



United States
Department
of Agriculture

WHS-11L-01
January 2012



A Report from the Economic Research Service

www.ers.usda.gov

Long-Term Growth Prospects for Wheat Production in Afghanistan

Suresh Persaud, spersaud@ers.usda.gov

Contents

Introduction.....	2
Growth and Instability of Wheat Production.....	4
Consumption and Imports.....	9
Prospects for Afghanistan's Wheat Market.....	13
Conclusions.....	24
References.....	25
Appendix 1.....	28
Appendix 2.....	31
Appendix 3.....	33

Approved by USDA's
World Agricultural
Outlook Board

Abstract

Afghanistan has had success at achieving higher output for wheat, its key staple food and major crop. From 1990-2009, wheat production grew 3.5 percent per year, driven primarily by yield increases. However, given expected increases in demand, imports are likely to grow in coming years even if this production growth is sustained, suggesting growing dependence on supplies from Pakistan and other countries. For Afghanistan to achieve self-sufficiency in the next decade, more widespread use of improved seed and fertilizer on irrigated and rainfed wheat fields would have to be combined with sharp increases in irrigated wheat area—an unlikely outcome.

Keywords: Afghanistan, Pakistan, wheat, flour, production, consumption, imports, irrigation, yield, projections, model, elasticity.

Acknowledgments

Appreciation is extended to: Cheryl Christensen, Chief of the Food Security and Development Branch of USDA's Economic Research Service (ERS), and Mathew Shane, leader of the ERS Macroeconomics group, for their support and comments; John Dyck, and Maurice Landes of ERS for their thorough reviews; USDA's Foreign Agricultural Service (FAS) staff members Michael Ward and Michael Shean; Hans-Joachim Braun, Director of Global Wheat Program at the International Maize and Wheat Improvement Center (CIMMYT); Hamdy Oushy (New Mexico State University), Kevin McNamara (Purdue University); and Rajiv Sharma, Senior Scientist, Global Wheat Program, CIMMYT-Afghanistan, for their valuable suggestions and helpful comments.

Introduction

Afghanistan, strategically positioned between Central Asia, the Middle East, and South Asia, is a landlocked country where key threats to food security stem from weak transportation links that limit Afghanistan's access to international markets, coupled with a domestic agricultural sector that is inadequate for meeting food needs. In Afghanistan, wheat is a staple food, accounting for over half of the population's caloric intake on average (Chabot and Dorosh, 2007). Imports from neighboring countries have played a key role in stabilizing wheat and flour prices in Afghanistan. Although Afghanistan imports wheat from a number of neighboring countries, Pakistan has historically supplied more than half of these imports.

Afghanistan's location and heavy reliance on Pakistan for imported wheat leaves Afghanistan vulnerable to fluctuations in Pakistani supplies and trade policies. For example, in 2008 Afghanistan's food supply network broke down due to a confluence of events, including shortfalls in Pakistani and Afghan wheat production and Pakistan's bans on wheat and flour exports (Persaud, 2010). Given Afghanistan's landlocked position, its reliance on a small number of regional suppliers to meet import needs, and continuing uncertainties surrounding the reliability of these imports, this study focuses on the long-term prospects for expanding domestic wheat production.

Afghanistan has had some success at achieving higher wheat output. From 1990-2009 wheat production grew 3.5 percent per year, driven primarily by yield increases that reflect long-term agricultural assistance efforts by international organizations and the presence of functioning seed and fertilizer markets (table 1) (Maletta, 2007; Favre, 2004; Maletta and Favre, 2003). However, model-based simulations indicate that this production growth, even if sustained until 2020, will not outpace expected increases in consumption,

Table 1
Wheat area, yield, and production growth in Afghanistan

Period average	Area (1,000 ha)	Yield ¹ (mt/ha)	Production (1,000 mt)
1979-81	2,300	1.20	2,754
1989-91	1,623	1.06	1,725
2008-10	2,355	1.42	3,350
<i>Growth rates (percent)²</i>			
1980-90	-4.10	-1.30	-5.3
1990-2009	1.51	1.97	3.5
1980-2009	0.10	0.40	0.5

mt = metric ton.

ha = hectare.

¹Computed by dividing 3-year average of production by its respective 3-year average of area.

²Least squares growth rate.

Source: USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database, and author's calculations.

suggesting growing dependence on supplies from Pakistan and other countries. To achieve self-sufficiency in the next decade, more widespread use of improved seed and fertilizer on irrigated and rain fed wheat fields would have to be combined with improbably sharp increases in irrigated wheat area.

Growth and Instability of Wheat Production

With mountainous terrain comprising roughly three-quarters of Afghanistan's land area and an arid to semi-arid climate, arable land in 2008 amounted to 7.794 million hectares or approximately 12 percent of the country's area (FAO, 2011). Most of Afghanistan's agricultural and irrigation development occurs along the country's few fertile valleys, which are formed by rivers extending from the Suleiman and Karakoram mountains and the Hindu Kush range (Rout, 2008). The vast majority of Afghanistan's wheat area and production is located in the northern plains bordering Turkmenistan and Uzbekistan (USDA, 2008).

During the main growing period there is little, if any, reliable rainfall, meaning that Afghanistan must depend on irrigation to meet the majority of its crop water requirements. Winter snowfall in the mountain ranges of central Afghanistan supplies over 80 percent of the country's annual precipitation (USDA, 2008). The primary storehouse of the country's irrigation water is in the Hindu Kush range (Rout, 2008). Snowmelt in the spring is the major source of irrigation water, running through rivers and streams that originate in the mountains. Given the absence of sufficient rainfall during the critical growing period, the timing and duration of annual snowmelt is a key factor in determining the volume of irrigation water and the length of time that it is available (USDA, 2008).

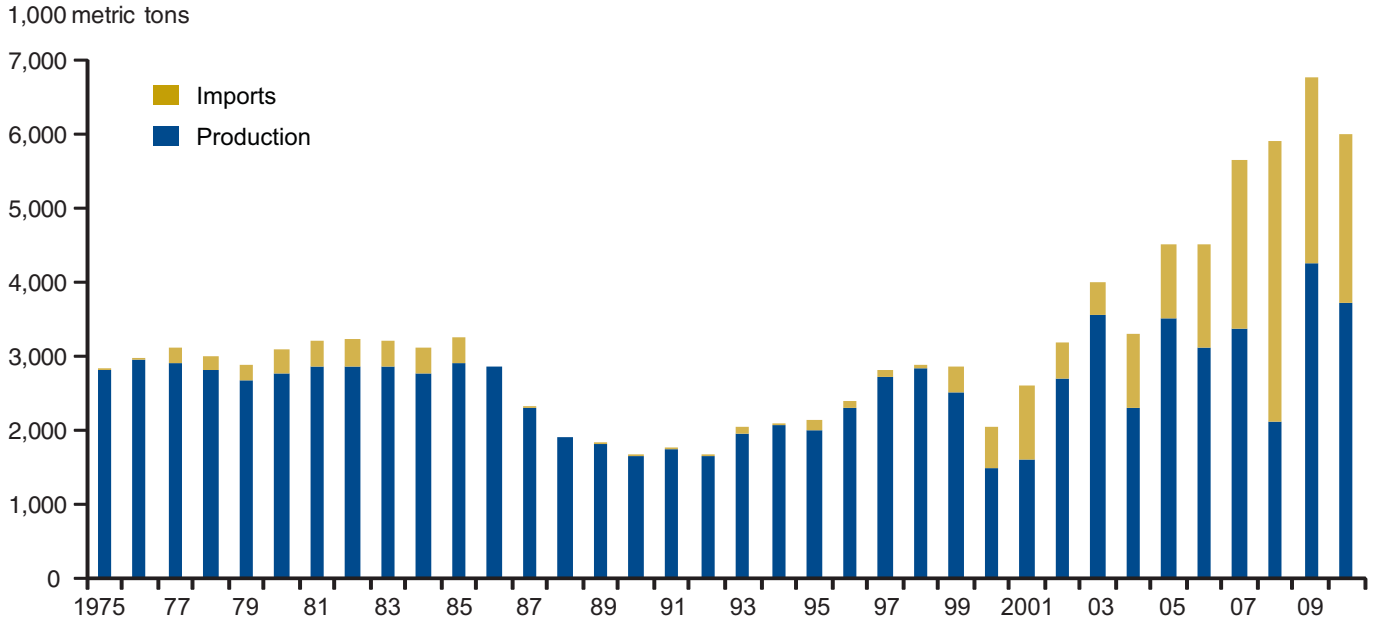
Uneven Historical Trends

In 1976 Afghanistan harvested 2.94 million metric tons (mmt) of wheat from about 2.4 million hectares (ha) of land, implying a yield of 1.23 mt/ha. Production remained stable for about 10 years thereafter, and then deteriorated sharply beginning in 1987 (fig. 1). Yield and area planted to wheat contracted, and by 1992 Afghanistan's wheat output was little more than half of its 1976 level (fig. 2). Grain production deteriorated due to the combined effects of prolonged droughts and the destruction of irrigation networks and infrastructure during years of conflict, first between Afghan and Soviet forces and then during the civil war that followed the 1989 Soviet withdrawal.

Wheat production trended upward from 1993-99, driven primarily by strong gains in yield. At 1.3 mt/ha in 1998, yield was at a then historic high in Afghanistan. However, throughout the 1993-99 period, the quantity of wheat harvested never exceeded the 1976 peak due to relatively slow growth in area cultivated to wheat. Moreover, these production gains proved to be fragile. Successive droughts in subsequent years led to substantial crop shortfalls in irrigated as well as rain-dependent areas, particularly in 2000 and 2001 when wheat production reached new lows, falling below the 1992 level.

Growing conditions were relatively favorable between 2002 and 2007. In 2003 production finally surpassed the earlier 1976 peak. The 2003 wheat harvest was estimated to be 3.55 million metric tons, a level that Afghanistan achieved again in 2005 and approached in 2007. These production peaks were achieved primarily as a consequence of higher yields. Throughout the

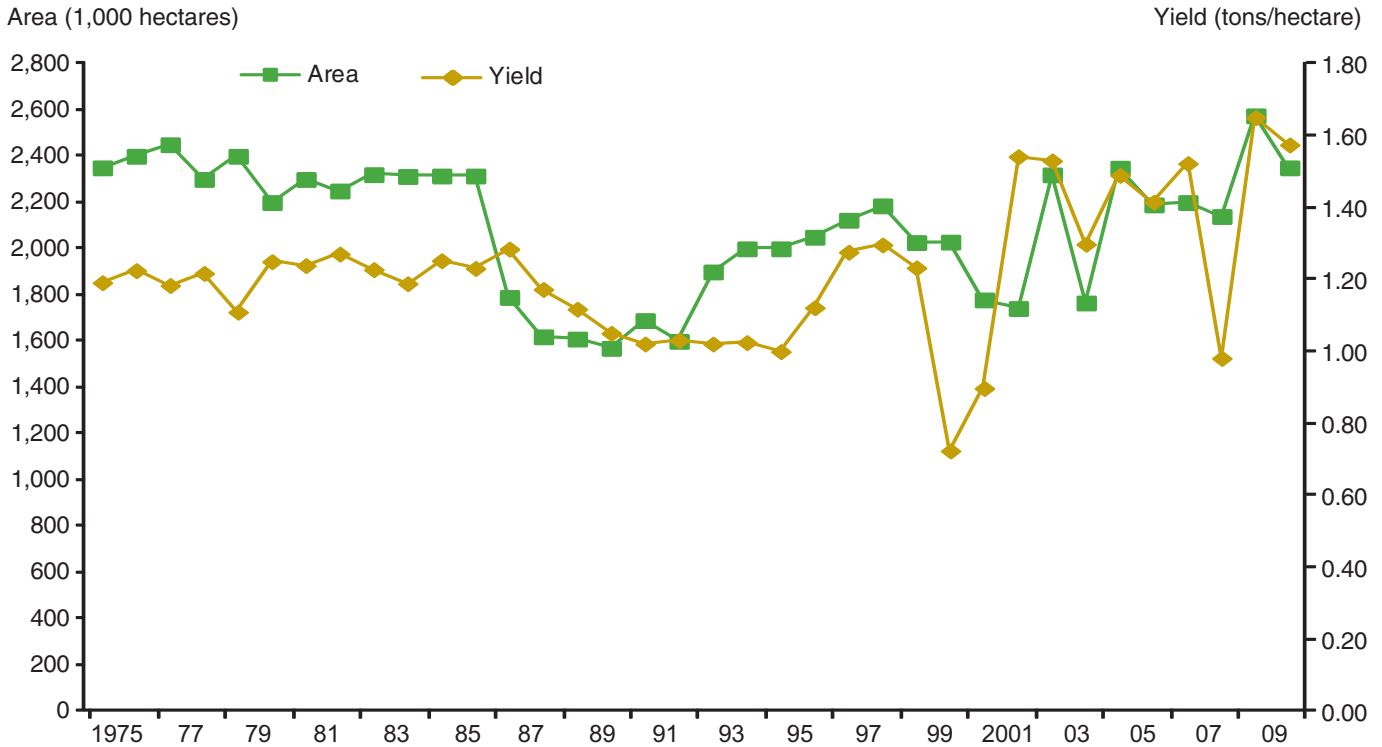
Figure 1
Wheat and flour supply in Afghanistan



Notes: Includes flour imports expressed in wheat equivalent. One ton of wheat converts, with some variation, to approximately 0.74 tons of flour. Data are on a marketing-year basis; 2008 refers to July 2008–June 2009.

