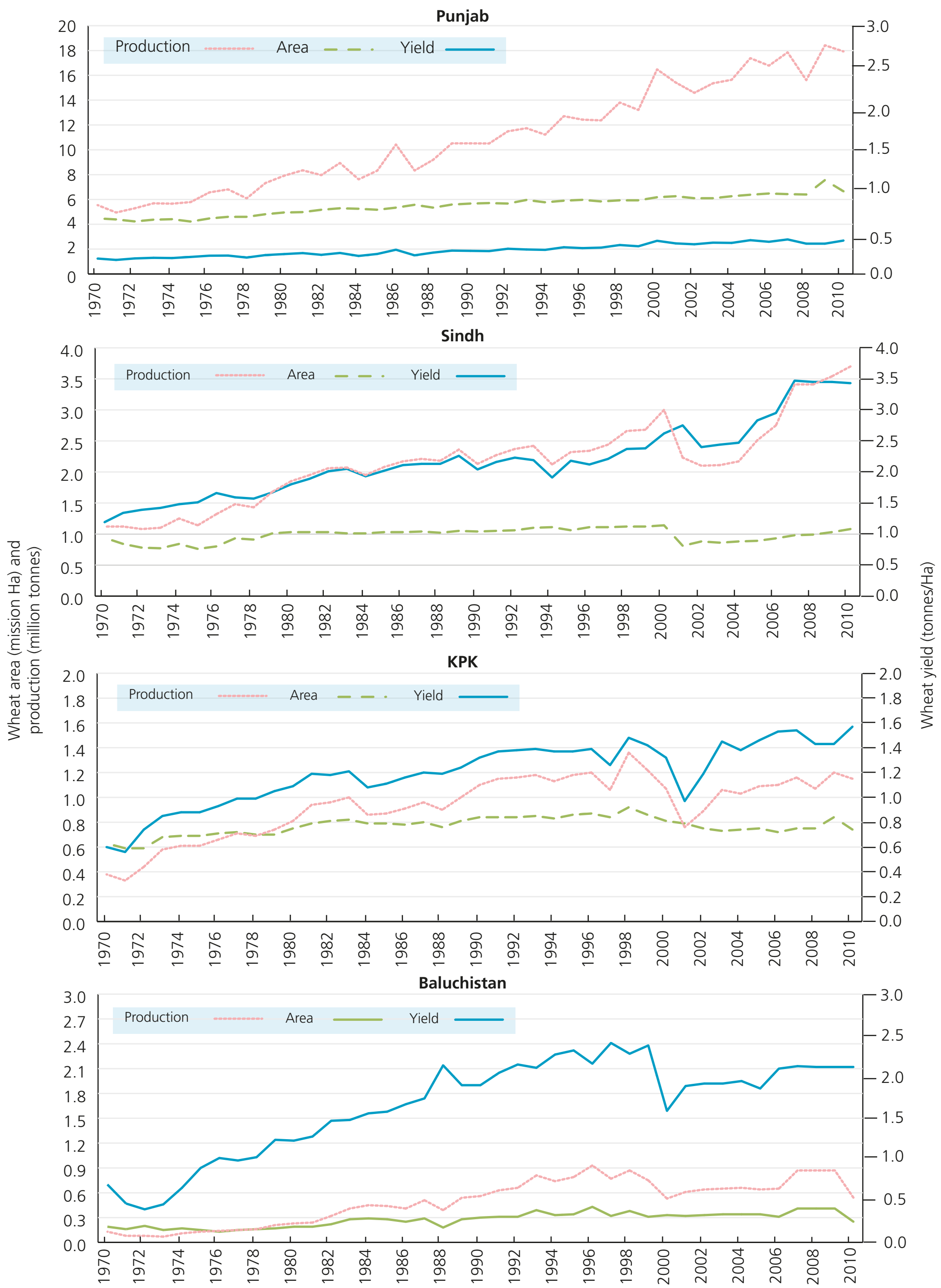


Figure A1.2: Relationship between weather shocks and wheat yield

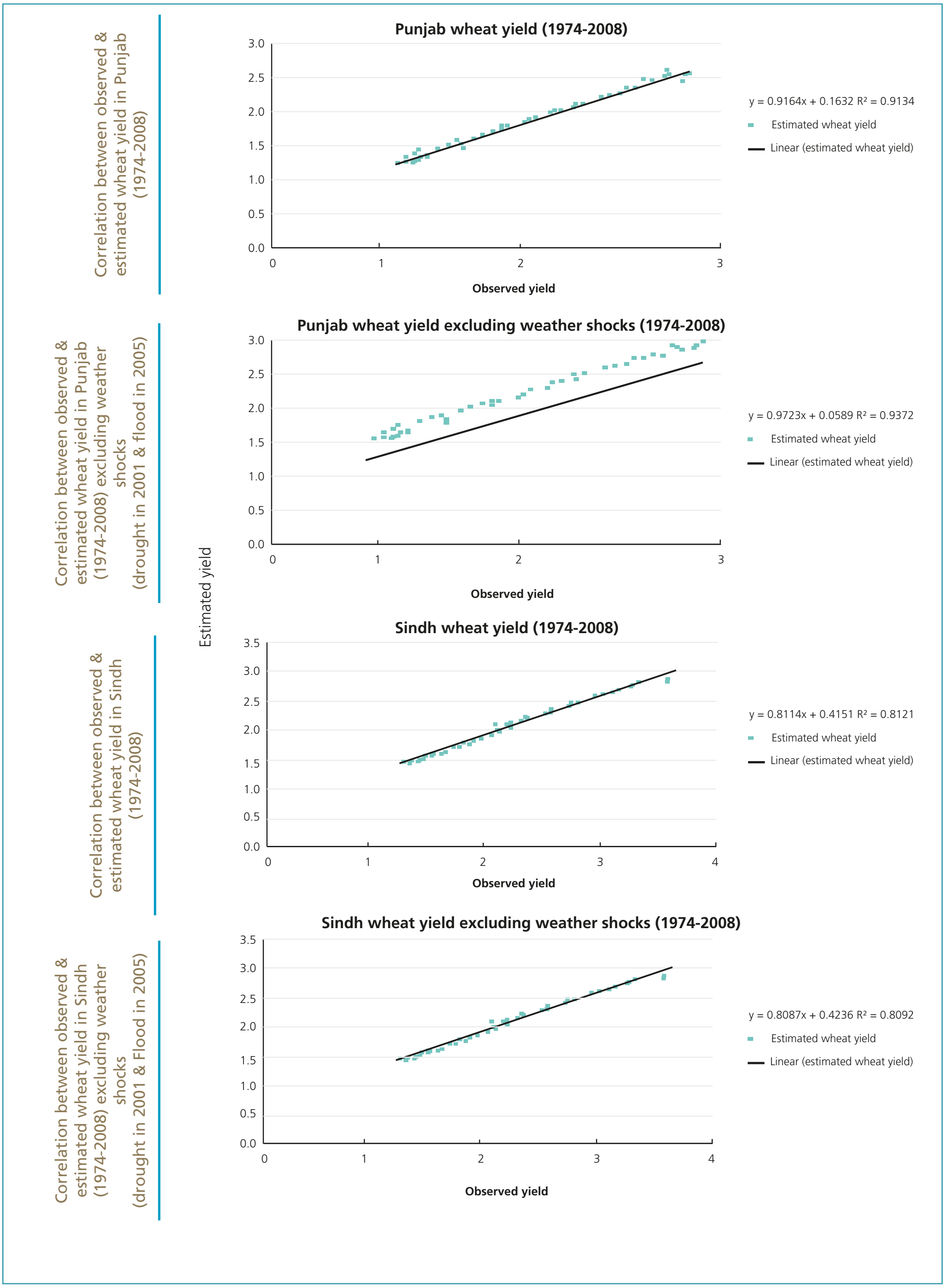
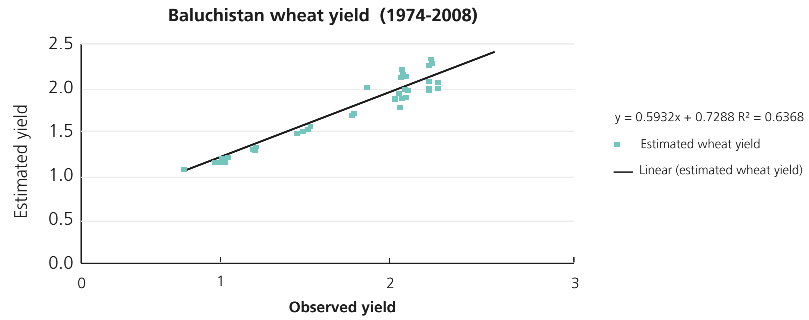
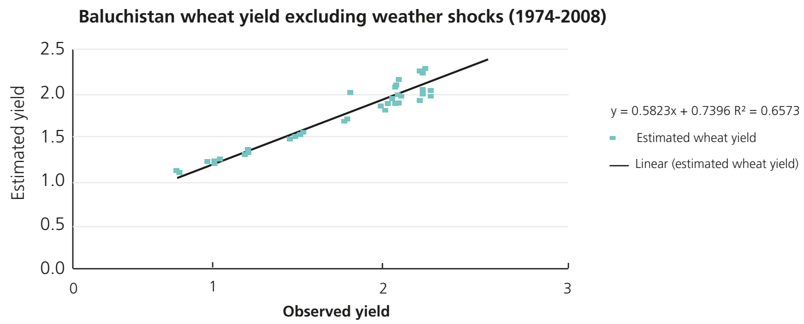


