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REBUILDING AGRICULTURAL MARKETS PROGRAM
RAMP LOCUST AND SUNN PEST IMPACT REPORT

JUNE 2006

REBUILDING AGRICULTURAL MARKETS PROGRAM (RAMP)

RAMP Impact Assessment # 4
Assistance to the Locust & Sunn Pest Sector

Submitted by:

Chemonics International, Inc.
Contract No. 306-C-03-00-00502-00

Submitted to:
Afghanistan Mission
U.S. Agency for International Development
Kabul, Afghanistan

June, 2006

Locust and Sunn Pest Control in Afghanistan: RAMP Impact Assessment

List of acronyms

ADB	Asian Development Bank
CADG	Central Asia Development Group
CFSAM	Crop and Food Supply Assessment Mission (FAO/WFP)
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information System
GPS	Global Positioning System
IP	Implementation Partner
MAAHF	Ministry of Agriculture Animal Husbandry and Food
PPQD	Plant Protection and Quarantine Department
RAMP	Rebuilding Agricultural Markets Program
ULV	Ultra-Low Volume
USAID	United States Agency for International Development
WFP	World Food Program

Summary

Food production in Afghanistan is highly sensitive to rainfall variations and in the course of the 21st century four years have been rated as “dry”. Uncontrolled locust and sunn pest populations greatly reduce crop yields and further compound the performance of the agricultural sector. This paper ascertains the value of pest control measures carried out by the Rehabilitating Agricultural Markets Program (RAMP) and its implementing partners during 2004 to 2006. Wheat is used to value the impact of these interventions. It is a is a widespread crop grown for food security and its agricultural cycle coincides with the biological cycle of these pests. It is estimated that the Afghan farmers saved 750,000 metric tons of wheat with a value of US$171 million, a 66-fold return to project investment. However, this assessment does not take into account the spillovers such as other crops saved from infestation, including high-value crops; training to national staff on pest control measures; and the empowerment of NGO’s to carry out and secure funding for pest control measures without support from RAMP.

I. Introduction

Agriculture accounts for one half of the Gross Domestic Product (GDP) in Afghanistan (excluding poppy cultivation), and it employs three-quarters of the rural population. Agricultural production is largely subject to variations imposed by sub-artic mountain climate with dry cold winters in the highlands and arid and semi-arid climates in the lowlands. Even though Afghanistan is not a poor country in terms of its per capita water availability, topography limits the options to harness and distribute the available water. Ten droughts have been reported since 1970 and a 28 percent chance to face a dry year.[1] Under this scenario, it is no surprising that, for example, in "….2004, widespread crop failure, caused by localized drought and plant and animal diseases—particularly the west, southwest and south—led to severe food shortages" (ADB, 2005a). Thus, Afghanistan faces the challenge to increase its food security with limited irrigated land as well as rainfed land, including agropastoral systems.[2]

Pests and diseases further reduce crop yields or, in some cases, completely wipe out farmers' crops in affected areas. Systematic preventive actions, however, can be taken to minimize the loss and damage of outbreaks of insect populations that diminish farmers' crop yields, weakening the already debilitated food security situation. The United States Agency for International Development's Rebuilding Agricultural Markets Program and its implementing partners have carried out locust and sunn pest control actions to support rural livelihoods in Afghanistan since 2004, which ultimately have contributed to the enhancement of agricultural markets in the provinces where RAMP operates.

The objective of this study is to assess the economic impact of locust and sunn pest control actions in the Afghan agricultural sector. Wheat is used as a proxy crop to assess the loss because it occupies more than 50% of the crop land and its agricultural cycle coincides with the life cycle of the pests.

II. Wheat and Food Security[3]

Wheat is the most important crop in Afghanistan in terms of area planted and production and this country has been a net importer of wheat since 1976 (FAO/WFP, 2003). The very short life expectancy at birth (43 years; ADB, 2005b) is one of many indicators of food insecurity and other material and social deprivations. Wheat production in 2000 and

[1] Droughts for 1971-72, 1977, 1982-83 are reported in Guimbert (2004), 1999-2002 in FAO (2005) and for 2004 in World Bank (2005). References to drought are imprecise because the lack of data and some authors refer to agricultural seasons based on long-duration wheat cultivation (starting in October and ending in May of the following year) or they refer to calendar years; crop yields and numbers of animals are used as indicators of "drought condition". It was not until April 2003 when the United States Agency for International Development and the United States Geological Survey launched the Agrometeorological Project to collect and systematize data in different provinces. A monthly newsletter is published by USAID-USGS, Kabul.

[2] Even though a 28 percent chance of drought is high, it is unknown how dry a drought is or how much rain is in an agricultural year not considered as drought (72 percent of the time).

[3] This section largely relies in the World Bank (2005) publication but has been updated for the last two years.

2001was below 1.7 million metric tons but increased to 2.8 million when the 3-year drought begun to cease in 2002, followed by remarkably good agricultural years in 2003, 2005 and 2006, averaging more than 4.2 million metric tons (Fig. 1). Poor rainfall distribution in the 2003-2004 season and lower prices due to the record supply from 2003 discouraged farmers to grow wheat in 2004. Commercial wheat imports and food aid have met the gap between demand and supply throughout these years. Twenty-three percent of the wheat consumed in Afghanistan from 2000 to 2006 has been imported, 16 percent commercially and 7 percent as food aid. Production has varied 42 percent in the last seven years, commercial imports have varied 62 percent and food aid importations have varied 41 percent. Variable rainfall and biological factors explain part of this variation in production but also wheat prices (and those of other commodities) influence farmers' behavior to allocate their scarce land, labor and capital.