Source: USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database.

Figure 2
Wheat area and yield in Afghanistan



Notes: Data are on a marketing-year basis; 2008 refers to July 2008–June 2009.

Source: USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database.

2002-07 period, there was no year in which estimated area planted to wheat exceeded the mid-1970s level. Yield, on the other hand, reached a new high in 2007 at 1.52 mt/ha, which was significantly above the previous 1998 peak (1.3 mt/ha).

The years of favorable wheat harvests were followed by below-average levels of rain and snow during the 2007/08 wet season, which reduced Afghanistan's 2008/09 wheat crop to 2.1 million metric tons.

Excellent growing conditions allowed Afghanistan's wheat crop to rebound in 2009/10 to a record 4.3 million tons. Yield rose to a new high of 1.65 tons per hectare, a 68-percent increase over the previous year, and significantly above the previous 2007 peak (1.52 mt/ha). At 2.6 million hectares in 2009/10, area planted to wheat finally rose above the 1976 level. Growing conditions have continued to be favorable and USDA forecasts that 2010/11 wheat production and yield will be 3.7 million tons and 1.57 tons per hectare, respectively (USDA, 2011).

Efforts To Raise Wheat Yields

The growth in wheat yields reflects long-term efforts at seed development and availability in Afghanistan supported primarily by the United States Agency for International Development (USAID), the Food and Agriculture Organization of the United Nations (FAO), and the International Center for Agricultural Research in the Dry Areas (ICARDA). These yield increases also demonstrate that seed and fertilizer markets have continued to exist and function, albeit with significant disruptions and under a great deal of adversity (Maletta, 2007; Favre, 2004; Maletta and Favre, 2003). This has allowed yield to reach a number of new highs when favorable growing conditions occur.

International organizations developed contracting arrangements with Afghan farmers to achieve the adoption of higher yielding seed varieties. These arrangements created demonstration-effects, allowing neighboring farmers to observe and gauge the impacts of adopting new seed varieties, while also facilitating farmer-to-farmer exchanges (Favre, 2004). These demonstration effects likely encouraged the adoption of higher yielding seeds through market-based mechanisms and supply chains.

Available information from the 2001-02 season indicates that wheat farmers in irrigated areas relied to a significant degree on markets to obtain seed (Maletta and Favre, 2003). In 2003, 58 percent of the seed planted was the farmers' own (saved) seed¹; approximately 40 percent was purchased in local bazaars, and the remainder was obtained from other sources such as humanitarian organizations. Similar results were found in rainfed wheat areas, where the farmers' own (saved) seed and bazaars provided 43 percent and 53 percent, respectively, of the wheat seed planted. In the irrigated wheat subsector, the data show a replacement rate of 39 percent for seed, which suggests a willingness on the part of Afghan wheat farmers to take risks to raise yield and hence production through a process of rapid adoption of improved seed (Favre, 2004).

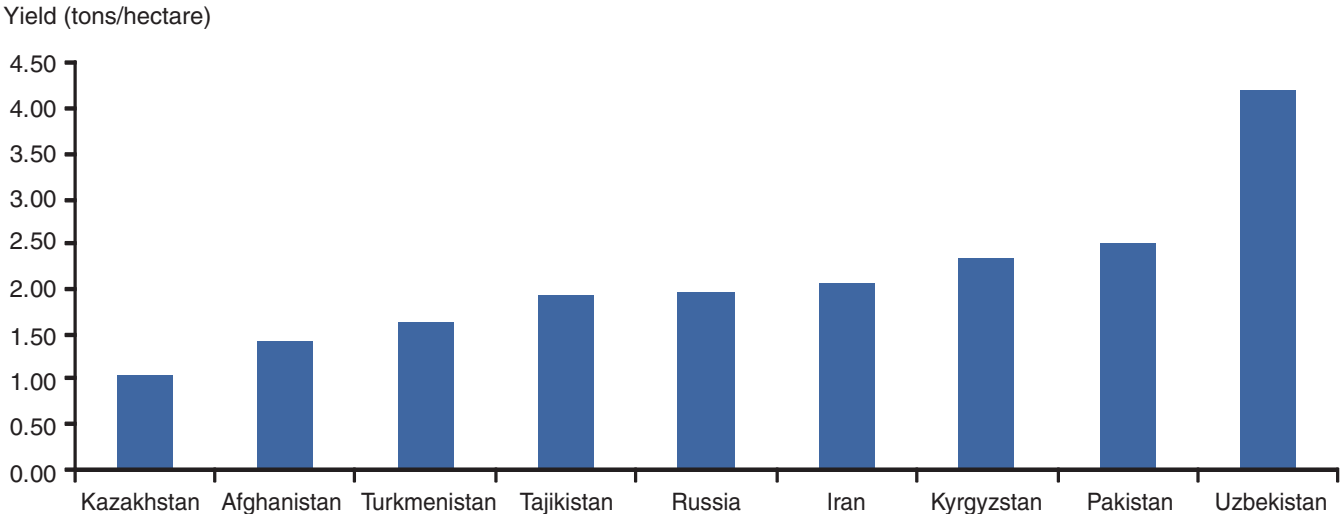
¹Farmers also retain wheat for household subsistence.

Total fertilizer use on all crops just before the Soviet invasion in 1979 is estimated at only about 50,000 mt (or roughly 20 kgs/ha). In recent years, however, the use of fertilizer has become widespread in irrigated wheat areas, with a national average of 179 kg per fertilized hectare of irrigated wheat in 2001-02. The 78 percent of surveyed farmers who used fertilizer on irrigated wheat, typically consisting of urea in the spring and diammonium phosphate (DAP) in the autumn, applied a total of 187,000 mt. This growth in nutrient application was fostered by private traders who sell imported fertilizer throughout the country in the absence of Government programs. The growth underscores the key role of markets in supplying agricultural inputs, despite chaotic, war-torn conditions (Favre, 2004). Fertilizer use continued to grow, by almost 50 percent, to 300,783 mt in 2003 (Roy, 2003).

The fertilizers used in Afghanistan are mainly urea and DAP, and to a lesser extent mono ammonium phosphate obtained from Iran. Afghanistan’s demand for DAP is met through imports from the United States, Australia, China, and Pakistan. Fertilizer from the United States and Australia tends to be shipped first to Pakistan, where it is repackaged and then sold to Afghanistan. Although Afghanistan imports urea from a number of countries, including Tajikistan, Iran, Uzbekistan and Saudi Arabia, the major supplier is Pakistan. Afghanistan’s relatively high prices attract shipments of urea and DAP from Pakistan. The Government of Pakistan’s fertilizer subsidies, including those that seek to cap domestic Pakistani prices, may be a factor contributing to cross border movements (Husain and Gilroy, 2009).

Although functioning markets for seed and fertilizer have allowed growth in yield and output, at 1.4 mt/ha (2002-09 average), Afghanistan’s yield is still low relative to most other countries in the region (fig. 3). Moreover, the historical performance of Afghanistan’s wheat production sector reveals its sensitivity to variations in weather and precipitation. The destruction and continuing disrepair of the country’s irrigation systems, aside from exacerbating the impact of adverse growing conditions, likely also explain the

Figure 3
Wheat yields in Afghanistan and in neighboring countries (2002-09 average)



Sources: USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database.

negligible growth in wheat area, which in turn constrained growth in output. Consequently, imports of wheat and flour have played a key role in fostering the growth and stability of Afghan consumption.

Consumption and Imports

Household surveys demonstrate the centrality of wheat in Afghan food consumption patterns, as wheat accounts for approximately 60 percent of total caloric intake (Government of Afghanistan, 2003). Indeed, the majority of the poor in Afghanistan rely largely on fresh bread and green tea for breakfast and lunch. At 186 kilograms per person per year (2002-09 average), per capita consumption of wheat in Afghanistan was below neighboring countries such as Turkmenistan, Uzbekistan, and Iran but significantly above Pakistan (fig. 4).² However, considerable uncertainty surrounds estimates of Afghanistan's population and consumption, implying that per capita consumption figures are likewise uncertain (see appendix 3).

Apparent per capita consumption of wheat has grown rapidly in recent years, increasing 7.4 percent per year from 2002-09 despite double-digit growth (11 percent) in real flour prices (fig. 5).³ Afghanistan's economy expanded rapidly over this period—official real (adjusted for inflation) gross domestic product per capita grew at an annual rate of 7.3 percent (IMF, 2010).⁴ Growth in wheat consumption cannot be attributed completely to rising income. Rehabilitation of the country's infrastructure and marketing channels allowing increased flows of grain into remote areas, combined with a relatively stable macroeconomic environment, have also fostered an upward trend in wheat consumption.⁵ Rising incomes are expected to lead to dietary diversification in Afghanistan (Maletta, 2007), and current levels of consumption are already high. Future growth in consumption may not be as rapid as in the past decade.

Role of Wheat Trade

Given the wide fluctuations in Afghanistan's wheat production, imports have helped to stabilize consumption levels and meet the food needs of

²Per capita consumption is approximated as (total domestic consumption—feed & residual) / population.

³In response to the 2007/08 price spikes, D'Souza and Jolliffe (2010) found that households shifted away from meat, fruits, and vegetables toward staples like wheat as a means of buffering the shock to their caloric (energy) intake. In urban areas, the authors found evidence of Giffen behavior, i.e., increases in demand in the face of price increases.

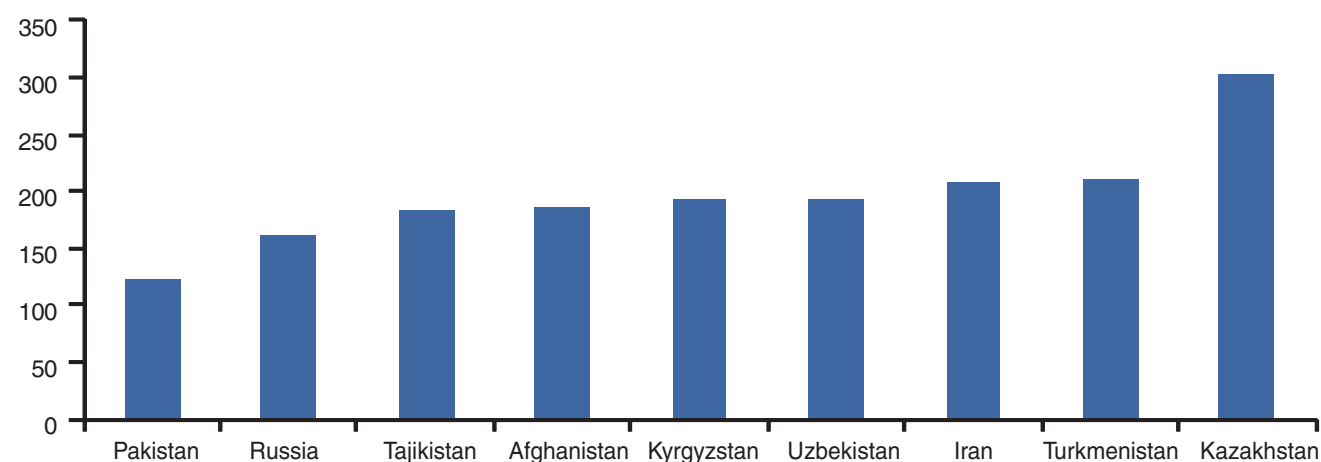
⁴This figure excludes Afghanistan's opium crop sector.