Figure A1.2: Relationship between weather shocks and wheat yield - Cont.d

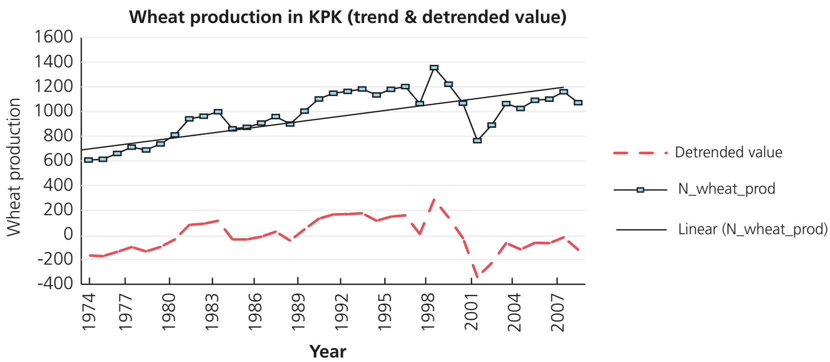
Correlation between Observed & Estimated Wheat Yield in Punjab (1974-2008)



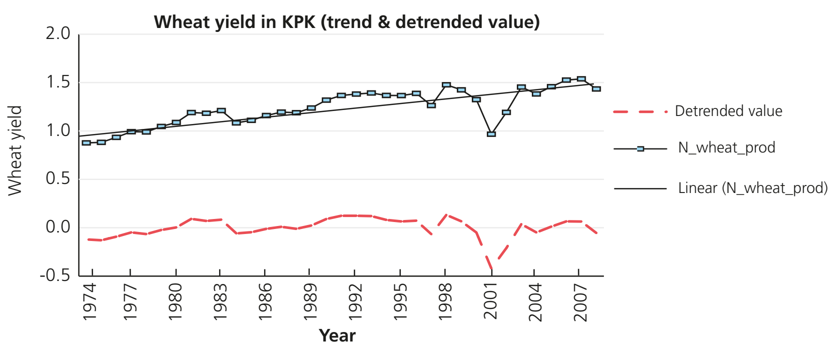
Correlation between Observed & Estimated Wheat Yield in Baluchistan (1974-2008) excluding Weather shocks (Drought in 2001 & Flood in 2005)



Correlation between Observed & Estimated Wheat Yield in KPK (1974-2008)



Correlation between Observed & Estimated Wheat Yield in KPK (1974-2008) excluding Weather shocks (Drought in 2001 & Flood in 2005)



Appendix 2: Simulated results with low DECR (Chapter 6)

Table A2.1 Simulated impact of flood and price increases on undernourishment (caloric intake: % of population <1 730 kcal/per day)

Category		POST-SHOCK (2010)				
	Baseline (2005/2006) % population <1 730 kcal/day	Scenario 1 % population <1 730 kcal/ day	Scenario 2 % population <1 730 kcal/ day	% Points Change due to market shock	% Points Change due to flood shock	% Points Change due to combined shock
Rural	23.3	32.7	38.8	9.4	6.2	15.5
Urban	28.9	35.2	35.7	6.2	0.5	6.7
Total	25.5	33.7	37.6	8.1	3.	12.0
MAIN PROVINCES						
Punjab	21.7	29.2	31.3	7.5	2.1	9.6
Sindh	33.4	43.3	52.7	9.9	9.4	19.3
KPK	15.1	17.2	18.4	2.1	1.2	3.3
Baluchistan	37.5	52.9	56.2	15.4	3.4	18.8
RURAL LIVELIHOOD GROUPING						
Employer *	22.3	33.0	37.5	10.7	4.5	15.2
Paid employee	31.0	44.3	51.1	13.3	6.8	20.1
Unpaid family worker	14.9	24.2	25.4	9.3	1.1	10.4
Owner cultivator	13.3	18.5	25.2	5.2	6.7	11.8
Sharecropper	20.2	26.7	44.2	6.5	17.5	24.0
Contract cultivator	16.5	20.3	24.6	3.9	4.2	8.1
Livestock only	22.2	27.9	33.0	5.8	5.1	10.8
URBAN LIVELIHOOD GROUPING						
Agriculture	23.7	30.5	32.3	6.8	1.8	8.6
Traders	30.4	36.3	37.2	5.9	0.9	6.8
Social & personal service	28.1	34.6	35.0	6.4	0.4	6.8
Service sector **	28.6	35.4	35.8	6.8	0.4	7.2
Industrial sector	28.7	36.0	38.0	7.3	2.0	9.2
INCOME GROUPING-RURAL						
Low	29.6	42.2	50.4	12.6	8.2	20.8
Middle	8.2	8.2	8.9	0.0	0.7	0.7
High	2.8	3.6	4.4	0.8	0.7	1.6
INCOME GROUPING-URBAN						
Low	51.6	66.1	67.3	14.4	1.2	15.7
Middle	23.2	23.2	22.9	0.0	-0.3	-0.3
High	8.1	9.6	9.8	1.5	0.2	1.7

* Employers is a livelihood group composed of mainly large employers (≥ 10 employees), small employers (<10 employees) and self employed non-agricultural businesses.