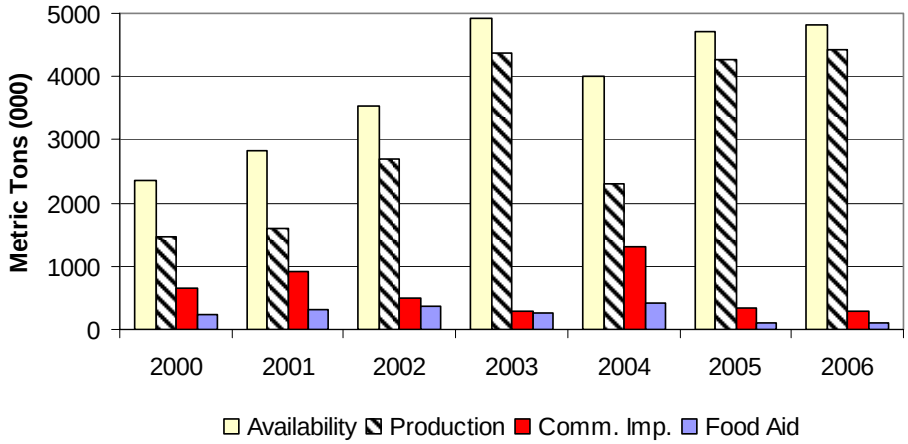

Figure 1. Wheat availability, production and imports in Afghanistan. Years indicate agricultural years of main wheat harvest in April and May; data on imports and availability are for the fiscal year July-June. Source: 2000-2004, FAO/FWP Kabul (cited by The World Bank, 2005); 2005, FAAHM (2005) and 2006, FAAHM (2006).

The area planted to wheat in 2002 was 2.3 million hectares or about 68 percent of the total cultivated area, and 1.7 million hectares in 2003. Over the 2002 to 2004 period, irrigated wheat area averaged about 1.0 million hectares, about 10 percent more than rainfed area. However, since yields on irrigated land are more than twice those in rainfed land (2.3 tons/ha versus 0.9 tons/hectare) over the same period, production on irrigated land accounts for about 70 percent of the total national production. Average yields of irrigated wheat vary little across the region but rainfed wheat yields are susceptible to regional climatic variations.

About half of the national wheat output is produced in the northern plains and foothills region—the breadbasket of the county, where both irrigated and rainfed crops are grown. This region is the major surplus area in the country, producing an estimated 283 kg/capita of wheat (average of 2002 and 2003), compared to a national average of 157 kg/capita. In the mountain region of the country, over 85 percent of the production is irrigated. Although the region accounts for 20 percent of the national production, it is a deficit

region (producing 67 kg/capita) due to the presence of large urban populations in Kabul and Jalalabad. The west—southwest region accounts for about 30 percent of wheat production, and produces approximately as much as it consumes (about 189 kg/capita of production). Apart from some rainfed wheat cultivated in Herat and Badghis provinces, almost all of the regions' wheat is irrigated.[4]

Wheat production has varied considerably in recent years because both drought and deterioration in irrigation infrastructure. After severe droughts in 2000 and 2001, adequate snowmelt in late 2002 permitted a large expansion in area sown in November-December for the wheat crop harvested in April-May 2003. Total wheat production in 2003 was 4.36 million tons, a record harvest, 62 percent higher than in 2002. Slightly over half (54 percent) of the total 1.7 million ton gain came from increases in irrigated wheat production (1 percent gain in area and a 43 percent increase in yield). The remaining gain in production derived from a near doubling of upland area and a 32 percent gain in upland yields. Production in 2004 was 2.29 million tons, 47 percent below the production for 2003. However, production in 2005 was only 2 percent below the production in 2003 and the production estimate for 2006 (FAAHM, 2006) is 1 percent above that of 2003. Considering the high frequency of "dry years" in the 21 century, 4 years out of 7, Afghanistan has done remarkably well. The gap between demand and supply has been filled with imports by the private sector and food aid.

The estimated irrigated wheat yields in Afghanistan averaged 2.0 tons/hectare in 2002 and 1.9 tons/hectare in 2004 (FAO/WFP, 2004), significantly less than the averages between 2.6 and 3.0 ton/hectare in Pakistan, Uzbekistan and Iran. The reported irrigated yields in 2003 (2.8 ton/hectare) were similar to those of the neighboring countries. Rainfed yields in 2004 (0.53 ton/hectare) were also lower than those in neighboring countries. Even in the major wheat producing provinces in the north and northwestern regions, average yields in 2004 were only about 2.2 tons/hectare (and only about 0.6 tons/hectare of rainfed wheat).

Relatively low use of improved wheat seed varieties is one reason for lower average yields. According to the agricultural survey of 2002, only about half (53 percent) of farmers used improve seed introduced in the last ten years. The remainder of the seed used was either indigenous seed or improved seed introduced more than ten years earlier, including the "zardana" variety widely used in northern Afghanistan.[5] There is a substantial use of fertilizer, however, which is imported by the private sector. In 2002, an average of 180 kg of fertilizer per hectare (mainly urea and di-ammonium phosphate) was used on irrigated wheat, totaling an estimated 187 thousand tons total on wheat

[4] Rainfed wheat is usually planted in December or January and harvested sometime between July and September, depending on farmers' assessment of how much soil moisture is available at planting and her/his rainfall expectations for the remaining part of the agricultural season. Once the decision is made, farmers may or may not use fertilizer and have reasonable yields or crop failure, depending on the rainfall pattern in the remaining part of the season.

[5] Unfortunately, some of the seed provided in the emergency distribution programs in 2002 and 2003 may have been of low quality. The amount of seed procured for distribution in autumn 2002 (23,000 metric tons) was nearly five times greater than what the contracted farmers were able to produce with a minimum quality control standard certified by FAO.

alone. Use of fertilizer and improved varieties adapted for rainfed conditions could be considered as a risk management option if knowledge of rainfall distribution is improved and its benefits are demonstrated to farmers.[6] Similarly, agropastoral systems could improve from better agroclimatological information.

There is scope for raising wheat yields and production in the country, provided security and economic incentives are favorable. Nonetheless, self sufficiency in wheat is not necessary for food security, provided that the country has sufficient purchasing power to buy wheat on the international markets and market flows are not inhibited by excessively high import prices, export bans in export countries, destruction or deterioration of transport infrastructure (canals, roads and bridges) or physical insecurity that effectively prevents trade.[7] Moreover, cultivation of higher-value crops may result in higher farm incomes.