⁵The prices of food commodities that substitute for wheat may have also exhibited an upward trend, thus discouraging consumers from shifting away from wheat.

Figure 4

Wheat consumption in Afghanistan and in neighboring countries (2002-09, average)

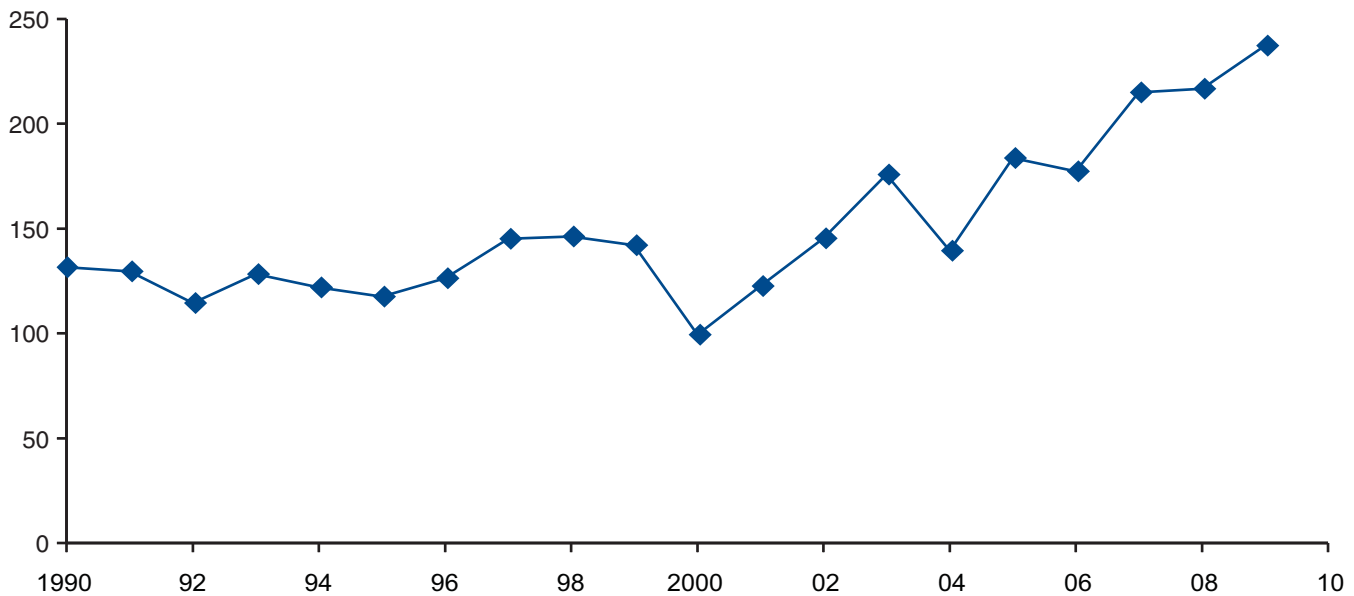
Consumption (kilograms/person)



Sources: USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database; and UN FAOSTAT database.

Figure 5
Per capita consumption of wheat in Afghanistan

Consumption (kilograms/person)



Sources: USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database; and UN FAOSTAT database.

Afghanistan’s growing population (see figure 1). Based on a measure of temporal variability known as the coefficient of variation, Afghan production has been three and a half times more variable than consumption, as imports have partially offset poor domestic harvests due to droughts, thereby dampening fluctuations in Afghan consumption (Persaud, 2010).

Afghanistan is a landlocked country, bordered on the west by Iran, on the south and the east by Pakistan, and on the north by Turkmenistan, Uzbekistan, and Tajikistan. Afghanistan imports wheat and flour from a number of neighboring countries. However, with a shared border of 1,600 kilometers and a long history of trade, Pakistan is the dominant supplier of wheat to Afghanistan. The private millers and traders of Pakistan work closely with Afghan traders (Khan, 2007). Pakistani wheat flour is widely accepted by Afghan consumers because of its quality, and Pakistani mills extend credit to Afghan traders seeking to purchase flour (Schulte, 2007; Khan, 2007).

Links to Pakistan Market

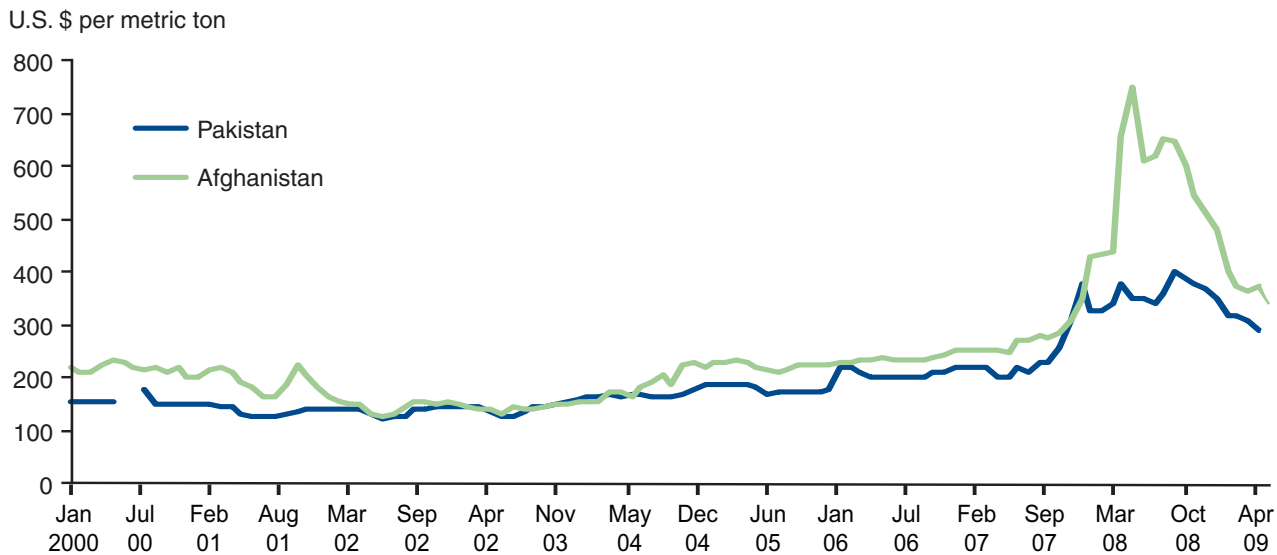
The Government of Pakistan has implemented price policies aimed at improving the availability of food for its population (Dorosh and Salam, 2006). The Government intervenes in domestic wheat markets by procuring wheat from farmers at a support price. The Government also releases wheat to the provinces, which is sold to the flour mills at a Government-determined “issue” or “release” price (USDA, 2009). These interventions, which tend to involve sales of wheat to flour mills at below-market rates, generate profits for millers while also incurring fiscal costs for the Government because the issue prices do not cover the full cost of procurement (domestic or imported), storage, and handling (USDA, 2009; Dorosh and Salam, 2006). The growth

of Pakistan's flour mills has been concentrated in provinces neighboring Afghanistan, and a large number of Pakistani mills operate only when they are able to purchase subsidized wheat from their Government (Khan, 2007). Pakistani traders have incentives to move flour into relatively high-priced nearby markets, thus providing strong competition for Afghan millers.

Since Pakistan is a major player in the Afghan grain market, wheat prices in Pakistan and Afghanistan tend to move in the same direction. Using monthly data for January 2002 through June 2005, Chabot and Dorosh (2007) conducted formal econometric tests to explore issues of (1) market integration between major markets within Afghanistan, and (2) market integration between Pakistani and Afghan markets. Cointegration results suggest that wheat prices in major markets in Afghanistan and in Lahore, Pakistan, tend to move together in the long run (Chabot and Dorosh, 2007). Changes in Pakistan's Government-fixed release or issue prices, to the extent that they influence market prices of wheat within the Pakistani market, would also shape prices that prevail in Afghanistan. Indeed, from 1999-2009, the real issue price of wheat in Pakistan and the real retail price of wheat in Afghanistan are well-correlated (correlation coefficient = 0.91), implying that shifts in Pakistan's price policies impact Afghan consumers.

In addition to Pakistan's price policies, its trade policies and domestic supply situation have influenced Afghan wheat prices. Although wheat price changes in these two countries have, over the years, generally been similar in terms of directionality, the gap between Afghan and Pakistani wheat prices increased sharply in 2008 (fig. 6). Afghanistan's food supply network broke down due to a confluence of events, including shortfalls in Pakistani and Afghan wheat production and Pakistan's bans on wheat and flour exports (Persaud, 2010).

Figure 6
Prices of wheat in Afghanistan and Pakistan



Notes: Pakistani wheat prices are Peshawar retail prices; Afghan wheat prices are simple averages of prices from Kabul, Jalalabad, Mazar, Faizabad, Hirat, and Kandahar.

Sources: Pakistan's wheat prices are from Government of Pakistan, *Monthly Review on Price Indices* (various issues). Afghan wheat prices are from the U.N. World Food Programme's *Price Analysis in Afghanistan* (World Food Programme, 2011).

As supply disruptions eased, Afghan-Pakistani price gaps decreased after May 2008.

More recently, Pakistan experienced large-scale flooding after unusually heavy monsoon rains that began at the end of July 2010. This latest shock to Pakistani agriculture is not an immediate threat to Afghan food security due to a combination of relatively abundant Afghan supplies, the availability of imports from Kazakhstan, and notably, Pakistan's high levels of wheat stocks that allow Pakistan to continue exporting. Also, despite the severe flooding, Pakistan's 2010/11 wheat crop is estimated at 23.9 mmt, only slightly below the previous year's (2009/10) record wheat production of nearly 24.0 mmt. In December 2010 the Government of Pakistan removed its ban on exports, allowing private traders in the country to export up to 1.0 mmt of wheat. The decision to lift the export ban will likely result in increased exports to Afghanistan (USDA, 2010).

Significant future growth in Afghan wheat consumption is likely, if domestic production and Pakistani policies support such growth. We expect population to grow at an annual rate of 2.25 percent through 2020, in line with Maletta (2007). Real GDP is projected to grow 6.94 percent per year from 2009-14, consistent with a recent International Monetary Fund Country Report (IMF, 2010). Population and income growth rates of these magnitudes raise the question of whether domestic production of wheat will keep pace with consumption, or whether Afghanistan will experience a widening gap between demand and domestic supply.

Prospects for Afghanistan's Wheat Market

Afghanistan's agricultural potential is limited by its predominantly mountainous terrain and arid to semi-arid climate. Nevertheless, further increases in wheat production and productivity are possible.

Water and Irrigation

Afghanistan's water resources include an estimated 75 billion cubic meters (bcm) of potentially available renewable water resources annually, comprised of 57 bcm of surface water and 18 bcm of ground water. Given the country's low precipitation, ground water supplies are recharged mainly by surface water. Although agriculture is the primary user of water, accounting for approximately 93 percent of Afghanistan's actual total water use, irrigation consumes only about 20 bcm per year—far less than the country's potentially available annual renewable water resources (75 bcm) (Ahmad and Wasiq, 2004).

The U.N. Food and Agriculture Organization estimates that 7.794 million hectares of Afghan land were arable in 2008 (FAO, 2011). However, given the country's relatively low and variable rainfall, irrigation is critical—approximately 85 percent of the total agricultural output and 70 percent of wheat production are supplied by irrigated areas. Afghanistan's potential irrigable area is about 5 million hectares, well above the currently developed area of about 2.6 million hectares (ADB, 2003).

The relatively modern, formal river-diversion structures that were built in the 1960s and 1970s in Afghanistan account for only 15 percent of the total irrigated area. Traditional systems that employ informal river-diversion structures maintained by the users account for about 55 percent of the total irrigated area, while traditional systems that are based on natural springs account for the remaining 30 percent. The very low efficiency rating of these irrigation systems (about 25 percent) indicates substantial room for reducing water wastage and increasing the irrigated area.⁶ Aside from damage resulting from conflicts and lack of maintenance, salinity and water logging problems affect a number of the more modern systems and larger traditional systems (ADB, 2003).

Mainly because of unpredictable water availability that has been exacerbated by years of military conflict, in 2009 only 3.2 million hectares, or less than half of the land that could be used for crops, was actually cultivated. Since only 3 of Afghanistan's 34 provinces have fully operating irrigation systems in place (Torell and Ward, 2010), cropped area may grow as a consequence of investments aimed at rehabilitating existing irrigation networks, without the necessity of building new dams (Maletta, 2007). Additions to cropped area, being irrigated land, would be expected to provide relatively high yields.