** Service sector is an urban livelihood group composed of transport, storage, real estate, & insurance sectors.

Figure A2.1 Percentage of people consuming less than the DECR due to simulated market and flood shocks by district (% of population below 1 730 kcal/day)

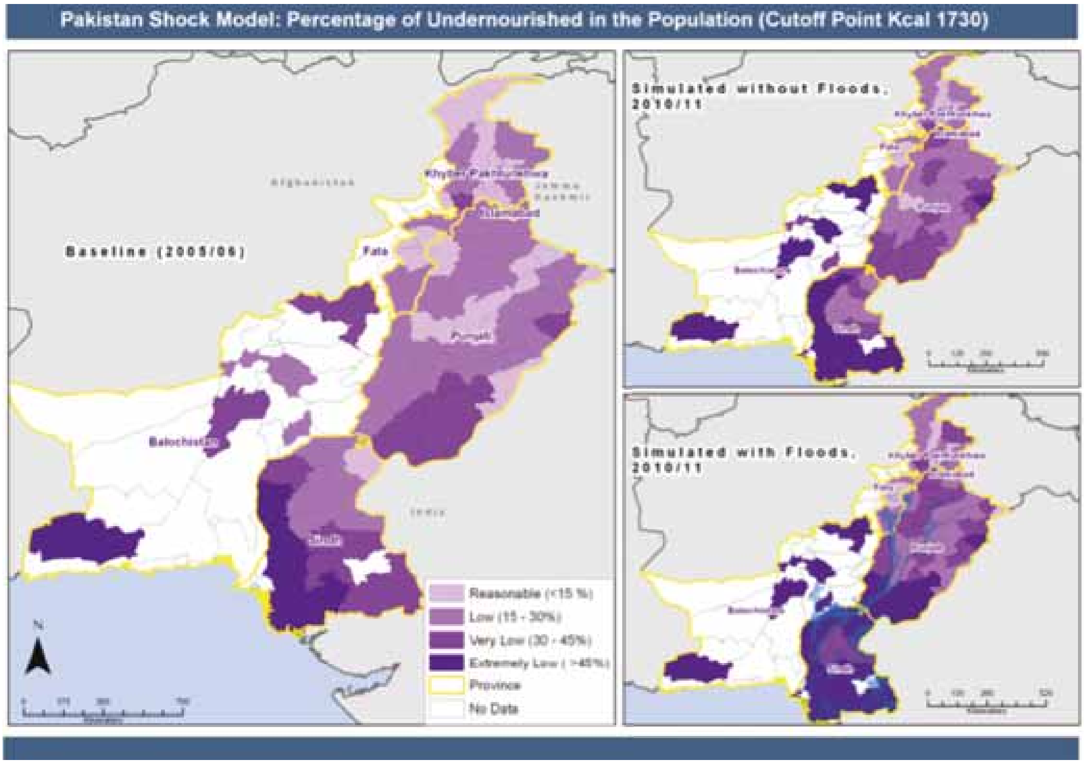


Table A2.2: Simulated shock impacts on the number of undernourished people (caloric Intake: 000 adults <1 730 kcal/per day)

Category		POST-SHOCK (2010)		
	Baseline (2005/2006) (A)	Scenario 1	Scenario 2 (B)	Total (A+B)
Rural	25.971	10.104	16.565	42.536
Urban	18.217	3.933	4.245	22.463
Nationwide	44.188	14.037	20.811	64.999

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

Table A2.3 Depth of hunger among undernourished population (number of kilocalories below the minimum daily energy requirement of 1 730 kcal/person/day)

Category		POST-SHOCK (2010)	
	Baseline (2005/2006) No. of kcal below 1 730 kcal/day	Scenario 1 No. of kcal below 1 730 kcal/day	Scenario 2 No. of kcal below 1 730 kcal/day
Rural	296	347	393
Urban	307	363	379
Total	301	353	388
MAIN PROVINCES			
Punjab	278	333	354
Sindh	348	385	443
KPK	239	246	255
Baluchistan	303	388	413
RURAL LIVELIHOOD GROUPING			
Employer	276	326	361
Paid employee	310	378	407
Unpaid family worker	208	252	359
Owner cultivator	258	269	351
Sharecropper	339	329	460
Contract cultivator	273	257	292
Livestock only	231	311	337
URBAN LIVELIHOOD GROUPING			
Agriculture	318	348	412
Traders	323	376	389
Social & personal service	309	359	375
Service sector	277	348	368
Industrial sector	284	345	352
INCOME GROUPING-RURAL			
Low	302	353	402
Middle	201	208	208
High	262	250	266
INCOME GROUPING-URBAN			
Low	336	401	423
Middle	232	242	241
High	246	265	264

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

Figure A2.2 Per capita severity of undernourishment due to simulated market and flood shocks by district (required kilocalories/day to reach minimum daily energy requirement of 1 730 kcal/person/day)