III. Background on Locust and Sunn Pest

Pests occur intermittently when triggered by favorable breeding conditions and are capable of causing disastrous levels of damage if uncontrolled. In Afghanistan, government controlled campaigns using chemicals begun in the 1930s with the assistance of the Soviet Union. These were discontinued in the 1980s due to conflict until FAO organized control operations from 1991 to 1999. Since 2000 there has been an outbreak and its effects have been accentuated by the drought (1999-2002) and absence of pest control operations. In 2002, FAO initiated emergency locust control operations in response to a request for assistance from the Transitional Government of Afghanistan. This was followed by emergency campaigns, supported by various donors, including the United States Agency for International Development, in 2003 and these efforts have been continued by RAMP since 2004.

3.1 Locust

The Moroccan locust (*Dociostaurus maroccanus*) is adapted to a hot dry summer and cold wet or cold dry winters. The eggs, which have spent the summer and winter in a state of dormancy in the soil, hatch in early spring. The wingless nymphs ("hoppers") march in dense bands, completely denuding the vegetation (Fig. 2a). They may cover a distance of about 3 km before becoming adults and developing wings. Should a band enter a cultivated field, they will destroy any crop in their path. As the hoppers grow, the area occupied by bands increases, up to forty-fold over the fourth-week period before becoming adult. This represents a compound rate of increase of 15 percent per day.

As the vegetation dries out, or is eaten, the adult locust swarms migrate in search of food. Cultivated areas, especially those which are irrigated, offer an inviting target. A swarm

[6] Knowledge of conditional rainfall probabilities and availability of improved seed and fertilizer has had a positive impact in rainfed wheat production in Kazakhstan and Syria (Ahmad et al. 2005). The potential for "drought management" strategies in different agroecological zones in Afghanistan needs to be assessed.
[7] Policies that provide additional incentives for wheat production (government procurement at high prices, import bans that raised domestic prices, subsidies explicitly targeted to wheat production), would involve pulling economic resources (land and labor) away from more productive uses.

will spend several days feeding, before migrating back to the breeding areas to lay eggs. They may do this 2 or 3 times. Locust may eat their own weight in vegetation every day. A swarm entering a cultivated field will completely destroy it in a few days, if not a matter of hours, before moving on. A single swarm, several square kilometers in size, may destroy many times its own area of crops if it happens to migrate into them (Fig. 2b). But this swarm has grown from a very small area, less than a hectare, of hatching hoppers.

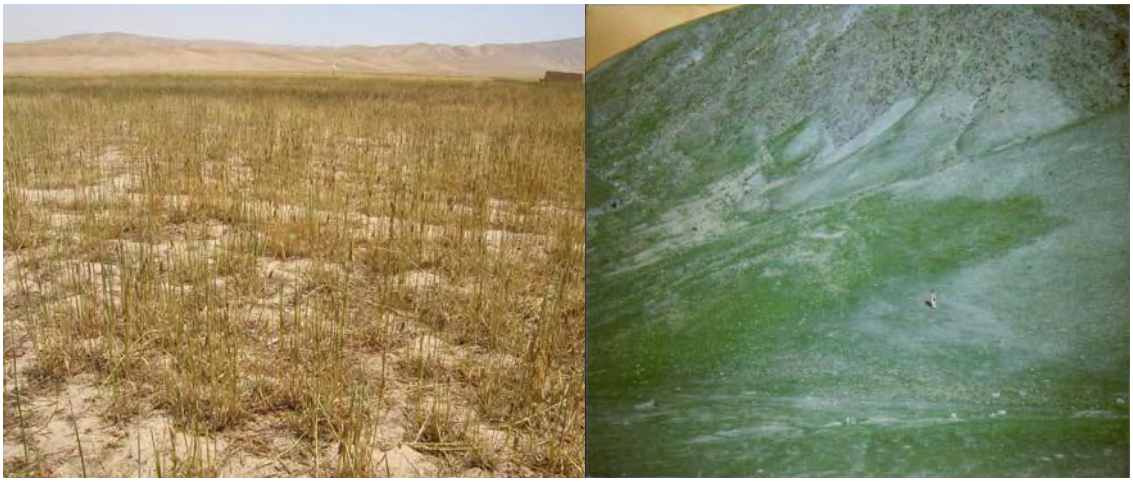

Figure 2a. Ripe wheat field attacked by adult locust; 2b. Ground denuded of vegetation by hopper band.

Locust Migration. Swarms of Moroccan locust can migrate up to 100 km, but smaller distances, 10 to 30 km are more usual. Studies of other locust species show the importance of prevailing wind in determining the displacement of swarms but they are visually attracted to green vegetation over short distances.

Locust Control. The measure of locust control is the area treated, but because locusts are mobile, this bears no direct relation to the area of crops sprayed.[8] A hectare of locust might, if unchecked, destroy 50 or more hectares of crops or none if it did not migrate into a cultivated area. On the other hand, a field may need to be sprayed repeatedly if reinvaded by successive swarms or hopper bands. Controlling locust at the hopper stage is much more efficient than at the adult stage for the following reasons:

- hoppers occupy a smaller area;
- they are susceptible to a lower dose of pesticide;
- they are less mobile and easier to locate.

However, because of the expanding area occupied by a given number of locust hoppers as they grow, the effectiveness of a unit of control decreases over time. From the initial

[8] There is no direct relationship between the number of locust killed and the area of crops saved (FAO, 2005). The risk is a function of distance from the original site of hatching, but this may be skewed by unknown factors determining the direction of swarm displacement.

hatching, the effort required to kill a given number of locust is increasing at 15 percent compound growth per day.