However, efforts to exploit water resources may lead to conflict among Afghan communities. Water is a shared resource, and projects that are designed to harvest water in one location may reduce its availability in adjacent farming communities. In addition to the lack of technical and financial resources, the issue of water rights has been a complicating factor in the

⁶Despite being a useful metric, irrigation efficiency, defined as the ratio between the estimated irrigation water requirements and the actual irrigation water withdrawal, does not account for the possibility that unused water can help recharge aquifers (FAO, 2004).

development of Afghanistan's surface-water irrigation systems (Rout, 2008). Land has remained idle, not only as a consequence of physical damage to canals, but also as a result of shortcomings in water management, depriving some farmers of access to water (Maletta, 2007).

Moreover, programs to harness Afghanistan's rivers may also generate tensions with neighboring countries, to the extent that such investments reduce the flow of water to adjacent countries that share the same river basin with Afghanistan. Afghanistan's three major watersheds include (1) the Helmand River, flowing from the southern slopes of the Hindu Kush and proceeding southwest to the Sistan Basin in Iran; (2) the Kabul River, which begins in the southeastern Hindu Kush and moves south through the city of Kabul, before turning east and joining the Indus River in Pakistan; (3) the Amu Darya, which begins on the northern slopes of the Hindu Kush. The Amu Darya basin is notable in that it extends into the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan, as well as Afghanistan (Ahmad and Wasiq, 2004). Large-scale investments aimed at actualizing Afghanistan's irrigation potential may in some cases require treaties with affected downstream countries.

Although farmers have responded to limited access to surface water by digging wells, ground water is a critical, and, for many households, the sole source of drinking water. Water tables in Afghanistan are already falling, requiring deeper wells. Shifts toward greater agricultural usage of ground water is risky and will likely come at the cost of human consumption (United Nations, 2008).

Given the difficulties and the potential for conflict that are associated with expanding the country's irrigation sector, imports of wheat have played an important role in allowing Afghanistan to compensate for its own domestic constraints on water availability. Water, a fundamental input for crop production, is embedded in agricultural products—trade in agricultural commodities can be viewed as a virtual flow of water from producing and exporting countries to importing countries. Thus, arid and semi-arid countries can achieve welfare improvements through food imports, while reducing potential competition among neighboring countries that share the same river basins.

Yield Potential

Observations of farmers who have adopted improved inputs, as well as evaluations of emergency programs that distribute fertilizer and improved seed, provide a rough indicator of the potential for increasing wheat productivity in Afghanistan.

Almost 20 years ago, the Swedish Committee Agricultural Survey estimated that yields from improved seed varieties ranged from 2.98 mt/ha in the Northwest to 3.47 mt/ha in the East Central region in 1993 (Swedish Committee for Afghanistan, 1993). A key point is that these were actual observed yields obtained by farmers and not experimental or expected yields. Since 1993, newer varieties of improved seed with even higher yields have been introduced. In 2001-02 and 2002-03 improved seeds yielded 3.0-4.0 mt/ha on average. Depending largely on soil quality as well as factors such as the availability and use of water and fertilizer, many Afghan

farmers achieved yields that were substantially higher than the average, e.g., yields in the range of 5.0-5.75 mt/ha (Maletta and Favre, 2003).

FAO distributed improved seed as part of its Agricultural Emergency program for the 2002-03 agricultural year and the result was an average yield of 3.30 mt/ha among program beneficiaries, who were mostly poor small farmers (Mollet, 2003).

Operating through nongovernmental organization (NGO) partners, the International Center for Soil Fertility and Agricultural Development (IFDC) and the International Center for Agricultural Research in the Dry Areas (ICARDA) provided fertilizer and improved seed to Afghan wheat farmers in an emergency distribution program. This program, which reached approximately 200,000 farmers in 13 provinces, entailed the distribution of about 15,700 mt of fertilizer for wheat in the spring and fall of 2002 and in the spring and summer of 2003. A combination of favorable weather conditions, the availability of fertilizers (mainly urea and DAP), and improved seed resulted in average wheat yields of 4 mt/ha with a considerable degree of variability around the average.

Estimates of incremental yield indicate that 15,700 tons of fertilizers provided an additional yield of 78,500 tons of wheat, i.e., 1 kg of fertilizer was associated with an additional 5 kg of wheat (Gregory, 2006). A great deal of caution is warranted if the objective were to generalize this incremental yield estimate beyond the recipient farmers and beyond the window of time in which the program was implemented. The estimated relationship between additional fertilizer and yield gain is conditional upon factors such as soil quality, weather conditions, and farmers' skill and knowledge. However, this fertilizer and seed distribution program did cover 13 agriculturally important provinces, and the average realized yield of 4 MT/HA is consistent with results noted earlier in this report (Gregory, 2006).

Oushy (2010) suggests that wheat yield can be increased by improving and diversifying crop rotations beyond the typical wheat/rice or wheat/corn cycle, thereby sustaining soil properties and productivity. These commonly used crop rotations have resulted in deteriorating soil condition and properties, including lower fertility, diminished organic matter, lower soil water-holding capacity, salinity, and weed and disease invasion (Oushy, 2010).

Moreover, since less than half of Afghanistan's wheat area is sown to high-yielding varieties, the average yield for the country as a whole will trend higher as the use of superior seed becomes more widespread. This will entail exploiting the genetic potential of existing seeds that are already available for use, rather than developing different strains. When new seed varieties were used in 2002-03, average wheat yields for irrigated fields were about 3 mt/ha (peaking at more than 6 mt/ha in some locations), while for rainfed areas the average was 1.1 mt/ha with peaks up to 3 mt/ha. These figures could understate yield potential—it is important to note that seeds classified as higher yielding include older strains as well as improved seeds that exhibit declining yield as a consequence of having been genetically contaminated by inbreeding with other varieties.

Projections to 2020

In the longer term, domestic wheat production in Afghanistan could expand significantly with greater use of improved inputs. However, even with dietary diversification tempering demand growth, wheat consumption could also grow significantly, propelled by strong growth in population, as well as improvements in marketing chains that connect consumers to domestic and external supplies of food.

It is not possible to project the prospects for Afghanistan's wheat market with certainty, given the impossibility of accurately forecasting the future growth of income, population, and food prices, and the unpredictable pace of improvements in technology and irrigation. Accordingly, we develop a quantitative framework that is capable of analyzing a range of different time paths and/or growth rates of key drivers of supply and demand. Specifically, we evaluate the likely role of yield growth and area expansion in the future growth in supply, and in meeting Afghan wheat demand using a multiyear simulation model (see box, "Characteristics of the Simulation Model").

Overview of Scenarios

Based on different scenarios of future growth of Afghanistan's wheat yields, we develop projections through 2020 of Afghanistan's domestic wheat production, imports, and consumption. The three scenarios considered in the model are similar in a number of ways. In all scenarios, for the 2010-20 period, real GDP grows at an annual rate of 6.0 percent (table 2). (By way of comparison, *IMF Country Report* (2010) predicts that real GDP will grow in the range of 6 to 7 percent per year for 2009-15.) Afghanistan's population grows at annual rate of 2.3 percent as in Maletta (2007). Stocks of wheat and flour are assumed to be negligible. The Afghan-Pakistani border remains porous, and moreover, neither Afghan nor Pakistani trade policies hinder wheat trade, implying that trade is based on Afghan demand and relative prices. Throughout the projection period, the prices of wheat and flour in Afghanistan track Pakistan's release price, which in turn moves in

Characteristics of the Simulation Model

The analytical framework incorporates behavioral relationships for consumption and area cultivated to wheat. Farm production of wheat in Afghanistan is an identity, computed as the product of area and yield. Similar to the USDA Baseline models, wheat area is specified as an increasing function of the expected returns from its cultivation, where the lagged wheat price and lagged yield represent expected returns. Yield growth is driven by various trend terms that represent differing rates of improvements in technology and irrigation. Consumption of flour (on a wheat-equivalent basis) is a function of income, population, and the own-price, i.e., the price of flour. Stocks are assumed to be zero. Imports are computed by subtracting domestic production from consumption, where all variables are on a wheat-equivalent basis. Pakistan's release price of wheat influences both wheat and flour prices in Afghanistan.

A more complete description of the model, including the model parameters, is given in appendix 1 and the equations are provided in appendix 2.

Table 2

Major Afghan wheat model analytical assumptions

Variable	Reference	High yield	Self-sufficiency
	<i>Percent</i>		
Population growth	2.25	2.25	2.25
Real Gross Domestic Product growth	6.00	6.00	6.00
Yield growth	0.90	1.97	5.50

Source: USDA, Economic Research Service.

lockstep with projections of Pakistan's government producer price generated by the USDA Baseline (USDA, 2011). Afghan wheat production does not rise rapidly enough to exert downward pressure on domestic flour prices in any scenario, i.e., Afghan flour prices do not fall below the margin-adjusted Pakistani release price. Since consumers face an identical price vector in all scenarios and income growth is the same in all cases, projected wheat consumption does not differ from scenario to scenario.

The critical distinctions among the three scenarios are that they incorporate different assumed rates of yield growth. In the Reference case (Scenario I), yield grows at an annual rate of 0.9 percent, which matches the projected yield growth for Other Asia & Oceania generated by the USDA Baseline (USDA, 2011).⁷ For perspective, this 0.9 percent rate of increase is above Afghanistan's 1980-2009 annual yield growth of 0.4 percent shown in table 1, but less than half of the country's more recent 1990-2009 annual yield growth of 1.97 percent. In Scenario II, yield continues to increase at its post-1990 rate of 1.97 percent per year to 1.91 mt/ha in 2020. Scenario III, for illustrative purposes, indicates the types of production and productivity advances that would likely be necessary for Afghanistan to eliminate its reliance on imports.

The model replicates the base year levels of Afghan wheat area, production, imports, consumption, and prices. The base year for the projections is 2010. The prior year is not an appropriate choice for the base period because the 2009 figure for apparent per capita consumption of wheat is an outlier—apparent consumption per person spiked to 237 kgs per person in 2009 (fig. 7). The consumption data are uncertain, as data on stocks are not available. Nevertheless, an advantage of using a 2010 base is that consumption for that year is more consistent with the recent historical trend, whereas a 2009 base amounts to starting the projections from an extreme observation. However, in evaluating the projections, it is changes relative to the base year—as well as the relative differences between the various scenarios—that are relevant. Moreover, the scenarios presented herein are neither forecasts nor predictions.

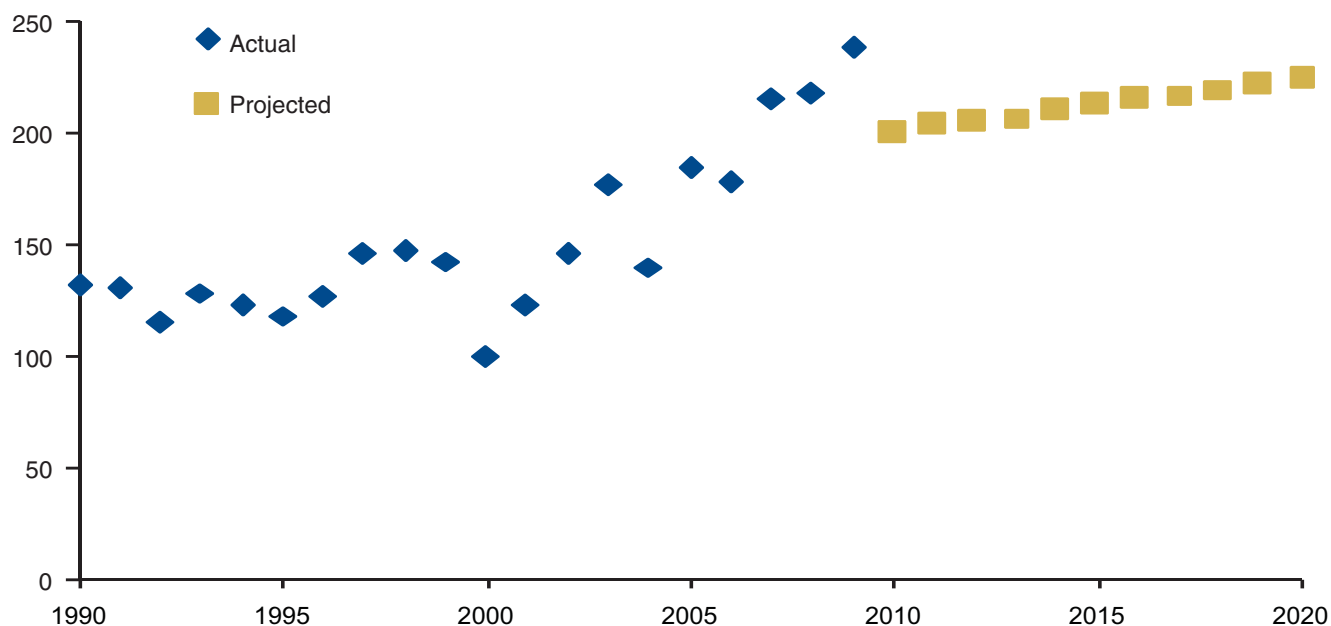
Scenario I: Reference

Afghan domestic prices of wheat and flour, which are shaped by Pakistan's government-determined release price, exhibit almost no growth in real terms from 2010-20 (table 3). On a wheat equivalent basis, per capita flour demand (consumption per person) grows 1.2 percent per year over the same period,

⁷USDA's Baseline includes Afghanistan in the Other Asia & Oceania region.