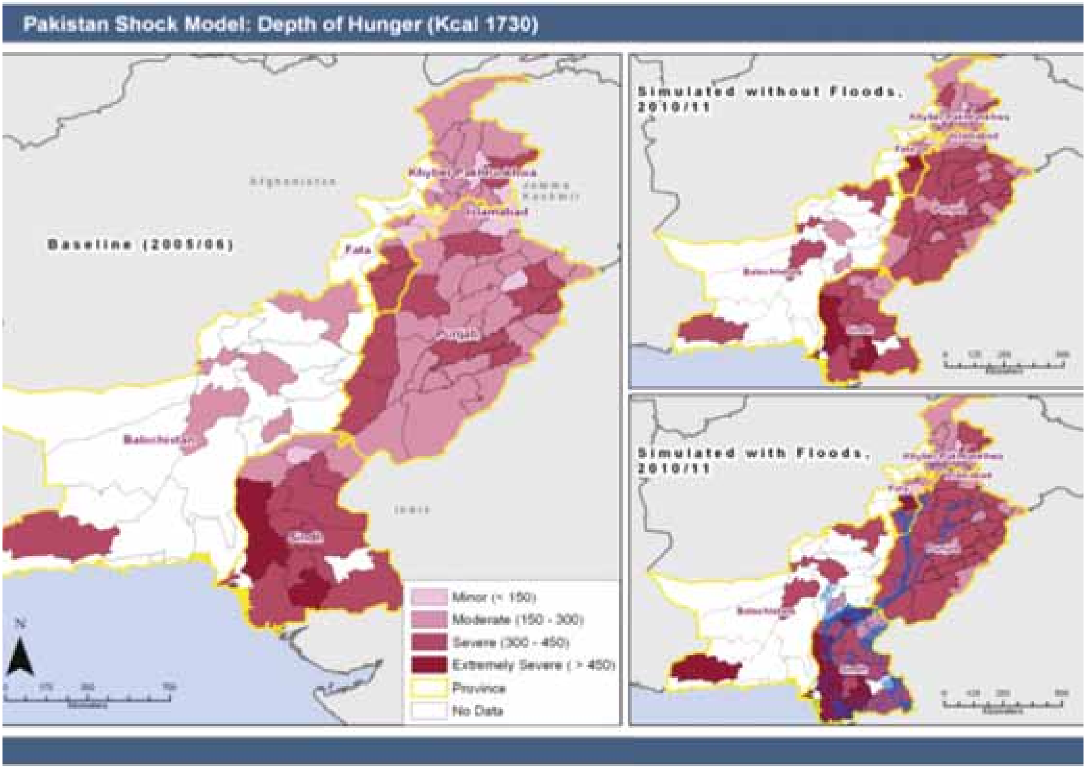
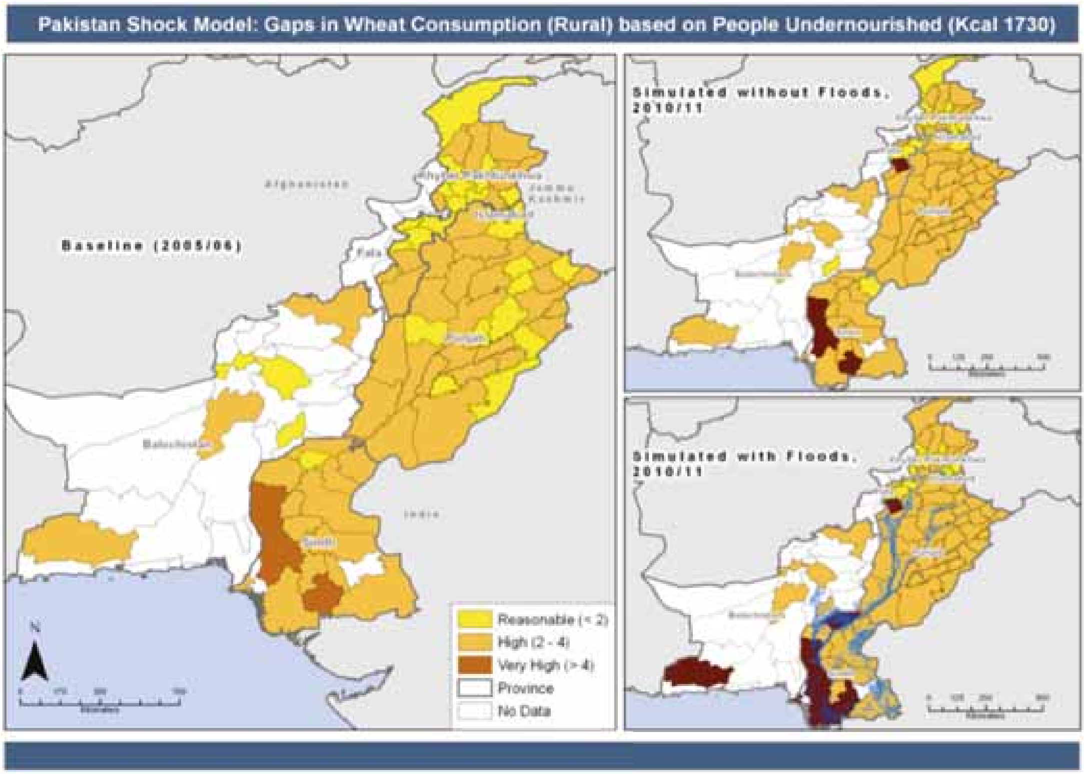


Table A2.4 Quantifying shock impacts in terms of food needed (tonnes of wheat per year) to meet undernourished requirements

Category		POST-SHOCK (2010)		
	Baseline (2005/2006) (A)	Scenario 1	Scenario 2 (B)	Total (A+B)
Rural	827 794	517 903	964 718	1 792 512
Urban	600 484	261 995	313 265	913 749
Nationwide	1 428 278	779 898	1 277 983	2 706 261

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

Figure A2.3 Wheat needed (kilograms/person/month) to meet requirements of the undernourished population (1 730 kcal/person/day) by district



Appendix 3: Simulated results with DECR of 2 100 kcal per day (Chapter 6)