Estimating Vulnerable Crops. The potential damage on crops depends on their spatial distribution of crops in relation to the site of egg-fields and the "risk footprint" from migrating swarms. The only available data on crop distribution is the Land Cover Survey carried out in 1999, which maps rainfed and irrigated cultivation, but takes no account of the variation between years in the area actually planted. However, it is available as a digitized GIS layer and can be used for spatial analysis. Upon request of the countries FAO and WFP carry out Crop and Food Supply Assessment Missions–CFSAM (i.e., FAO/WFP 2003, 2004) which include an estimate of the area planted in each province for the major crops. It is therefore possible to estimate approximately the actual distribution of crops by applying a correction factor which is the ratio between the crop area in the Land Cover Survey in each province and the area planted in the province as given by the Crop Assessment Missions.

3.2 Sunn Pest

Sunn pest is a complex of species of large sap-sucking plant bugs, belonging to the Hemipteran families Pentatomidae and Scutelleridae. They feed on the ears of wheat during the milky stage and are capable of causing significant crop loss. Flour made from damaged grain reduces baking quality and bread made from it is almost inedible. The straw of infested wheat is also valueless as livestock forage (FAO, 2005).

In Afghanistan, Sunn pest comprises four known species, each with its own distinct characteristics and distribution. *Eurygaster integriceps* was the subject of the original research on the biology and pest status of the group carried out in Iran during the 1960s. It is widely distributed throughout the country and is the major species in Helmand province. *Aelia acuminata* is able to feed on dry grain at the end of the season, and is widely distributed throughout the north, particularly from the province of Herat to the province of Faryab. *Carpocoris fuscispinus* is also widely distributed throughout the country, but its population is very low. Finally, *Dolycoris penicillatus* is generally the most abundant species in the northern provinces of Herat, Badghis, Faryab, Sar-i-Pol, Juzjan and, to a lesser extent, the provinces of Balkh and Samangan (Fig. 3).

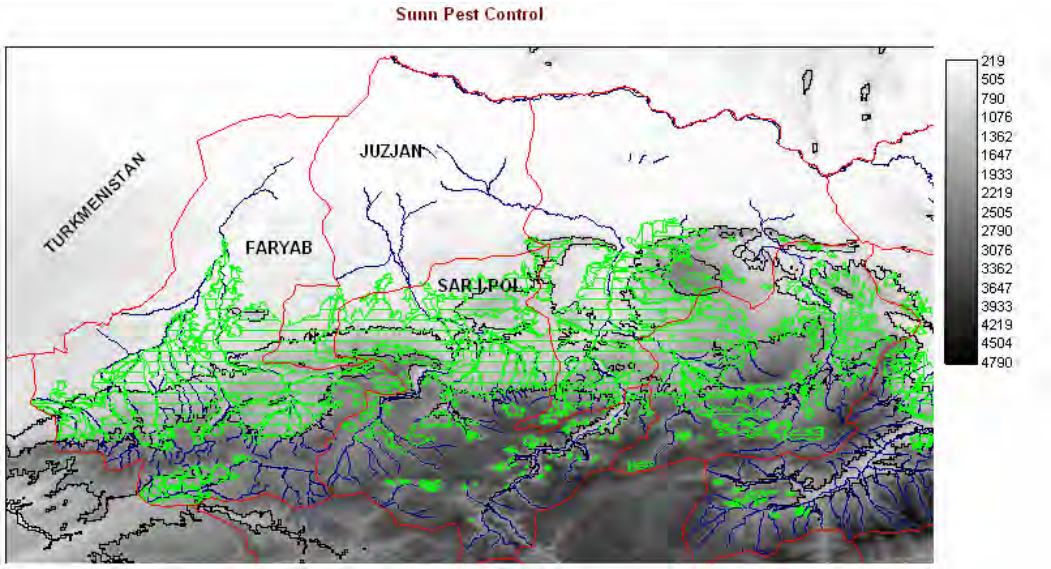

Figure 3. The Provinces of Juzjan, Sar-i-Pol and Faryab, showing the 1000 m and 2000 m contours and the area of rainfed cultivation (green hatching).

Adult *D. penicillatus* spend the winter at about 2 000 meters in bushes under the snow. In the spring, they migrate to the low altitudes where the first flush of vegetation is occurring. Here they breed and may cause damage to a variety of crops. Once adult, the new generation migrates to mid-altitudes, where it causes extensive and severe damage to ripening wheat. At the end of the growing season, the insects enter a period of summer dormancy (aestivation) and then in the autumn, migrate to high altitudes, where they hibernate in dense aggregations.

During the 1990s, FAO developed a system of sunn pest control by which farmers used sweep nets to remove the insects from the crop physically and to carry out chemical control using hand-held, battery-driven ultra light volume sprayers. This was supported by a program of survey and extension to ensure that farmers were warned and equipped in advance of the arrival of the migrating adults.

In 2002, FAO carried out a survey of sunn pest hibernation sites, using the methodology developed in the 1990s. At that time, following a severe drought, the sunn pest population was found to be low, but it was apparent that a return to normal rainfall and the spread of wheat cultivation following the return of refugees, would result in an increase in numbers that would eventually reach outbreak proportions. In spite of this, FAO was unable to continue the program of surveillance. Consequently, in 2004, there was a disastrous outbreak, mainly in Faryab and Sar-i-Pol, for which no preparation had been made.

FAO and its collaborators (under RAMP) carried out a pest control program since 2004 with the following objectives:

I. Locust control: i) to prevent damage to crops from locust attack; and ii) to reduce substantially the locust population to a level at which it can be maintained without major international assistance.

II. Sunn pest control: i) to enable farmers to protect their crops from sunn pest attack; and ii) accumulate data to provide the basis for a sustainable long-term management scheme.[9]

IV. Methodology

Wheat is used as a proxy crop to estimate the impact of the interventions. Prior to the estimation of the impact, the area affected by pests and yields in the absence of infestation is assessed to determine the tonnage of wheat saved. Different wheat prices are used for the three years with or without a discount for low quality of grain (in the case of sunn pest).

4.1 Locust

The hectares planted to rainfed and irrigated wheat, and yields, by province for 2004 and 2005 are shown in Table 1.

Table 1. Wheat production in selected northern provinces in 2004 and 2005.