Figure 7
Projected per capita consumption of wheat (all scenarios)

Kilograms per person



Sources: 1990-2010 data are from USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database. ERS model replicates 2010 data; 2011-20 figures are results of ERS model.

due to a combination of growth in per capita GDP of 3.7 percent per year and stability in flour prices. Total demand, as distinct from per capita consumption, increases at an annual rate of 3.5 percent to 8.4 mmt in 2020. Hence, projected increases in consumption are not as rapid as in the past decade (fig. 8). Nevertheless, this growth in demand still exceeds projected increases in output, as indicated below.

Table 4 shows the average yields on irrigated regions (2.36 mt/ha) and rainfed regions (0.92 mt/ha) for the base period. Yield on irrigated land is 2.6 times higher than on rainfed areas. This figure, which matches the irrigated-to-rainfed ratio computed from yield data provided by Maletta (2004) for 2002/03, is also similar to the yield ratio computed from figures recently provided by CIMMYT.⁸ Also in the base period, the proportion of irrigated (rainfed) area is 45 percent (55 percent). The ratios of irrigated-to-rainfed wheat areas and irrigated-to-rainfed wheat yields result in a national average yield of 1.57 mt/ha for Afghanistan as a whole, which matches the 2010 data from USDA (2011).

Farmers rely on functioning seed and fertilizer markets to expand the share of land cultivated with improved seed varieties and to increase nutrient application. In the Reference scenario, the yield in Afghanistan, i.e., the national average, grows at an annual rate of 0.9 percent, from 1.57 mt/ha in the base period to 1.72 mt/ha in the terminal year (fig. 9). The yield increases obtained in the Reference scenario do not require that Afghanistan increase the proportion of its irrigated wheat area or that the country improve its yields on rainfed areas. By assumption, the rainfed yield remains constant at 0.9 mt/ha throughout the projection period, while in contrast the irrigated yield rises from 2.36 mt/ha in 2010 to 2.7 mt/ha in 2020 (see table 4). If the proportion

⁸Personal communication January 9, 2011.

Table 3
Results of Afghanistan wheat model

	Scenario I			Scenario II		Scenario III	
	Reference			High yield		Self-sufficiency	
	Base year	Terminal year	Annual growth	Terminal year	Annual growth	Terminal year	Annual growth
			Percent		Percent		Percent
Area (1,000 ha)	2,350	2,666	1.3	2,774	1.7	3,147	3.0
Yield (mt/ha)	1.57	1.72	0.9	1.91	1.97	2.68	5.5
Production (1,000 mt)	3,700	4,591	2.2	5,308	3.7	8,427	8.6
Consumption (1,000 mt)	6,000	8,427	3.5	8,427	3.5	8,427	3.5
Per capita consumption (kgs/person)	199	224	1.2	224	1.2	224	1.2
Wheat imports (1,000 mt)	2,300	3,836	5.2	3,119	3.1	0	--
Afghan wheat price (\$/mt)	341	340	0.0	340	0.0	340	0.0
Afghan flour price (\$/mt)	498	497	0.0	497	0.0	497	0.0
GDP (\$ millions)	15,608	27,952	6.0	27,952	6.0	27,952	6.0
Population (millions)	30.2	37.7	2.3	37.7	2.3	37.7	2.3

mt = metric ton.

ha = hectare.

kg = kilogram.

GDP = Gross Domestic Product.

Sources: Area, yield, production, consumption, and imports are from USDA, Foreign Agricultural Service, Production, Supply and Distribution online database. Population and GDP are from International Monetary Fund (2011). Prices of wheat and flour are from the U.N. World Food Programme's Price Analysis in Afghanistan (World Food Programme, 2011).

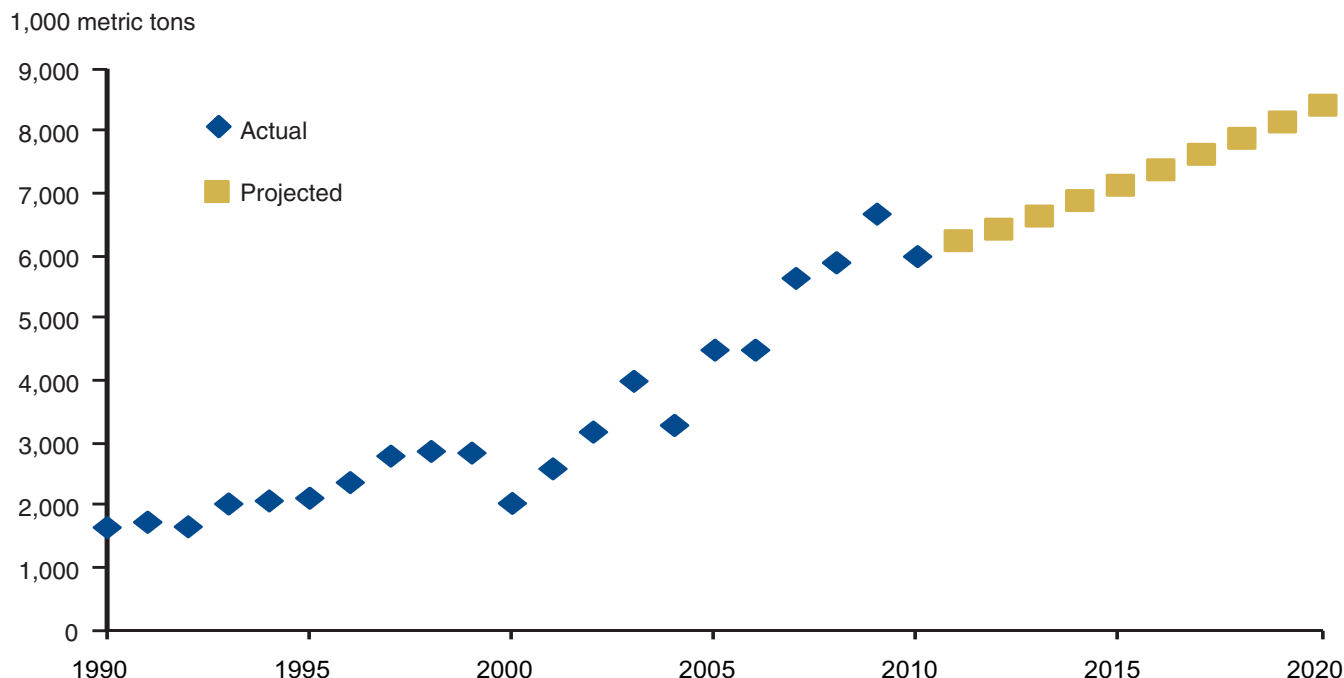
of irrigated wheat area remains at 45 percent throughout the projection period and the ratio of irrigated-to-rainfed yields climbs to 2.9-to-1.0 in 2020, the average yield for the country as a whole rises to 1.72 mt/ha in the terminal year. This 2020 figure is above the 2002-09 average yields for Kazakhstan and Turkmenistan but below all other countries in the region (see figure 3).

Area cultivated to wheat in Afghanistan is higher in 2020 than in the base period (see table 3 and figure 10)—returns from planting wheat improve, entirely as a result of the upward trend in yield. Area and yield grow at annual rates of 1.3 percent and 0.9 percent, respectively, and wheat output rises to 4.6 mmt in 2020 (fig. 11). Nevertheless, at 2.2 percent per annum, growth in domestic wheat production does not keep pace with demand, and imports continue to increase (fig. 12) 5.2 percent per year. By 2020, approximately 46 percent of Afghanistan's wheat demand is met by imports, versus 38 percent in the base period.

Scenario II: High Yield Growth

Prices, income, and hence consumption remain the same as in the Reference scenario. Afghanistan's wheat yield increased rapidly from 1990-2009, and

Figure 8
Projected wheat consumption (all scenarios)



Sources: 1990-2010 data are from USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database. ERS model replicates 2010 data; 2011-20 figures are results of ERS model.

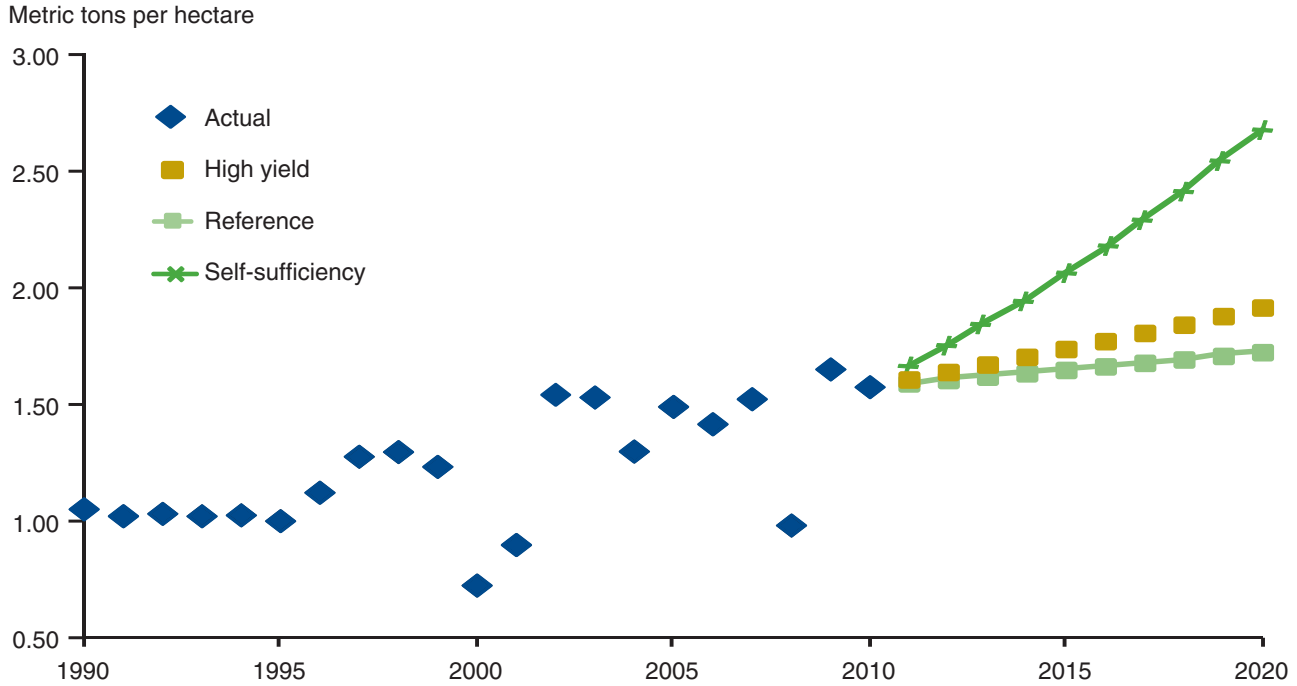
Table 4
Yield assumptions for Afghan wheat model

Variable	Base period	Reference terminal year	High-yield growth terminal year	Self-sufficiency terminal year
<i>Percent</i>				
Irrigated wheat area	45	45	45	64
Rainfed wheat area	55	55	55	36
<i>Metric ton/hectare</i>				
Average yield on irrigated land	2.36	2.70	3.13	3.50
Average yield on rainfed land	0.92	0.92	0.92	1.20
National average yield	1.57	1.72	1.91	2.68

Source: USDA, Economic Research Service.