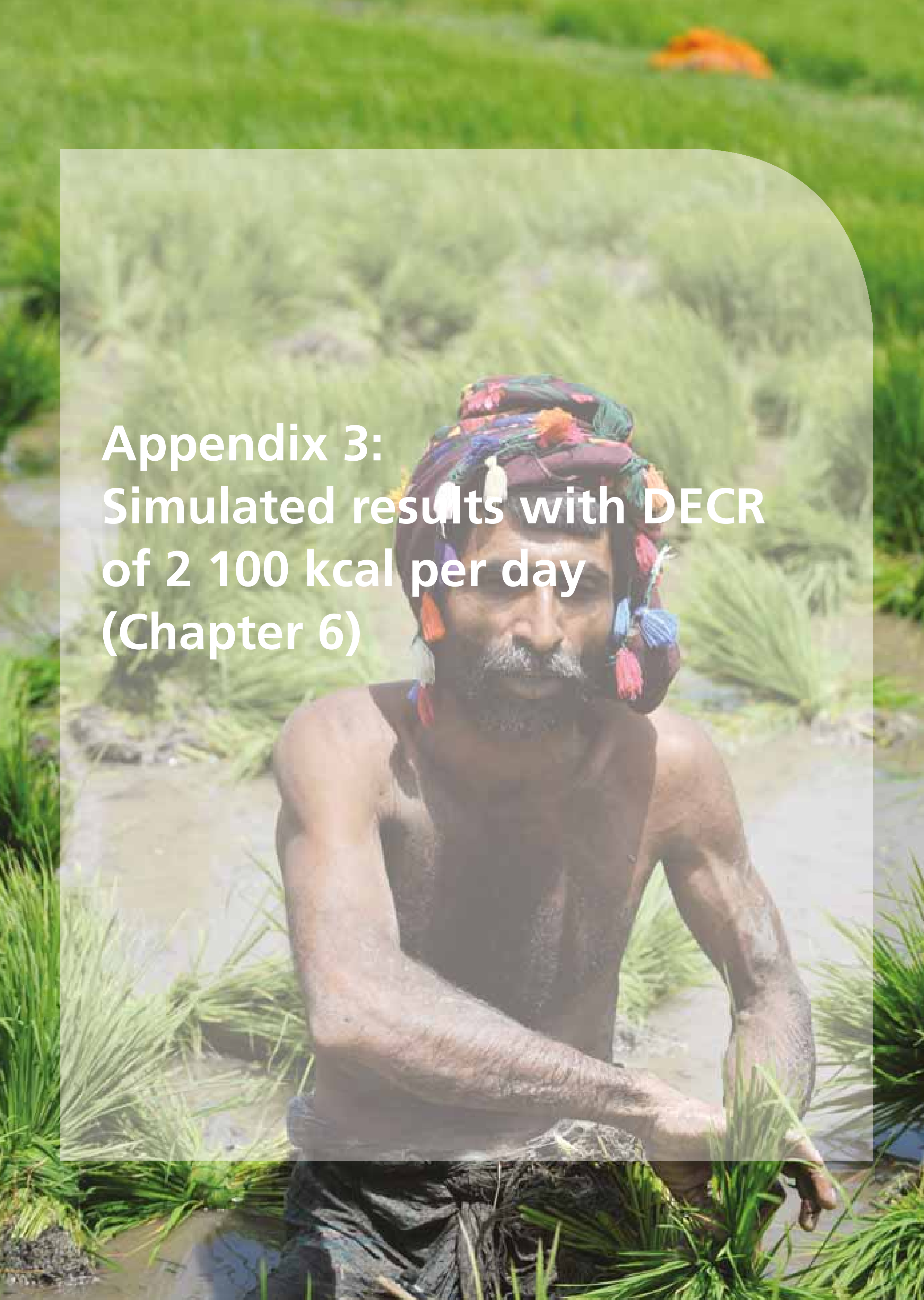


Table A3.1: Simulated impact of flood and price increases on undernourishment (caloric intake: % of adults <2 100 kcal/per day)

Category		POST-SHOCK (2010)				
	Baseline (2005/2006) % population <2 100 kcal/ day	Scenario 1 % population <2 100 kcal/ day	Scenario 2 % population <2 100 kcal/ day	% Points change due to market shock	% Points change due to flood shock	% Points change due to combined shock
Rural	45.6	54.0	58.7	8.3	4.7	13.0
Urban	51.0	55.2	55.3	4.2	0.1	4.3
Total	47.8	54.5	57.3	6.7	2.9	9.5
MAIN PROVINCES						
Punjab	41.8	48.2	50.2	6.4	2.0	8.4
Sindh	57.2	65.7	71.3	8.4	5.6	14.1
KPK	37.7	39.7	40.9	2.0	1.2	3.2
Baluchistan	62.2	73.3	76.3	11.1	2.9	14.0
RURAL LIVELIHOOD GROUPING						
Employer	45.9	54.8	58.4	8.9	3.6	12.5
Paid employee	55.3	66.0	70.5	10.7	4.5	15.1
Unpaid family worker	33.5	37.1	43.1	3.6	5.9	9.5
Owner cultivator	31.7	37.4	43.6	5.7	6.2	11.9
Sharecropper	48.1	55.3	67.3	7.2	12.0	19.2
Contract cultivator	34.8	40.4	45.6	5.6	5.2	10.8
Livestock only	40.3	50.0	51.7	9.7	1.7	11.4
URBAN LIVELIHOOD GROUPING						
Agriculture	41.1	45.2	47.7	4.0	2.5	6.6
Traders	55.5	59.4	60.1	3.9	0.7	4.6
Social & personal service	49.3	53.3	53.8	4.1	0.4	4.5
Services ector	50.5	56.4	57.2	5.9	0.8	6.7
Industrial sector	53.6	58.6	60.6	5.0	2.1	7.0
INCOME GROUPING-RURAL						
Low	55.4	66.3	72.3	11.0	6.0	16.9
Middle	24.7	24.3	24.9	-0.4	0.6	0.2
High	10.9	13.8	16.0	3.0	2.1	5.1
INCOME GROUPING-URBAN						
Low	78.3	85.8	86.1	7.4	0.4	7.8
Middle	49.8	50.2	49.6	0.3	-0.5	-0.2
High	22.4	25.6	25.8	3.2	0.3	3.5

Table A3.2: Simulated shock impacts on the number of undernourished people (caloric intake: 000 adults <2 100 kcal/per day)

Category		POST-SHOCK (2010)		
	Baseline (2005/2006) (A)	Scenario 1	Scenario 2 (B)	Total (A+B)
Rural	50 535	8 899	13 802	64 337
Urban	32 140	2 639	2 714	34 855
Nationwide	82 675	11 538	16 516	99 192

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

Table A3.3: Depth of hunger among undernourished population (number of kilocalories below the minimum daily energy requirement of 2 100 kcal/person/day)

Category		POST-SHOCK (2010)	
	Baseline (2005/2006) No. of kcal below 2 100 kcal/day	Scenario 1 No. of kcal below 2 100 kcal/day	Scenario 2 No. of kcal below 2 100 kcal/day
Rural	429	509	570
Urban	465	537	551
Total	445	520	562
MAIN PROVINCES			
Punjab	425	502	524
Sindh	494	563	652
KPK	351	371	381
Baluchistan	483	603	629
RURAL LIVELIHOOD GROUPING			
Employer	409	490	539
Paid employee	463	566	616
Unpaid family worker	413	463	485
Owner cultivator	366	407	495
Sharecropper	407	441	618
Contract cultivator	388	402	434
Livestock only	409	466	524
URBAN LIVELIHOOD GROUPING			
Agriculture	478	539	581
Traders	463	533	547
Social & personal service	468	540	553
Service sector	452	518	533
Industrial sector	438	518	521
INCOME GROUPING-RURAL			
Low	445	531	597
Middle	309	313	324
High	282	278	282
INCOME GROUPING-URBAN			
Low	532	641	664
Middle	382	384	382
High	333	356	355