		Rainfed		Irrigated	
Province	**Year**	**area (ha)**	**yield (MT/ha)**	**area (ha)**	**yield (MT/ha)**
Balkh	2004	60,000	0.42	78,000	2.44
	2005	154,000	1.05	89,000	2.50
Kunduz	2004	20,000	1.00	85,000	2.33
	2005	14,000	1.40	93,000	2.50
Samangan	2004	110,000	0.55	12,000	3.33
	2005	127,000	1.05	16,000	2.62
Baghlan	2004	60,000	0.75	50,000	1.99
	2005	74,000	1.50	54,000	2.50
All provinces	**2004**	**250,000**		**225,000**	
	2005	**369,000**		**252,000**	

Source: FAO/WFP (2004) and FAO (2005).

Risk assessment for 2004 and 2005. It is assumed that control operations indicate the presence of locust that threatened crops in the vicinity. The problem is to define the level of risk and the extent of the vicinity. Without an accurate measure of locust numbers in each location and with no direct relationship between areas treated, numbers of locust killed and crops saved, all records of control are treated equally. All $1/10^{th}$ degree squares in which control took place are identified. The area of irrigated and rainfed cultivation within each square is extracted using the IDRISI GIS.

It is assumed that all crops within a square in which control occurred were at risk. Bearing in mind that in some squares with a high locust density, the risk would have

[9] The objective of this assessment is not to evaluate the effectiveness of FAO interventions in the sustainability of these practices, rather, only the estimation of economic benefits in the short-term.

extended beyond the square, it is assumed that the total crop area at risk was equal to the sum of the area of crops in the squares in which control took place. In other words, the squares with low risk and those which would have extended further average out. This is not a very robust assumption, as it has no model of adult swarm displacement. It should be valid if the crop areas and locust control are distributed randomly with respect to each other, but, in 2005, this ceased to be true as it will be discussed below. However, in the present state of knowledge, there is nothing better (FAO, 2005).

Crop Assessment for 2004 and 2005. The area of crops within the squares in which pest control took place is calculated as follows. The data are expressed as IDRISI raster images: i) Two IDRISI raster images (irrigated and rainfed cultivation) with pixels indicating crop presence having a value of 1 and all others having a value 0. ii) Two IDRISI raster images (irrigated and rainfed cultivation) in which each province has a value (hectares reported by CFSAM as planted to wheat, divided by the hectares recorded by Land Cover Survey in that province). iii) An IDRISI raster image in which each square in which pest control took place has a value of 1 and all other areas 0.

The three layers are overlaid by multiplying them together and the total values of the pixels in the resultant raster image recorded. The number of pixels in each province is extracted from this image to a table and multiplied by 4 to allow for the fact that there are 4 hectares to each pixel. This procedure is carried out separately for irrigated and rainfed cultivation. The quantity of wheat is estimated by multiplying the number of irrigated and rainfed hectares by the yields for each province recorded by CFSAM.

A correction factor to the crop areas given by the Land Cover Survey is calculated for each province from the CFSAM data[10] and the results of these estimations carried out by the end of 2005 are included in Table 3.

Table 3. Estimate of crops saved in 2004 and 2005.

		Area (ha)		Production (MT)		
Province	**Year**	**Rainfed**	**Irrigated**	**Rainfed**	**Irrigated**	**Total**
Balkh	2004	19,047	27,815	8,000	67,869	75,869
	2005	19,676	14,833	20,660	37,082	57,742
Kunduz	2004	1,945	33,406	1,945	77,836	79,782
	2005	2,835	44,427	3,968	111,067	115,036
Samangan	2004	16,891	4,266	9,290	14,206	23,496
	2005	11,802	2,493	12,392	6,531	18,923
Baghlan	2004	35,719	34,943	26,789	69,537	96,327
	2005	5,664	14,092	8,496	35,230	43,726
Total	2004	**73,603**	**100,431**	**46,024**	**229,448**	**275,473**
	2005	**39,977**	**75,844**	**45,516**	**189,910**	**235,427**

Source: FAO/WFP (2004) and FAO(2005).

Crop assessment and risk infestation for 2006. The assessment for wheat yield in May 2006 was done using the Normalized Difference Vegetation Index (NVDI) provided by

[10] Detailed procedures used in the treatment of land satellite images are provided in FAO (2005).

the Agrometeorological Network in Kabul (USAID/USGS, 2006).[11] The image comparing the situation in April 2006 with respect to that in April 2005 shows less vegetation in the provinces of Kunduz, Balkh and Baghlan, and very small difference is observed for Samangan (Fig. 4). The comparison of April 2006 with respect to the long-term average (2003-2006) shows a more pronounced water deficit, as expressed by the NVDI. Based on the qualitative balance of colors in the 2006/2005 NVDI image it is estimated that wheat yields in 2006 in Kunduz, Balkh and Baghlan are likely to be 15 percent below those of 2005 and 5 percent below in Samangan.[12] These estimates were further multiplied by the ratio of area under rainfed wheat to area under irrigated wheat in 2005 (Table 4). This multiplier assigns more weight to the provinces with more reliance in rainfed wheat than those with more reliance on irrigated wheat assuming that irrigated wheat is almost independent of rainfall availability (farmers have enough water to compensate for the possible water deficit if rainfall is scarce).

Table 4. Estimate of rainfall effect in the 2005-2006 season.

	Province			
	Balkh	**Kunduz**	**Samangan**	**Baghlan**
Rainfed to irrigated area, 2005	1.33	0.06	4.73	0.40
Decreased vegetation (NDVI)	-0.15	-0.15	-0.05	-0.15
Rainfall effect in 2005-06	-0.20	-0.01	-0.24	-0.06

Source: Table 3, and RAMP assessment of the NDVI image for April 2006 (USAID/USGS).

Wheat yield estimates for 2006 have been released by FAAHM (2006) and are very similar to the yields for 2005. However, their assessment was based on the March image of NDVI. Our assessment, based on the April image, is much more conservative because "harvesting of rainfed wheat is done as late as in August/September, especially in the highlands" (FAAHM, 2006, p. 6).