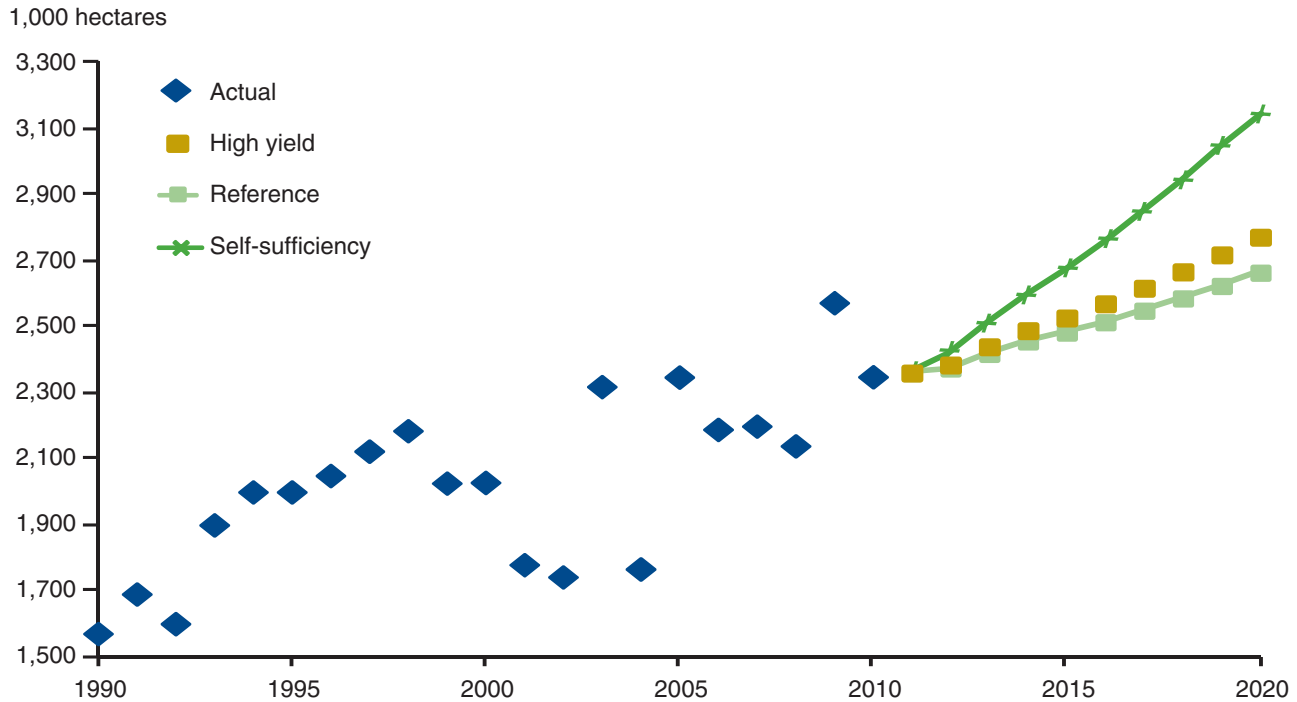
Scenario II analyzes the impacts of sustaining this strong growth through 2020. Thus, yield grows at an annual rate of 1.97 percent, from 1.57 mt/ha in the base period to 1.91 mt/ha in the terminal year (see figure 9). Just as in the Reference case, the yield increases obtained in Scenario II do not require that Afghanistan increase the proportion of its irrigated wheat area or that the country improve its yields on rainfed areas. The yield on irrigated fields does however rise from 2.36 mt/ha in 2010 to 3.13 mt/ha in 2020 (see table 4). Note that the yield improvement considered in this scenario is within the genetic potential of existing wheat cultivars discussed earlier in this report.

Figure 9
Wheat yield under alternative scenarios



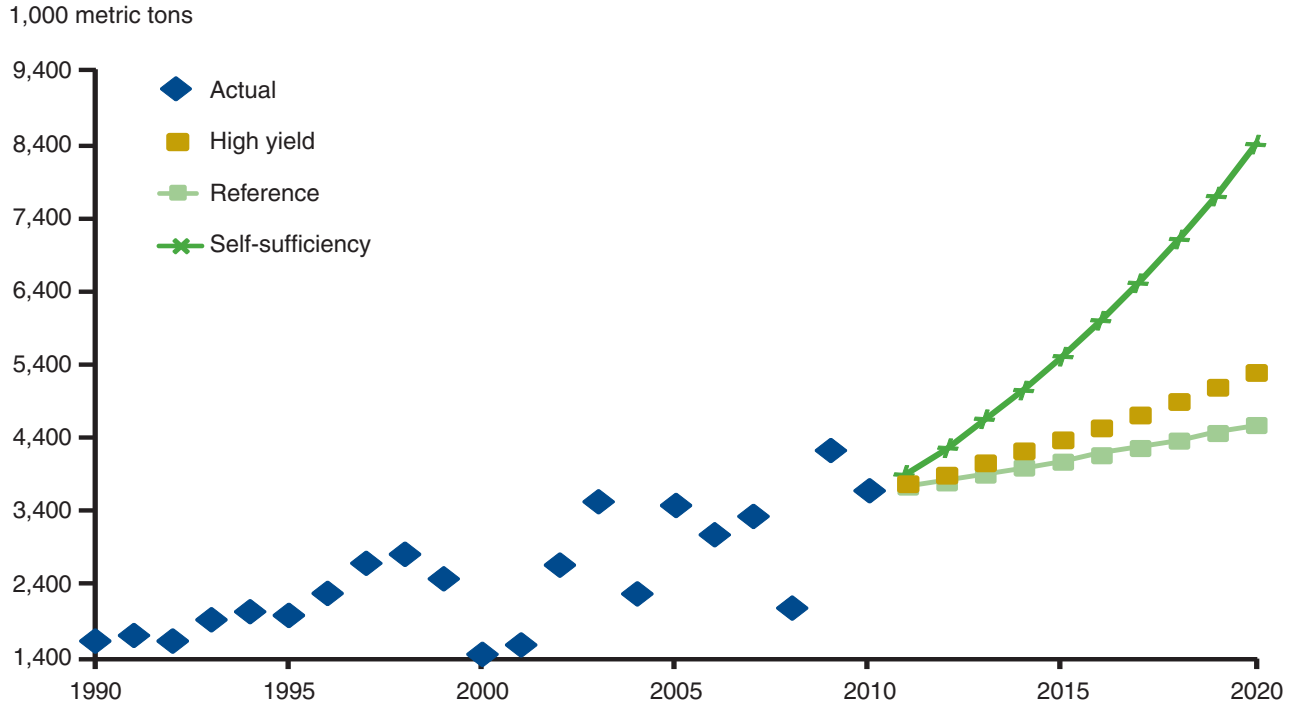
Sources: 1990-2010 data are from USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database. ERS model replicates 2010 data; 2011-20 figures are results of ERS model.

Figure 10
Wheat area under alternative scenarios alternative scenarios



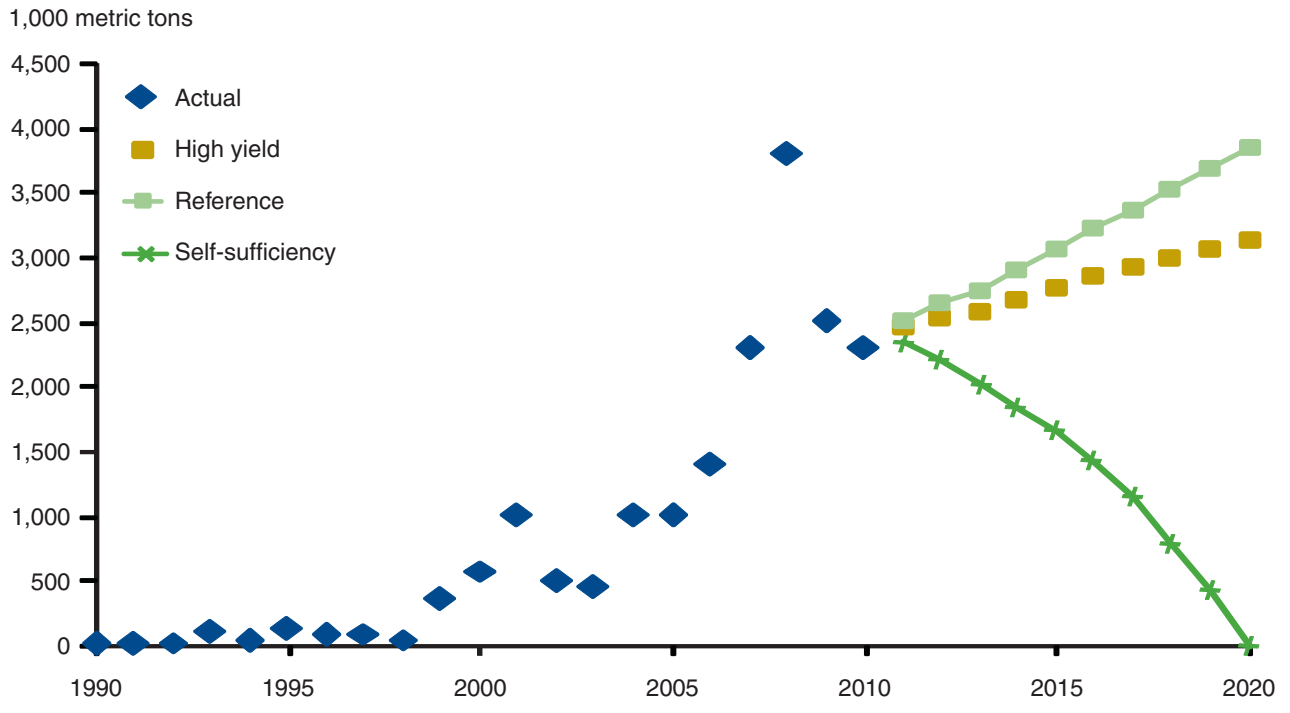
Sources: 1990-2010 data are from USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database. ERS model replicates 2010 data; 2011-20 figures are results of ERS model.

Figure 11
Wheat production under alternative scenarios



Sources: 1990-2010 data are from USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database. ERS model replicates 2010 data; 2011-20 figures are results of ERS model.

Figure 12
Wheat imports under alternative scenarios



Sources: 1990-2010 data are from USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database. ERS model replicates 2010 data; 2011-20 figures are results of ERS model.

For the country as a whole, national average yield rises to 1.91 mt/ha in the terminal year. This 2020 figure, which is in line with the 2002-09 average yields for Tajikistan and Russia, is well below those of Pakistan and Uzbekistan (see figure 3).

Area cultivated to wheat now expands more rapidly than in the previous scenario (see table 3 and figure 10), as faster improvements in yield (see figure 9) accelerate the growth in returns from producing wheat. Area, yield, and production increase at annual rates of 1.7 percent, 1.97 percent, and 3.7 percent, respectively. At 5.3 mmt in the terminal year, wheat production in Scenario II is 15.6 percent higher than the 2020 level from Scenario I (4.6 mmt). Nevertheless, with consumption outpacing domestic output, imports continue to trend higher (see figure 12), growing 3.1 percent per annum (see table 3).

Scenario III: Self-Sufficiency

The productivity advances considered in the previous scenario may be somewhat optimistic. Scenario III illustrates, as a hypothetical case, what would be required for Afghanistan to achieve self-sufficiency. Accordingly, this scenario models the impacts of even faster rates of technological change on irrigated fields. Unlike the previous two experiments, yield on rainfed land now grows as a result of adopting higher quality seed. In addition, the proportion of Afghanistan's wheat area that is irrigated now rises as a consequence of improving water availability/management.