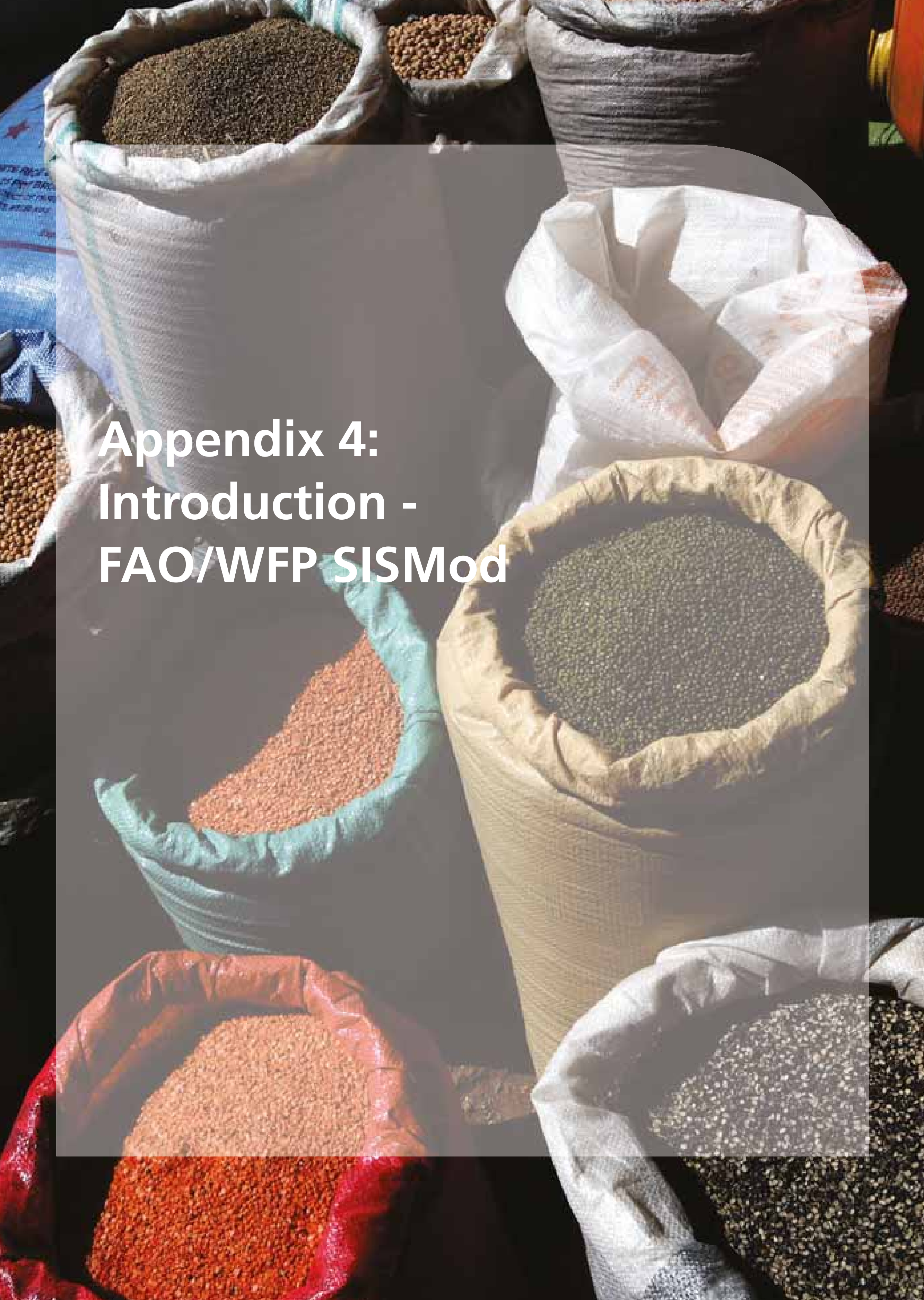
Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

Table A3.4: Quantifying shock impacts in terms of food needed (tonnes of wheat per year) to meet undernourished requirements of 2 100 kcal/day

Category		POST-SHOCK (2010)		
	Baseline (2005/2006) (A)	Scenario 1	Scenario 2 (B)	Total (A+B)
Rural	2 340 301	916 993	1 587 307	3 927 608
Urban	1 605 408	400 223	456 687	2 062 094
Nationwide	3 945 709	1 317 216	2 043 994	5 989 703

Scenario 1: market shocks (price increases). Scenario 2: combined floods and price increase.

Appendix 4: Introduction - FAO/WFP SISMod



2013
A tool to measure the impact of shocks on food security in vulnerable countries

Project rationale

- The FAO/WFP Shock Impact Simulation Model (SISMod) has been developed to address the notable rise in the number of people facing various types of shocks (market, economic, political and climatic), which leads to challenges in addressing food insecurity in developing countries. Previously, it had proved difficult to provide quantitative estimates on the impact that various shock factors have on the livelihoods and food security of different population groups at a nationally representative level.
- Shocks arise from rapid changes in economic, political, market or climatic conditions, and affect different population groups differently. These shocks can have lasting impacts on livelihoods and food security, impeding development and progress. Interventions are often criticised for being "too little, too late", but often actors do not have the necessary tools to make quantitative assessments that can help them identify who is most affected, to what extent and where.
- The initial phase of the current project focused on shock-prone food-deficit countries representing different levels of exposure to shocks: Bangladesh, Nepal, Pakistan, Tajikistan, Niger, Tanzania and Uganda.

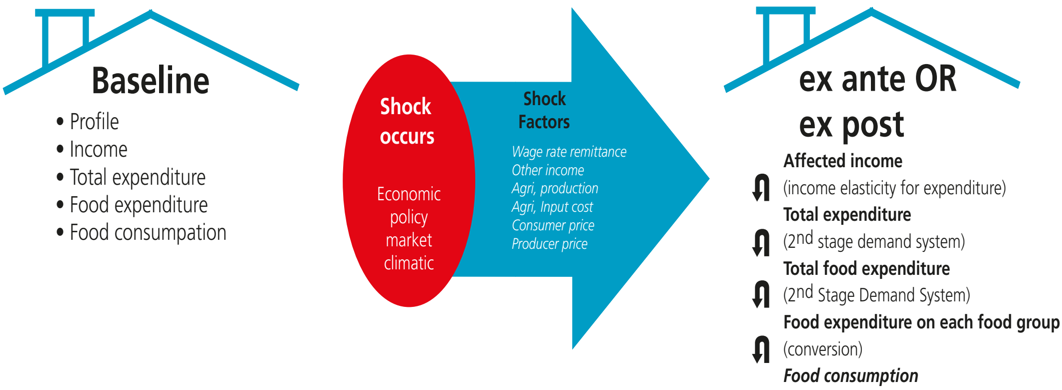
What is the SISMod tool?

SISMod is an Excel/Access based tool for food security monitoring and analysis. It is a comprehensive tool, which brings new possibilities for conducting quantitative analyses at the onset of a shock that impacts market stability and household food access. It can be used to calculate the impacts of shocks on different population groups, particularly in terms of food security outputs, which often require immediate action in times of shock. SISMod can be used for the following:

- to provide quantitative estimates of the ex ante and ex post impact of various types of shocks (e.g. market, economic, political and climatic) on livelihood and food security;
- to identify those who are most affected by shocks and the extent to which they are affected (for example, by geographic location, by different livelihood groups and by gender); and
- to simulate future scenarios of potential shocks and possible interventions.

How does SISMod work?

SISMod is a country-specific model that uses national household survey data as the baseline. The SISMod approach is to simulate the impact of shock factors by applying the modeling system.



What shocks can be simulated?