[11] NDVI provides an estimation of the health of vegetation and the means of monitoring changes in vegetation over time. Values close to zero mean little or no vegetation and values close to +1 (0.6-0.9) indicate high density of green leaves.

[12] This is a visual assessment of the NVDI images published by the USAID/USGS (2006).

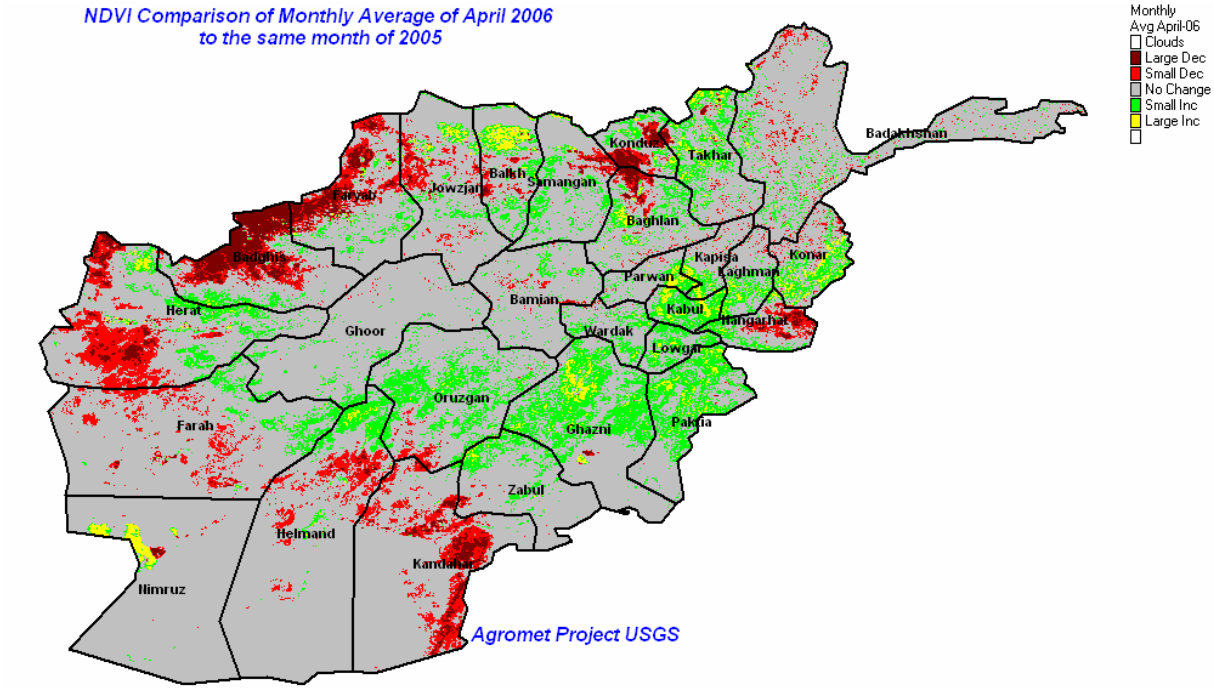

Figure 4. Normalized Difference Vegetation Index for (USAID/USGS, Kabul).

Further, the effect of pest control practices in 2004 and 2005 is assumed to have a negative effect in the incidence of locust in 2006. A 15 percent less incidence of locust is assumed for 2006 based on the "less tonnage saved in 2005" compared to 2004 (difference between tonnage in 2004 minus tonnage in 2005 relative to the tonnage in 2004, Table 3). Continuous application of control measures in locust also tend to reduce the cost of these control measures, this is the underlying working hypothesis of FAO regarding the sustainability of pest control programs.

Both rainfall and pest control effects are added, then multiplied by the saved metric tons in 2005 (Table 5). For example, in Balkh, the effect of water deficit plus the declining incidence of locust outbreak adds to 35 percent, which is used to estimate the total number of metric tons saved in 2006 (37,500). The estimate for the 4 northern provinces is 180,400 metric tons. These estimates need to be verified once the areas and yields for rainfed and irrigated wheat become available, the incidence of locust infestation is known in the different provinces and further adjusted by the Land Cover Survey data in GIS.

Table 5. Estimate of number of metric tons saved in 2006.

Province	Saved MT in 2005	Rainfall effect in the 2005-06 season	Pest control effect in previous years	Estimated MT saved in 2006
Balkh	57,742	-0.20	-0.15	37,591
Kunduz	115,036	-0.01	-0.15	96,679
Samangan	18,923	-0.24	-0.15	11,605
Baghlan	43,726	-0.06	-0.15	34,531
Total	235,427			180,407

Source: Tables 3 and 4.

4.2 Sunn Pest

In the spring of 2005 the extensionists carried out a survey of the known breeding areas for sunn pest (Fig. 5); breeding was observed mainly below 1000 m altitude. The surveyors visited the villages in their areas to distribute nets where there were infestations and to organize chemical control where this was necessary. They were also instructed to sample the density of sunn pest by counting the number caught in ten sweeps of the net.