Prices, income, and hence consumption remain the same as in the previous two experiments. To achieve self-sufficiency in the next decade, more widespread use of improved seed and fertilizer on irrigated and rain fed wheat fields would have to be combined with improbably sharp increases in irrigated wheat area. In line with the feasible 2020 targets indicated by Maletta (2007), rainfed (irrigated) yields rise to 1.2 mt/ha (3.5 mt/ha), as farmers rapidly adopt improved inputs. The critical factor in Scenario III is that it incorporates unrealistically sharp increases in irrigated area. By the end of the projection period, irrigated fields account for the majority (64 percent) of land cultivated to wheat (see table 4). Consequently, Afghanistan achieves a national average yield of 2.68 mt/ha at the end. This 2020 figure is above the 2002-09 average yield for Pakistan, and is second only to Uzbekistan among neighboring countries (see figure 3). Area cultivated to wheat now expands more rapidly than in the previous scenario (Table 3 and Figure 10), as faster improvements in yield (see figure 9) accelerate the growth in returns from producing wheat. With production increasing at an implausible 8.6 percent per year, Afghanistan closes the domestic supply-demand gap and ceases to be an importer in 2020 (see figure 12). However, substantial growth in Afghanistan's irrigation sector, aside from requiring considerable financial resources, would likely necessitate international agreements with downstream neighboring countries that would face reduced water availability as a result of increased usage in Afghanistan.

Conclusions

In Afghanistan, wheat is a key staple food, accounting for over half of the population's caloric intake on average. Since 1990, Afghanistan has had some success at achieving higher wheat output, driven primarily by yield increases. The historical growth in wheat yields reflects long-term efforts at seed development and increased availability by international organizations. These productivity advances also demonstrate that seed and fertilizer markets have continued to exist and function, albeit with significant disruptions and under a great deal of adversity. This has allowed yield to reach a number of new highs when favorable weather conditions have occurred. However, the historical performance of Afghanistan's wheat production sector also reveals its sensitivity to variations in precipitation. The destruction and continuing disrepair of the country's irrigation systems, aside from exacerbating the impact of adverse growing conditions, is also a likely explanation of the negligible growth in wheat area, which in turn constrained growth in output. Consequently, imports have played a key role in fostering the growth and stability of Afghan wheat consumption.

Despite the country's predominantly mountainous terrain and arid to semi-arid climate, there is long-term potential for increasing domestic wheat production. Irrigation systems have been damaged or have not been maintained, and the country's irrigated area is below its potential. Large areas of Afghanistan are still planted with traditional, low yielding wheat seeds. However, even if Afghanistan sustains its rapid post-1990 production growth, domestic wheat output will not outpace expected increases in consumption, suggesting growing dependence on supplies from Pakistan and other countries. To close the gap between domestic supply and demand, yields on both rainfed and irrigated areas would have to rise. Moreover, self-sufficiency would also entail increases in the proportion of the country's wheat area that is irrigated, i.e., the majority of the country's wheat area would have to be irrigated. Substantial growth in Afghanistan's irrigation sector may necessitate international agreements with downstream neighboring countries, to the extent that they face reduced water availability as a result of increased usage in Afghanistan. Given the difficulties that are associated with expanding the country's irrigation sector, imports of wheat will very likely continue to play an important role in allowing Afghanistan to compensate for its own domestic constraints on water availability.

References

- Ahmad, Masood, and Mahwash Wasiq. *Water Resource Development in Northern Afghanistan and Its Implications for Amu Darya Basin*, World Bank Working Paper No. 36, The World Bank, Washington, DC, June 2004.
- Asian Development Bank. *Rebuilding Afghanistan's Agriculture Sector*, Manila, Philippines, April 2003.
- Chabot, Philippe, and Paul A. Dorosh. "Wheat Markets, Food Aid and Food Security in Afghanistan," *Food Policy* 32:334–53. 2007.
- Dorosh, Paul, and Abdul Salam. *Wheat Markets and Price Stabilization in Pakistan: An Analysis of Policy Options*, Pakistan Institute of Development Economics (PIDE), PIDE Working Papers 2006:5. 2006.
- D'Souza, Anna, and Dean Jolliffe. *Rising Food Prices and Coping Strategies: Household-level Evidence from Afghanistan*, World Bank Policy Research Working Paper No. 5466. The World Bank, Washington, DC. November 2010.
- Favre, Raphy. *Review of the Wheat Seed Sector in Afghanistan: Implications for Seed Programming and Regulatory Frameworks*, Aizon PLC, Addis Ababa, Ethiopia. March 2004.
- Gastel, Antonius G. van, Koffi Amegbeto, and Siddiqi Shamsuddin. *Recounting the impact of emergency seed and fertilizer aids in Afghanistan*, International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, 2007.
- Government of Afghanistan. National Rural Vulnerability Assessment Survey. Ministry of Rehabilitation and Rural Development. 2003
- Gregory, Ian. *The Role of Input Vouchers in Pro-Poor Growth*, International Center for Soil Fertility and Agricultural Development (IFDC). Abuja, Nigeria. 2006.
- Husain, Adil, and Andrew Gilroy. "Afghanistan's Fertilizer Market: Reliant on Imports from Neighboring Countries," Emerging Asia Limited. Shanghai, China. January 19, 2009.
- International Monetary Fund. World Economic Outlook Database. IMF, Washington, DC, April 2011.
- International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria 2007.
- International Monetary Fund, *Islamic Republic of Afghanistan: Sixth Review Under the Arrangement Under the Poverty Reduction and Growth Facility*, Country Report No. 10/22. IMF, Washington, DC. January 2010.

- Khan, Shamsheer. *Pakistan Wheat Subsector and Afghan Food Security: A special report by the Famine Early Warning Systems Network (FEWS NET)*, United States Agency for International Development (USAID). May 2007.
- Maletta, Hector. "Food and agriculture in Afghanistan: a Long Term Outlook," in *Afghanistan: How Much of the Past in the New Future*, G. Picco and A.L. Palmisano (eds). Istituto di Sociologia Internazionale di Gorizia. Gorizia, Italy. 2007.
- Maletta, Hector. *The Grain and the Chaff: The Cost of Production of Wheat in Afghanistan in a Farming System Perspective*, Afghanistan Ministry of Agriculture and Animal Husbandry (MAAH) and United Nations Food and Agriculture Organization (FAO), Kabul, Afghanistan. April 2004.
- Maletta, Hector, and Raphy Favre. *Agriculture and Food Production in Post-War Afghanistan*, Afghanistan Ministry of Agriculture and Animal Husbandry and United Nations Food and Agriculture Organization. Kabul, Afghanistan. August 2003.
- Mollet, Mathias. *After Winter Crop Performance Evaluation of the Emergency Agricultural Input Program—Autumn 2002 Season*, United Nations Food and Agriculture Organization, Kabul, Afghanistan. 2003.
- Oushy, Hamdy. *Farm Resource Management in Afghanistan—Training Course*. United States Agency for International Development (USAID) / New Mexico State University (NMSU) / Afghanistan Water, Agriculture, and Technology Transfer (AWATT) project in Afghanistan. November 2010.
- Persaud, Suresh. *Price Volatility in Afghanistan's Wheat Market*, Outlook Report WHS-10d-01, USDA, Economic Research Service. May 2010. Available at: <http://www.ers.usda.gov/publications/whs/2010/04apr/whs10d01/>.
- Rout, Bob. *How the Water Flows: A Typology of Irrigation Systems in Afghanistan*, Afghanistan Research and Evaluation Unit Issue Paper Series. Kabul, Afghanistan. June 2008.
- Roy, Amit H. *The Rebuilding of Afghanistan's Agriculture: The IFDC Solution*, International Center for Soil Fertility and Agricultural Development (IFDC), Muscle Shoals, AL. 2003.
- Schulte, R.B. *Northern Wheat Trader Survey and Afghan Food Security: A Special Report by the Famine Early Warning Systems Network (FEWS NET)*, United States Agency for International Development. August 2007.
- Swedish Committee for Afghanistan. *Agriculture Survey of Afghanistan, 1992-1993*. 17th Report, Islamabad, Pakistan. December 1993.
- Torell, Gregory L., and Frank A. Ward. "Improved Water Institutions for Food Security and Rural Livelihoods in Afghanistan's Balkh River Basin," *Water Resources Development*, Vol. 26, No. 4, pp. 613–37, December 2010.

- United Nations Food and Agriculture Organization. FAOSTAT database. Rome, Italy. Accessed October 2011.
- United Nations Integrated Regional Information Networks (IRIN), Office for the Coordination of Humanitarian Affairs. *Ground water Overuse Could Cause Severe Water Shortage*, Kabul, Afghanistan. September 2008.
- United Nations Food and Agriculture Organization. *Review of Global Agricultural Water Use Per Country*, Rome, Italy. 2004.
- U.S. Department of Agriculture, Foreign Agricultural Service. USDA Production, Supply and Distribution (PSD) database. Accessed October 2011.
- U.S. Department of Agriculture, Foreign Agricultural Service. *Pakistan Allows Wheat Exports*, GAIN Report. December 10, 2010.
- U.S. Department of Agriculture, Foreign Agricultural Service. *Pakistan Grain and Feed Annual Report 2009*, GAIN Report No. PK9002. March 11, 2009.
- U.S. Department of Agriculture, Foreign Agricultural Service. *Afghanistan: Severe Drought Causes Major Decline in 2008/09 Wheat Production*, Commodity Intelligence Report. August 12, 2008.
- U.S. Department of Agriculture, Office of the Chief Economist. *USDA Agricultural Projections to 2020*, OCE-2011-1. 2011. Available at: <http://www.ers.usda.gov/publications/OCE111/>.

Appendix 1

Elasticities and Within-Sample Predictions

Formal estimates of supply and demand elasticities for wheat in Afghanistan are not available in the literature. Limitations in both the quantity and quality of Afghan data, as discussed in Persaud (2010), pose a significant if not insurmountable challenge for econometrically estimating demand and supply parameters.

Demand Elasticities

Chabot and Dorosh (2007) estimated demand and net imports in 2003-04 under alternative assumptions for production levels and demand parameters. Their three sets of assumed demand elasticities were (1) completely inelastic income and own-price elasticities (2) a low elasticity scenario using income and own-price demand elasticities of 0.2 and -0.2, respectively, and (3) a high elasticity scenario using income and own-price demand elasticities of 0.5 and -0.5, respectively. Chabot and Dorosh's aim was to assess the consistency of reported production and availability changes derived from the alternative data sources with movements in market prices, rather than arguing for a particular set of elasticities.

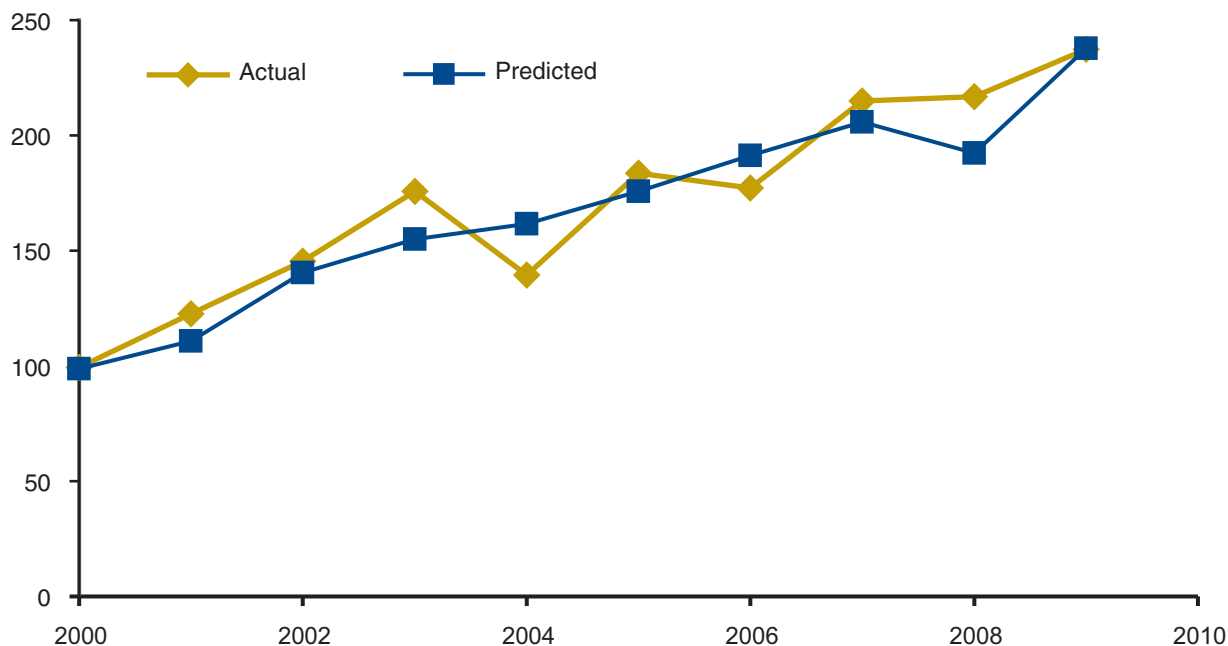
Recent trends in per capita consumption, the real price of flour, and real GDP per capita are consistent with income and own-price elasticities of 0.32 and -0.2, respectively (close to Chabot and Dorosh's low elasticity scenario) and a 7-percent trend term that reflects the rehabilitation of the country's infrastructure and marketing channels. Thus, a 1-percent increase in real GDP per capita is associated with a 0.32-percent increase in per capita consumption of flour; a 1-percent increase in the real price of flour is associated with a 0.2-percent decrease in per capita flour consumption. These elasticities and the trend term, along with 2000-09 data for real GDP per capita and the real price of flour, are used to compute within sample predictions of per capita wheat consumption. The assumed demand parameters are plausible in that they generate predictions of consumption that track the actual 2000-09 consumption data reasonably well (appendix fig. 1). It is important to note that the demand projections to 2020 are based on the above-mentioned elasticities while excluding the trend term in order to avoid unrealistically high consumption levels. Rising incomes are expected to lead to dietary diversification in Afghanistan (Maletta, 2007), and current levels of consumption are already high. Projected increases in consumption are expected to be rapid, although not to the same degree as in the past decade.