The model currently focuses on changes in key factors which impact livelihood and food security outcomes:

√ agricultural production (major crops and major livestock breeds) due to climate shocks at subnational level
√ agricultural inputs/costs (fertilizer, seeds, and subsidies) at subnational level
√ retail & wholesale prices of major commodities in major markets
√ agricultural wage rate and non-agricultural wage rate
√ remittances, private transfers, public intervention, programs and safety nets

√ macro-economic factors and trade policies (including consumer price index, exchange rate, tariff, population)

KEY output indicators for interventions

The model generates estimates of the impacts on key livelihood variables as listed below:

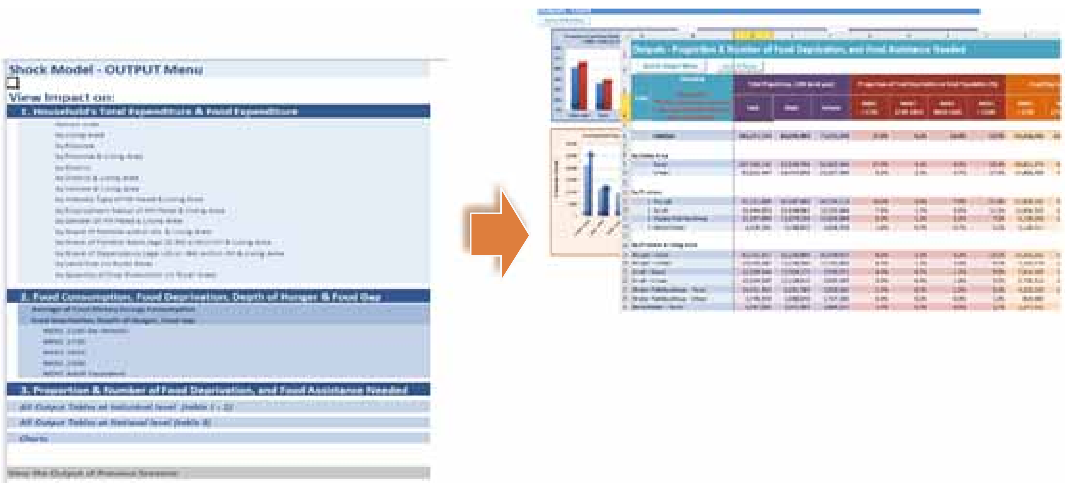
- proportion of people consuming less than a specified level of dietary energy consumption (DEC) (i.e. below a specified threshold);
- number of people who need food assistance after shocks;
- depth of hunger (kcal/person/day), i.e. deficit in absolute terms between the average DEC of the needy population and the threshold level;
- gap of food needs (kg of cereal/person/year), i.e. cereal needed to meet the needs of the undernourished population;
- total food assistance needed to meet the needs (ton/year);
- agricultural assistance needs after shocks;
- indicators for gender/smallholder/MDG studies;
- changes in household income and expenditure;
- changes in agricultural production and food availability; and
- other indicators as requested.

Outputs display options

In the SISMod tool, the outputs are listed on the "OUTPUT tab" and presented in table and chart format for quick reference and use:

Output indicators by groups

For better targeting, the shock impacts at household level are aggregated by various groupings, and the outputs can be viewed by different population groups, including:



Grouping for geographical analysis for food distribution

- nationwide total
- by living area (Urban/Rural)
- by province (e.g. Pakistan: Punjab/Sindh/Khyber Pakhtunkhwa/Balochistan)
- by district (e.g. Pakistan: covering 82 out of 102 districts)
- by district & living area

Grouping by gender index for gender analysis

- by gender of household head & living area
- by index on the ratio of females within household & living area
- by index on the ratio of female adults (age 15-64) within household & living area
- by gender and marital status of household head

Grouping by production/land ownership size for smallholder family farming analysis

- by index on land size (operated)
- by index on per capita production quantity
- by index on per capita value of production sold

Grouping by income/income source for poverty analysis

- by income group & geographic area
- by industry type of household head & geographic area
- by employment status of household head & geographic area

Other groupings based on the objectives of the intervention program and policy analysis.

Applying the outputs

The model can be used for comprehensive situation analysis, simulation and monitoring of the impact of shocks on household livelihoods and food consumption. It can also generate values for estimated populations with food needs, which can be used in WFP operations and other interventions.

By regularly updating the time series data, the model can be used to monitor situations of changing market conditions. Such regular updates would enable the SISMod to be applied in crisis situations.

For policy purposes, the model can be used to deduce the effect of shocks in past situations and draw lessons for future shocks, in order to better understand how to target interventions to protect those at the greatest risk of loss of income and food consumption. The model is country specific; users will observe that the impact of shocks is largely context specific. Similar shocks in different parts of the country can lead to similar or different outcomes, depending on the type of shock, its magnitude and the profile of the household. The model can be run and compared with the results from other countries to better understand the need to tailor interventions and policy in food security to country needs.

The quantitative estimates supplied by SISMod can be used to support other impact assessments, such as the Household Economic Analysis or WFP and FAO emergency assessments.

Potential users

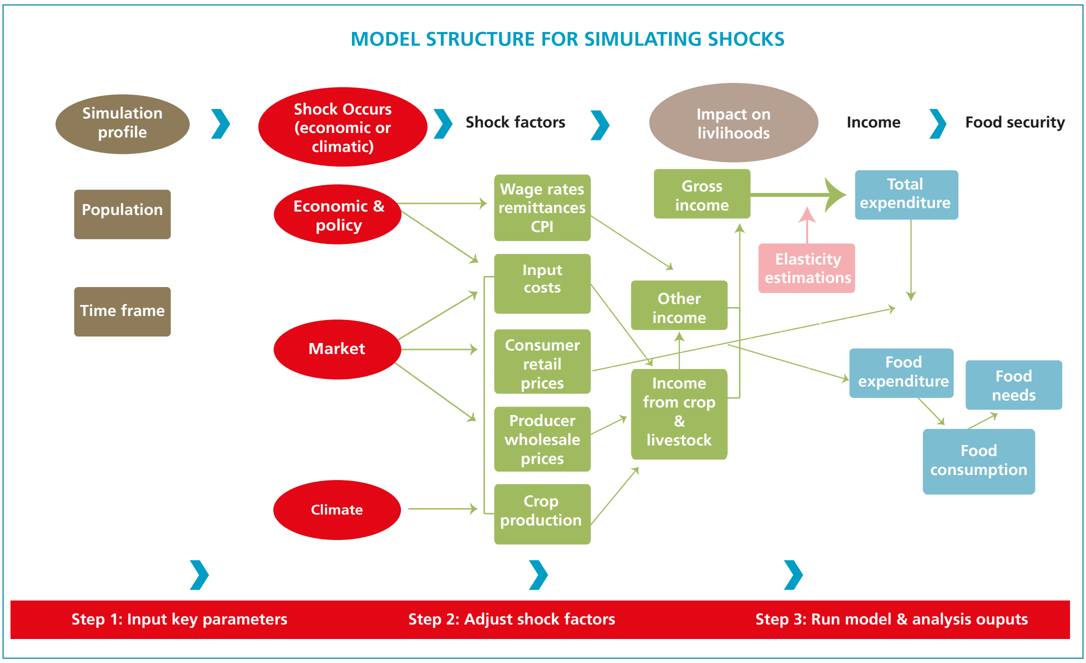
SISMod allows timely assessment of emerging issues by generating up-to-date subnational food security data, and simulates the outcome of different intervention/policy scenarios. This will be valuable to a wide range of potential users including WFP, FAO, and national/international aid bodies who carry out Food Assistance Interventions and Economic/Policy Analysis on:

