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.

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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

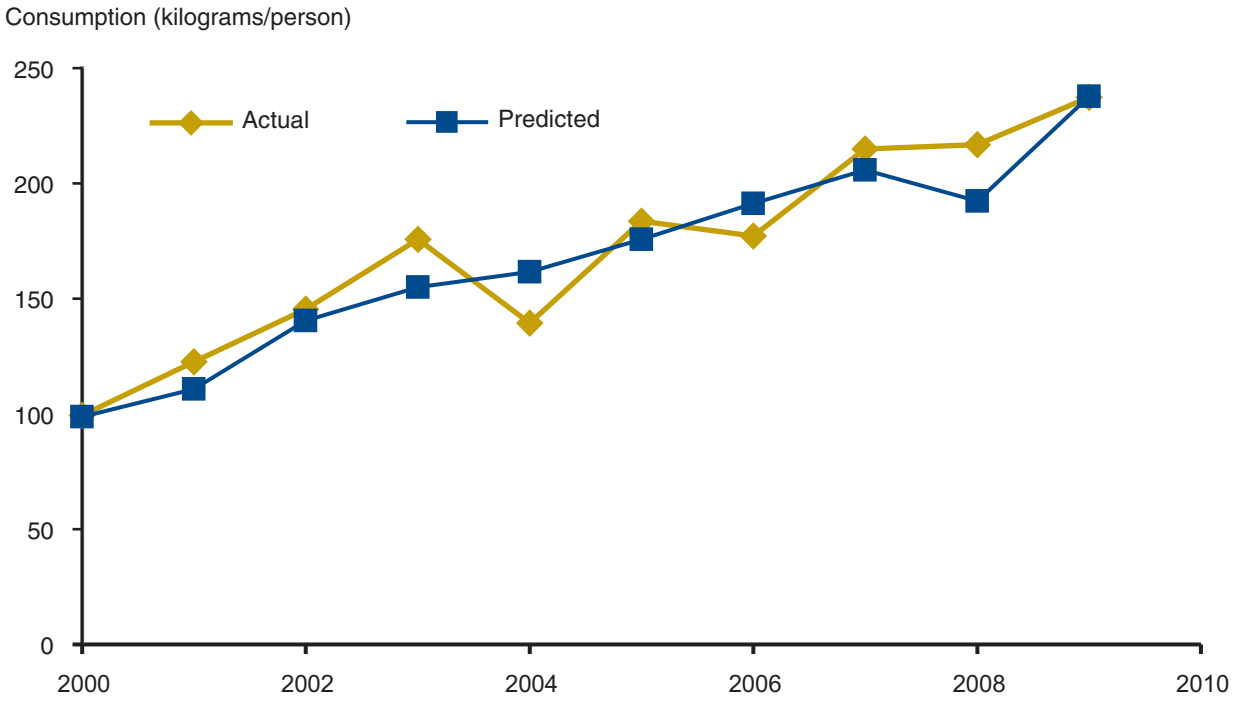
Chabot and Dorosh (2007) estimated demand and net imports in 2003-04 under alternative assumptions for production levels and demand parameters. Their three sets of assumed demand elasticities were (1) completely inelastic income and own-price elasticities (2) a low elasticity scenario using income and 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.

Appendix figure 1
Actual and model predictions of per capita consumption of wheat



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.

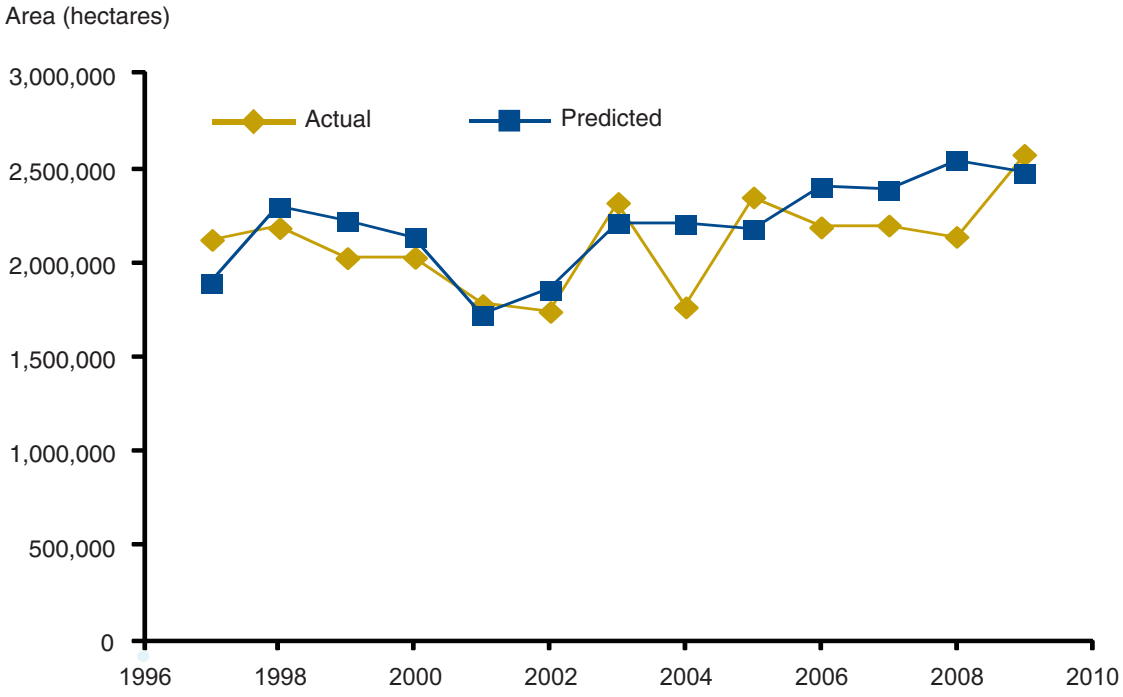
Similar to the USDA Baseline models, we posit a relationship between area and expected returns from wheat cultivation, where the lagged wheat price and lagged yield represent expected returns. It is not possible to obtain data on farm prices in Afghanistan; it is necessary to instead use retail prices 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

[9]Opium 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) WHPrice = **PakRelPrice * (1 + WHMargin**)

(2) FLPrice = **PakRelPrice * (1 + FLMargin**)

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

(4) FLDemand = FLDemandPerCap***POP**

(5) $WHArea_t$ = $\mathbf{WH^1}$*****$WHPrice_{t-1}$ + $\mathbf{WH^2}$*****$WHYield_{t-1}$ + $\mathbf{WH^3}$***Trend + constant**

(6) $WHYield_t$ = $WHYield_{t-1}$***Trend**

(7) WHProduction = WHArea*WHYield

(8) WHImport = FLDemand - 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
Ln(Per capita flour demand) equation:		
*ln*FLPrice (FL^2)	-0.2	--
*ln*GDPPerCap (FL^1)	0.32	--
Constant	--	4.5129
Ln(Wheat area harvested) equation:		
$ln\text{WHPrice}_{t-1}$ (WH^1)	0.20307	--
$ln\text{WHYield}_{t-1}$ (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.