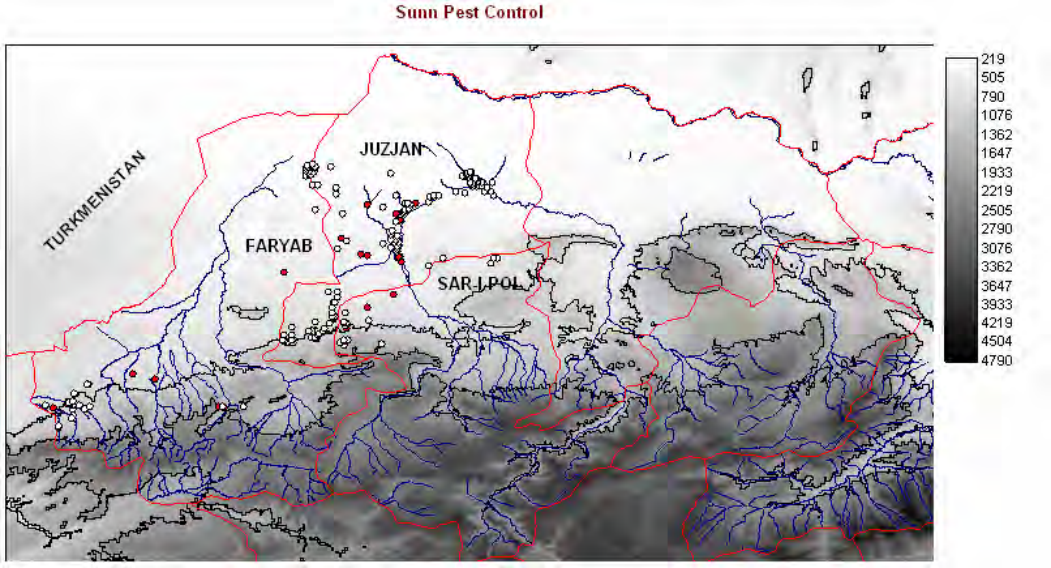

Figure 5. Sunn pest spring survey 2005; points in red indicate nymphs recorded.

For the first year, this activity was carried out between mid-November and mid-December 2004 with extensionists visiting about 2000 farms in six provinces. The total number of nets distributed to the farmers was approximately 44,500. It is assumed that one net is can protect one hectare. About 18,500 liters of delamethrin were distributed and it is assumed that one liter of pesticide can protect one hectare against sunn pest (FAO, 2005). Surveyors sampled wheat plants and analyzed them at the Plant Protection and Quarantine Department (PPQD) of the Ministry of Agriculture and Food in Kabul to estimate the overall level of sunn pest damage.

RAMP specialists in collaboration with CADG assessed that the damage of infestation in 2005 decreased yields by 30 percent (out of 2.8 metric tons per hectare under irrigation, and out of 1.2 metric tons per hectare under rainfed conditions in a good year as 2005 without infestation).[13] The saved tonnage is equivalent to the 30 percent reduction in yield (Table 6).

Table 6. Estimated tonnage saved due to sunn pest control in 2005 and 2006.

		PROVINCE						
Year		**Juzjan**	**Sar-i-Pol**	**Faryab**	**Herat**	**Balkh**	**Helmand***	**Total**
	No. Ha	10,730	10,242	24,249	17,124	870	20,000	83,215
	MT	9,013	8,603	20,369	14,384	731	39,200	92,301
2005	Saved MT	3,863	3,687	8,730	6,165	313	16,800	39,557
	No. Ha**	10,730	10,242	24,249	17,124	870	--	63,215
	Rainfall effect***	-0.4	0	-0.25	-0.05	-0.05	--	--
	MT	5,408	8,603	15,277	13,665	694	--	43,647
2006	Saved MT	2,318	3,687	6,547	5,856	297	--	18,706

* Helmand conducted pest control measures independently of RAMP in 2006.
** Assumed to be the same as in 2005.
*** Estimate from NDVI image of April 2006.

The estimation of metric tons saved in 2006 campaign was done taking into consideration the Normalized Difference Vegetation Index for the month of April (USAID-USGS, 2006). The image shows less vegetation in 2006 compared with 2005 in the northwestern provinces of Juzjan, Faryab, Herat and Balkh (Fig. 4). The exception is the province of Sar-i-Pol with more vegetation than last year in the same month. It is assumed that rainfall deficits in 2006, approximated by the NDVI, will decrease wheat yields by 40 percent in Juzjan, 0 percent in Sar-i-Pol, 25 percent in Faryab, 5 percent in both Herat and Balkh. The conservative approach followed in the estimation of yields in 2006 is very important for rainfed wheat cultivated in the highlands of Juzjan, Faryab and Balkh because harvesting could take place as late as August/September. It is assumed that the number of hectares under control in 2005 will be at least the same as in 2006.[14]

4.3 Wheat prices 2004-2006

Wheat price in Afghanistan in July 2004 varied from 8 Af/kg to 10.5 Af/kg with a median of 9 Af/kg, which is equivalent to US$188 per metric ton (FAO/WFP, 2004). Prices in July 2005 varied from 9 to 12 Af/kg with a median at 10.5 Af/kg, which is equivalent to US$ 219 per metric ton (FAAHM, 2005a). The price for 2006 was assumed to be 7.5 percent above the price of 2005 (food consumer price index, FAAHM, 2006), which is equivalent to US$230 per metric ton. This is a conservative assumption also congruent with the record high wheat production expectations by FAAHM (2006) at

[13] FAO suggested to assume that one half of the 1.2 metric tons/ha are lost due to sunn pest infestation. RAMP's assessment for effect of sunn pest is dual, 30 percent reduction in yield and 45 percent reduction due to lower price of grain due to poor quality.
[14] As of this writing, the campaign is in motion and the final area covered with additional staff is highly dependent on the field conditions, in and out of the cropping areas, and the highly variable population dynamics of *D. penicillatus*. FAO has duplicated the number of surveyors deployed in the field.

about 4.4 million metric tons. The price of wheat is reduced by 45 percent if there is damage of sunn pest (see footnote 12).

V. Results

5.1 Locust Control

The wheat tonnage saved in 2004 and 2005 in Table 3 and RAMP estimates for 2006 in Table 5 were multiplied by the corresponding prices of wheat to obtain the impact of locust control measures (Table 7).

Table 7. Wheat tonnage saved and value of locust control measures.

	Production (MT)			Value (US$)		
Province	**2004**	**2005**	**2006**	**2004**	**2005**	**2006**
Balkh	75,869	57,742	37,591	14,225,438	12,631,063	8,659,464
Kunduz	79,782	115,036	96,679	14,959,125	25,164,125	22,270,811
Samangan	23,496	18,923	11,605	4,405,500	4,139,406	2,673,392
Baghlan	96,327	43,726	34,531	18,061,313	9,565,063	7,954,435
Total	**275,473**	**235,427**	**180,407**	**51,651,375**	**51,499,656**	**41,558,102**
Total MT saved in 3 years			**691,307**			
Total Value (US$) saved in 3 years						**144,709,133**

Source: FAO (2005) and personal communication with Andrew Harvey (FAO Locust and Sunn Pest Specialist).
Figures for 2006 are estimates by RAMP (see text).