Elasticities for Wheat Area Harvested

In the absence of econometric estimates of wheat supply elasticities, Gastel et al. (2007) estimated the "economic surplus" (i.e., producer and consumer surplus) resulting from emergency seed and fertilizer aid based in part on an own-price demand elasticity of -0.1 and assumed own-price supply elasticities of 0.228 and 0.4. Similar to Chabot and Dorosh (2007), Gastel et al.

Actual and model predictions of per capita consumption of wheat

Consumption (kilograms/person)



Sources: Actual data are from USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database and the International Monetary Fund (2010); predicted values are USDA, Economic Research Service calculations.

(2007) do not argue for a set of point estimates, and instead use various elasticities to generate scenarios.

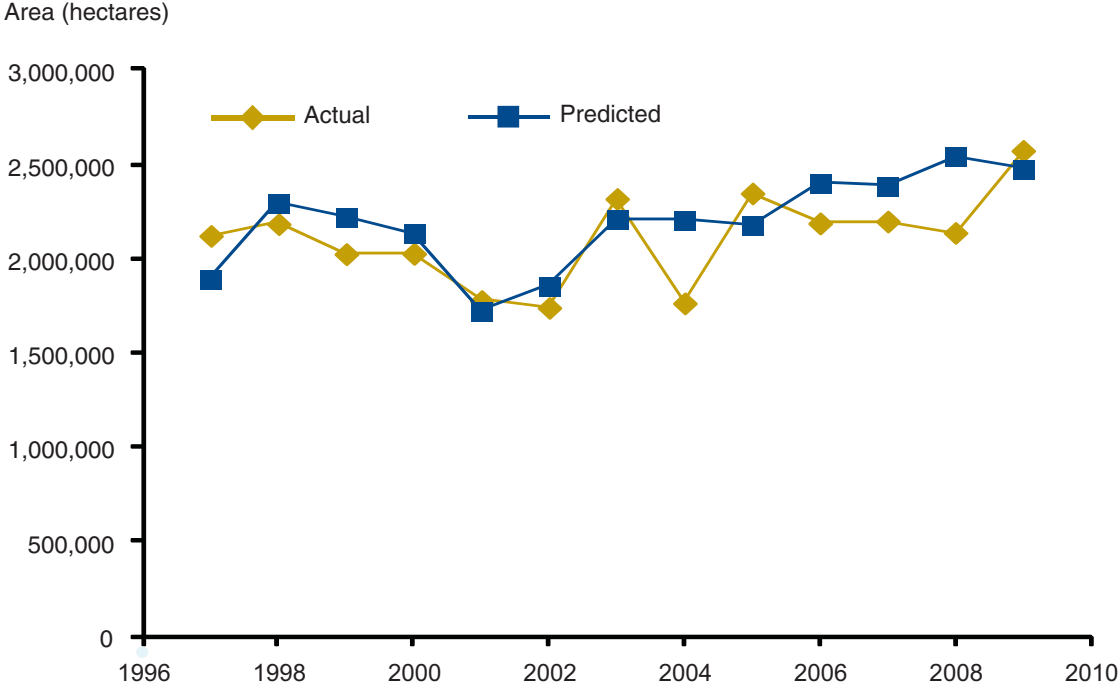
Similar to the USDA Baseline models, we posit a relationship between area and expected returns from wheat cultivation, where the lagged wheat price and lagged yield represent expected returns. It is not possible to obtain data on farm prices in Afghanistan; it is necessary to instead use retail prices of wheat. This approach is reasonable if changes in producer prices mirror changes in available retail prices. Prices of competing crops are not available. However, wheat is the dominant crop in Afghanistan, which would suggest that a given percentage change in the area cultivated to competing crops would have only a small percentage impact on wheat production.⁹ On the other hand, since a relatively large amount of Afghanistan’s land area is cultivated to wheat, even small percentage changes in wheat area can significantly change the production of competing crops.

Recent trends in area, the lagged real price of wheat, and lagged yield are consistent with own-price and yield elasticities of 0.20 and 0.42, respectively, and a 1-percent trend term. Thus, a 1-percent increase in the real price of wheat is associated with a 0.20-percent increase in wheat area in the following year, all other things remaining the same; a 1-percent increase in wheat yield is associated with a 0.42-percent increase in wheat area in the following year, all other things remaining the same. These elasticities, along with 1997-2009 data for the real price of wheat and wheat yield, are used to compute within sample predictions of wheat area. These model predictions are not capable of capturing or replicating weather-induced contractions in

⁹Opium poppy, while a major cash crop, is grown on a relatively small land area, accounting for only about 2 percent of cultivated land in Afghanistan (Chabot and Dorosh, 2007).

wheat area. However, the assumed supply elasticities are plausible in that they generate predictions of area that, overall, track the growth in the actual 1997-2009 data reasonably well (appendix fig. 2).

Appendix figure 2
Actual and model predictions of wheat area



Sources: Actual data are from USDA, Foreign Agricultural Service, Production, Supply and Distribution (PSD) online database and the International Monetary Fund (2010); predicted values are USDA, Economic Research Service calculations.

Appendix 2

Model Equations

(Variables in **bold** below are exogenous.)

$$(1) \text{WHPrice} = \text{PakRelPrice} * (1 + \text{WHMargin})$$

$$(2) \text{FLPrice} = \text{PakRelPrice} * (1 + \text{FLMargin})$$

$$(3) \text{FLDemandPerCap} = \text{FL}^1 * \text{GDPPerCap} + \text{FL}^2 * \text{FLPrice} + \text{constant}$$

$$(4) \text{FLDemand} = \text{FLDemandPerCap} * \text{POP}$$

$$(5) \text{WHArea}_t = \text{WH}^1 * \text{WHPrice}_{t-1} + \text{WH}^2 * \text{WHYield}_{t-1} + \text{WH}^3 * \text{Trend} + \text{constant}$$

$$(6) \text{WHYield}_t = \text{WHYield}_{t-1} * \text{Trend}$$

$$(7) \text{WHProduction} = \text{WHArea} * \text{WHYield}$$

$$(8) \text{WHImport} = \text{FLDemand} - \text{WHProduction}$$

Appendix table 1

Variable list

Variable	Description	Unit	Base value
WHPrice	Afghan wheat price, real	US \$ / ton	341
WHPrice _{t-1}	Afghan wheat price, lagged one year	US \$ / ton	318
FLPrice	Afghan flour price, real	US \$ / ton	498
PakRelPrice	Pakistani release price of wheat, real	US \$ / ton	284
WHMargin	Wheat marketing margin	percent	20.0
FLMargin	Flour marketing margin	percent	75.1
FLDemandPerCap	Per capita consumption of flour	kgs / person	199
GDPPerCap	Gross domestic product per capita, real	US \$ / person	517
FLDemand	Total flour consumption	1,000 tons	6,000
POP	Population	millions	30
WHArea	Wheat area harvested	1,000 hectare	2,350
WHYield	Wheat yield	tons / hectare	1.57
WHYield _{t-1}	Wheat yield, lagged one year	tons / hectare	1.65
WHProduction	Wheat production	1,000 tons	3,700
WHImport	Wheat imports	1,000 tons	2,300

Notes: Base year for deflator set to 2010. The variable for wheat imports (WHImport) includes wheat flour quantities on a wheat-equivalent basis. Flour consumption (FLDemand) is on a wheat-equivalent basis.

Sources: Area, yield, production, and imports are from USDA, Foreign Agricultural Service, Production, Supply and Distribution online database. Afghan prices of wheat and flour are from the U.N. World Food Programme's Price Analysis in Afghanistan (World Food Programme, 2011). GDP deflators, population, and GDP are from the International Monetary Fund (2011). Pakistani release price of wheat is from Agricultural Prices Commission, Government of Pakistan.

Appendix table 2

Parameters and elasticities for Afghanistan wheat model

Equation and coefficient	Elasticity	Parameter
<i>Ln</i> (Per capita flour demand) equation:		
<i>Ln</i> FLPrice (FL ²)	-0.2	--
<i>Ln</i> GDPPERCap (FL ¹)	0.32	--
Constant	--	4.5129
<i>Ln</i> (Wheat area harvested) equation:		
<i>Ln</i> WHPrice _{t-1} (WH ¹)	0.20307	--
<i>Ln</i> WHYield _{t-1} (WH ²)	0.41714	--
TREND (WH ³)	--	0.01
Constant	--	9.33874

ln = natural logarithm.

FLPrice = Afghan flour price, real.

GDPPERCap = gross domestic product per capita, real.

WHPrice = Afghan wheat price, real.

WHYield = wheat yield.

Source: USDA, Economic Research Service.

Appendix 3

Data Sources and Uncertainties

There is considerable uncertainty surrounding estimates of population, production, consumption, and trade flows for Afghanistan. Total population estimates are approximations, since large segments of the population flow in and out of the country, including the seasonal movement of nomadic tribes into Pakistan and the large return of refugees in 2002-04, both of which were difficult to count accurately.

The U.N. Food and Agriculture Organization and the U.N. World Food Programme develop crop production estimates for Afghanistan, working under adverse conditions of war, rural insecurity, and poor transport infrastructure, while also coping with tight budget and time constraints. Government data at the provincial level are limited, and this further increases the difficulties of quantifying crop production for Afghanistan as a whole (Chabot and Dorosh, 2007). From 2000 forward, Afghan wheat production estimates from FAO are strongly correlated with USDA Production, Supply and Distribution (PSD) data. This report uses PSD data, since this source provides data through 2009, as well as estimates for 2010.

Estimates of trade flows are uncertain—reliable independent customs data on Afghanistan's wheat imports are not available (Chabot and Dorosh, 2007), and there is a great deal of unofficial cross-border trade (Persaud, 2010). USDA PSD online database may provide the best estimates of wheat and flour imports. Based on USDA's Foreign Agricultural Service (FAS) Global Agriculture Information Network (GAIN) reports as well as conversations with FAS Agricultural Specialists from Islamabad, market sources are utilized to account for official and unofficial trade in the USDA PSD import numbers for wheat and flour. Although trade figures are uncertain, various sources such as FAS GAIN reports, United States Agency for International Development (USAID), the U.N. World Food Programme, and the World Trade Atlas, agree that Pakistan is the dominant supplier of wheat (primarily in the form of flour) to Afghanistan. Kazakhstan ranks a distant second in most years, but revised trade data indicate a significant increase in 2008-09 Kazakh wheat and flour exports to Afghanistan that moderated the drop in Afghan consumption.

This report uses price data collected by the World Food Programme in the six major cities of Afghanistan: Kabul (the capital), Kandahar in the Southwest, Hirat in the West, Mazar-e-Sharif in the Northern province of Balkh, Fayzabad in Badakhshan province at the Northeast, and Jalalabad in the Eastern province of Nangarhar. WFP price data are useful for evaluating the affordability of food for low-income segments of the population. By design, the data series represents the lowest-priced food varieties available in urban bazaars. Consequently, the average retail prices in these cities are likely to be higher than the WFP price series. Nevertheless, the data collection method is straightforward and consistent: WFP data collectors identify the minimum price after recording a sample of prices in different stalls of each bazaar (Maletta, 2004). No data exist on producer prices in Afghanistan.