- crop and food security assessments (e.g. CFSAM)
- rapid or emergency food security assessments after disasters and market shocks (e.g. EFSA)
- rapid market situation assessments (e.g. EMMA, MIFIRA)
- joint UN MDG assessments
- programme formulation activities (e.g. emergency operations, recovery and rehabilitation)
- disaster risk planning
- gender impact analysis
- smallholder and trade policy analysis

Structure of SISMod

The tool combines data sets from FAO, WFP, World Bank and national sources on key household/livelihood, economic, market and production data to model the effect of various key shock factors.

The conceptual model of SISMOD is shown in the following diagram:



What is the methodology used?

SISMod adopts the Agricultural Household Model (AHM) approach developed by Singh et al. (1986). The AHM incorporates both the production and consumption sides. It integrates the price effects on different markets and takes into account the interactions between them. The fundamental difference between an AHM and pure consumer model is that the household budget is generally assumed to be fixed in a pure consumer model, while in AHM it is endogenous, and depends on production decisions that contribute to income through farm profits in AHM. The traditional price effect is composed of the farm profits effect (as a producer), which adds a positive influence to the negative Slutsky effects on food demand (as a consumer). Similarly, other income factors such as remittance, wage rate and safety net/transfers have been modelled through household income equations.

The foundation of the SISMod analysis is built on a series of modules that take into account household income and expenditure, and estimates demand/supply/price transmission elasticities based on household survey data, national sources on food prices and other assessments. SISMOD works by linking together components such as market monitoring, crop production monitoring, the income generation module, a two-stage household budget allocation module, and changes in shock factors.

These modules track the changes in shocks factors based on either a) past patterns linked to the VAM or GIEWS monitoring systems, or b) forecasts based on a partial equilibrium model or short term price analysis. The household income module includes the following components: crop & livestock income, wage income, remittance income, and other income. To pass on the shock effects to income and then to total household expenditure, the household average propensity to consume (APC) is estimated by using household survey data.

The demand side module consists of a two-stage food demand system. The first stage allocates total household expenditure to broad groups of goods such as food, clothing, fuel, housing, durable goods, education, medical items, and other items. A nonlinear seemingly unrelated regression was used to estimate a linear expenditure system (LES) of equations for the first-stage budget allocation. In the second stage, the food demand equation for each food item is defined as a function of the real price of the commodity, real consumer expenditures per capita, and real prices of other foods.

The real price of the commodity is expected to be negatively related to food demand. The signs of the other two variables are ambiguous because expenditure elasticities can be positive or negative, and other foods can be substitutes or complements. The model bases these calculations on the national and subnational context where possible. Given the income and price elasticities, the percentage change in each food item consumed will be determined by the percentage change in price (own and cross price) and percentage change in income.

Deriving per capita dietary energy consumption: Food consumption in quantities is converted into dietary energy consumption by using energy conversion factors for energy-yielding macronutrients (protein, fat and carbohydrates). Food consumption is usually measured at the household level, so we define the household level quantity of food and the total dietary energy intake, measured in kilocalories per household. The changes in dietary energy consumption are given by the changes in food consumption.

Deriving Food Needs: The food energy gap refers to the condition of people whose dietary energy consumption is continuously below minimum dietary energy consumption needs for maintaining a healthy life and carrying out light physical activity. The minimum dietary energy consumption need for a specified age and sex group in the household is estimated, based on household members' age and gender.

SISMod also allows users to have additional options to establish different thresholds to run in the same analysis for different policy intervention objectives. The estimated additional food assistance needs as a result of shocks is measured as the cereal (e.g. maize) equivalent weight (kg).

(For a more detailed explanation of the methodology, please refer to Section Two of this book.)

How do you run the model?

The complete SISMod tool consists of two files:

a) Excel - SISMod_PAK_v1.xlsm and
b) Access - SISMod_PAK_v1.accdb

These files have to be saved in a specific folder: C:\FAO_WFP_ShockModel\Pakistan (i.e. a main folder FAO_WFP_ShockModel, with a subfolder Pakistan).

Microsoft Excel (2007 or above) and Microsoft Access (2007 or above) are required to run the model. Depending on computer processing speed, it may be necessary to close all other open files and programs, to ensure that the SISMod tool processes properly (because of its large database).

Users have to make an effort to familiarize themselves with the SISMod methodology in order to ensure that the data input is accurate, model outputs are accurately interpreted. The step-by-step instructions given in the user manual should be followed throughout the modelling excise. Three main steps are required to run the model:

1. Input key parameters:
   a) Users select the time frame (shock year) of the shock, define the boundaries of minimum dietary intake according to analysis or intervention need. Users also have to update or forecast the market and economic data series at subnational level or national level by using the modules and past data in the model.

b) The SISMod tool projects the population size for the shock year and computes shock factors based the data series inputted.

2. Adjust shock factors (optional):
   If users need to further adjust the shock factors to create scenarios, they have to input the percentage change from the baseline for each shock factor which is being modelled. Single or multiple shock shocks can be changed, depending on the scenario.

3. Run model and analyse outputs:
   a) Users trigger the running of the model by one-click.
   b) The SISMod tool simulates key livelihood and food security indicators reflecting shock impacts: income/expenditure, food expenditure, food consumption and food assistance needs, with options to account for livelihood, gender and geographical differences.

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Recent increases in global food prices, high frequency of natural disasters and political crises have had adverse effects on household food security. National and global methods for prompt assessments are weak in supporting timely responses to food crises in many developing countries. While many sudden-onset natural disasters leave little time for assessment and response, man-made disasters present even more challenges to conducting increasingly complex and in-depth analyses. Therefore, there has been an urgent need to develop an effective Early Warning System that signals potential shocks and allows a quick response to crises.

This book presents such a system developed jointly by FAO and WFP: a shock impact modelling system (SISMOD) that simulates the impacts of shocks on household income and food consumption and assesses the need for food assistance. SISMOD builds on existing nationally representative household survey data in Pakistan. This model reduces the need for in-depth nationwide assessments, which can then be limited to the most affected areas and populations. Geographic and community targeting is made possible as SISMOD provides estimates of the proportion of undernourished people by livelihood, income group and geographical area.

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