In 2004, the tonnage saved in the four provinces in northern Afghanistan was 275,000, it was 235,000 in 2005 and it was estimated at 180,000 in 2006. The lower number of tons saved in 2005 was offset by the price increase from 2004 to 2005. The value of saved wheat was US$51.5 million in both years. A further decline in the estimate of metric tons saved in 2006 with respect to 2005 determined a US$10 million lower value of the pest control measures in 2006 even though the assumed price of wheat is 7.5 percent above that price in 2005. The tonnage saved over 2004 to 2006 is about 0.69 million metric tons and the benefit claimed by RAMP is US$144.71 million.

There are few, if any, satisfactory studies of actual damage by locust. Estimating potential damage by s is highly problematic. The procedure used by FAO seeks to apply an objective and reasonable method to the available data within the capacity of the project (FAO, 2005). However, it is accepted that the method has limitations. This method takes no account of crops other than wheat which were at risk from s. This is because of lack of data. It takes no account of potential long distance (>10km) displacement of adult swarms. This was significant in years (such as 2005) when pest control was predominantly in remoter areas away from crops, but close enough for s to migrate into them. The use of a grid means that the risk is not estimated precisely by distance, since the locust control would not necessarily be in the centre of the square. However, where, as is the case here, many squares are contingent, this should not cause an error. It takes no account of the savings in control costs the following year achieved by reducing the locust population.

RAMP estimates for wheat saved in 2006 due to locust require verification. This estimate is conservative and takes into account the available information on NDVI, which is used for productivity and land use studies and is sensitivity of figures to rainfed areas and irrigated areas; also, it takes into account effect of previous campaigns to arrest locust infestation.

5.2 Sunn pest control

The 2005 and 2006 estimates of tonnage saved and the value of not facing reduced grain price if infestation is avoided is presented in Table 8. Yield in 2006 was adjusted for lower rainfall availability, as suggested by the NDVI image of April 2006. About 58,000 metric tons of wheat is saved for both years with a value of US$12.9 million and US$13.6 million were saved in the price of wheat grain not damaged by sunn pest with a combined effect of $26.5 million.

Table 8. Wheat tonnage saved and savings in grain price in 2005 and 2006 due to sunn pest infestation.

	Saved MT	Value (US$) Saved MT	Savings in grain price (US$)	Total (US$)
2005	39,557	8,653,181	9,085,840	17,739,022
2006	18,706	4,309,044	4,524,496	8,833,539
Total	**58,263**	**12,962,225**	**13,610,336**	**26,572,561**

Source: Table 6.
2006 are estimates adjusted by NDVI.

5.3 RAMP's impact

The combined control measures for both locust and sunn pest between 2004 and 2006 accrued to 750,000 metric tons of what saved with a value of US$171 million (Table 9), which is the impact claimed by RAMP. The average tonnage saved per year, 250,000 metric tons, is equal to the average annual food aid since 2000 (Fig. 1); thus, representing a meaningful contribution to Afghan food security. The cost of the control program over the three year period was US$2,575,770 with returns to investment of 6650 percent, or a 66-fold benefit relative to the cost.

Table 9. Tonnage and value of wheat saved with pest control between 2004 and 2006.

	MT	US$
Locust	691,307	144,709,133
Sunn pest	58,263	26,572,561
Total	749,571	171,281,694

Source: Tables 7 and 8.
Sunn pest control did not take place in 2004.

Spillovers. There are a number of areas in which the project has had a beneficial effect beyond the immediate objective of preventing crop damage by locust and sunn pest:

i) it has given confidence to farmers that the government and aid community can intervene effectively to deal with potential disasters;
ii) it has revived community action in dealing with pest control;
iii) it has re-engaged provincial Ministry of Agriculture, Animal Husbandry and Food (Plant Protection and Quarantine Department) staff in field operations;
iv) it has built up knowledge of locust and sunn pest control technology in the farming communities (FAAHM, 2005b);
v) farmers, extensionists and policy makers have realized that other crops than wheat have also benefited from pest control;
vi) sunn pest control in Helmand province is currently carried out by CADG with financial support from other sources besides RAMP. It is extremely encouraging that some implementing agencies are becoming self-sufficient to carry out control measures;
vii) the Agrometeorological Monthly Bulletin has set the stage as a real time service provider for GIS applications and impact assessments (as this one). Its long-term mission will improve the knowledge base to cope with scarce and variable rainfall.

These are spillovers that may accrue in future benefits but could not be quantified at this stage. Higher and less variable wheat production contributes to reduce food insecurity and favors the conditions for farmers to adopt crops with higher value added.

VI. Conclusion

Pest control interventions by RAMP and its implementing partners have paid off with large quantity of wheat being saved. About 691,000 metric tons were saved from locust infestation between 2004 and 2006. In addition, 58,000 metric tons were saved from sunn pest attack in 2005 and 2006. The wheat tonnage saved in 2004 and 2005 with both pest control interventions adds to 0.551 million metric tons, which is 8 percent of the national production or 105 percent of the food aid received by Afghanistan (Fig. 1) during those years. RAMP conservative predictions for 2006 include 180,000 metric tons of wheat saved due to locust control and 19,000 metric tons due to sunn pest control.

The estimated value of the wheat tonnage saved to the Afghan people is US$144.71 million for locust control and US$26.57 million for sunn pest. The total of US$171.28 million is valued using wheat, a low value crop. Personnel from the Ministry of Agriculture, Animal Husbandry and Food have been trained and re-engaged in pest control interventions. The successful campaign to control sunn pest in Helmand last year was key to secure funds for the 2006 campaign in that province, and is now been executed by CADG. The methodology to monitor pests, the design of effective preventive actions, and the use of GIS with the support of updated agrometeorological information provided by the USAID/USGS has benefited farmers.

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