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AFGHANISTAN AGRICULTURAL SECTOR SUPPORT PROJECT/PRIVATE SECTOR AGRIBUSINESS (AASSP/PSA) FUNDED BY THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
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EXECUTIVE SUMMARY

The Afghanistan Agricultural Sector Support Project (ASSP) has been involved in an ongoing assessment of cereals production for Afghanistan. Developing better wheat acreage and production estimates have been an important part of this assessment - particularly since other estimates are either unreliable or lack statistical rigor, and conflict with each other. Improving upon estimates of current production of Afghanistan's most important foodgrain, wheat, is an essential first step toward determining food availability and planning for the rehabilitation of the agricultural sector.

A wheat planting survey was undertaken by ASSP during the fall of 1992. The objectives of the survey were twofold. First, to provide an indication of the area planted to wheat and allow preliminary production projections for 1993 to be made well in advance of the actual harvest. And second, to use the information to check the accuracy of the satellite imagery interpretation showing agricultural areas, and the validity of assumptions used in earlier mathematical models to estimate wheat production. Because most rainfed wheat is planted early in the new year, the wheat planting survey was limited to irrigated areas.

The survey methodology is best described as a modified area frame sampling technique. Sample points were selected at random from areas identified as "irrigated agriculture" from satellite imagery by the Earth Satellite Corporation (EarthSat), a U.S. based sub-contractor to DAI. The procedure then required that survey teams go to the sample points using a geographic positioning device (GPS), and record the land use along a 500 meter survey line. The teams were also instructed to interview farmers, where available, about their cultural practices. The wheat planting survey is the second effort undertaken by the project to estimate wheat area for Afghanistan using this methodology. The first survey done in Balkh and Jawzjan Provinces in the northern part of the country also involved taking crop cut samples to estimate wheat yields.

Eleven provinces were initially selected for the wheat planting survey based on their share of total agricultural area. These provinces are thought to account for over two-thirds of the total agricultural land in Afghanistan and further have the advantage that they represent all the historically important agricultural regions in the country. However, because of poor security conditions in northern and other parts of Afghanistan, the survey was limited to four provinces: Kandahar, Helmand, Ghazni, and Herat.

The teams completed 52 sample points in Helmand, 48 in Kandahar, 41 in Ghazni, and 49 in Herat Province. The survey was unable to cover the provinces completely because poor security conditions made several sample points inaccessible, and because the approach taken

in numbering the points systematically excluded the southern most portion of each province. For each sample point not completed, the surveyors substituted contingency points, also randomly selected, from a numbered list provided to them.

Farmers were interviewed about their planting plans in some cases where the surveyors reached the sample points before the winter crop had been planted. As a result, the estimates are based on a mixed methodology of direct observation and interview. This methodology tends to impart upward and downward biases to the estimates, although the biases are not thought to have substantially affected the results.

The survey found that the proportion of satellite imagery defined "irrigated agricultural area" that was under wheat varied considerably among provinces. It accounted for a third of the total area in Helmand, about a quarter in Ghazni and Herat, and only one-fifth in Kandahar Province. These results are largely consistent with the findings of an earlier ASSP survey for Balkh and Jawzjan Provinces where a third of the total "agricultural" area was estimated as being under wheat. Further, wheat accounted for between 50-65% of the total crop area in all provinces except Helmand where it was considerably higher.

The total irrigated wheat area planted for 1992/93 is estimated at 73,587 hectares for Helmand, 39,232 ha for Kandahar, 32,961 ha for Ghazni, and 52,105 ha for Herat. These estimates refer to land under fall planted wheat in areas classified as "irrigated agriculture" from satellite imagery. They exclude spring planted irrigated wheat (where present) as well as whatever irrigated wheat might be planted in satellite imagery defined "rainfed agricultural areas." Since nearly all the irrigated wheat in Helmand and Kandahar Provinces is planted in the fall and winter, the wheat area estimates for these two provinces are thought to better represent the total irrigated wheat acreage.

A comparison with other estimates suggests that, with the exception of Helmand Province, the irrigated wheat area for 1992/93 is lower than what it was in pre-war years, and substantially lower than recent estimates obtained from preliminary interpretation of satellite imagery. Provisional irrigated wheat production projections have also been made for each province. However, these projections are extremely tentative because they depend upon uncertain assumptions about wheat yields.

Despite its limitations with respect to non-sampling errors and incompleteness, the ASSP survey demonstrates that its methodology to estimate crop area is practical in the unique set of circumstances that exist in Afghanistan. This methodology can provide objective and reliable estimates of crop area (and production when combined with crop cut samples) with a relatively modest outlay of resources.

It is unclear, however, whether a wheat planting survey in fall is advisable given the problems associated with combining farmer interviews with direct observation and the inability to cover rainfed areas. A better alternative may be to carry out the survey in March whose results would still become available three months earlier than a June wheat production survey.

ACKNOWLEDGEMENTS

The 1992/93 Wheat Planting Survey would not have possible without the participation of a large number of persons. Some of them are named below:

Fred Warren, Miles Toder, Kamil Lodhi (survey design and analysis)

Asif Niazi, Mehdi Hasanan, Muznah Iqbal, Faridoon (sample point selection programming and plotting)

Fayaz Khan, Haider Ghani (training and coordination)

Temur Aziz, Ajmal Hussain, Mohammad Usmani, (logistical planning and supervision)

Nabi Aslamy (agronomy and crop identification)

Khairullah Dawlaty (training and translation)

Muzzafaruddin Hashemi (data editing and coding)

Hashim Ali, Shazia Yousafzai (data entry programming)

In the ultimate analysis, it was the surveyors and drivers who went into Afghanistan who made the survey possible. These surveyors, named below, demonstrated their ability to work under difficult conditions. That they completed the survey despite receiving news before they left that the follow on ASSP project had been cancelled, is a testimony to their commitment to Afghanistan's development.

Hedayatullah, Mohammad Naseem, Mohammad Hanif, Attiullah, Mohammad Ibrahim, Abdul Khalil, Jalaluddin, Mohammad Shah, Fazal Mohammad (team leaders),

Naquib ur Rehman, Shafiqullah, Naquibullah, Mohammad Aqa, Abdul Wahid, Abdul Jamil, Abdul Wakil, Saleh Mohammad, Mohammad Noman, Assadullah Habibi, Jellaluddin, Mohammad Rafi, Inayatullah, Rahmuddin, Mohammad Shafi, Heyatullah, Abdul Mannan, Mohammadzai (surveyors)

Kamil Lodhi was responsible for analyzing the data and writing the final report.

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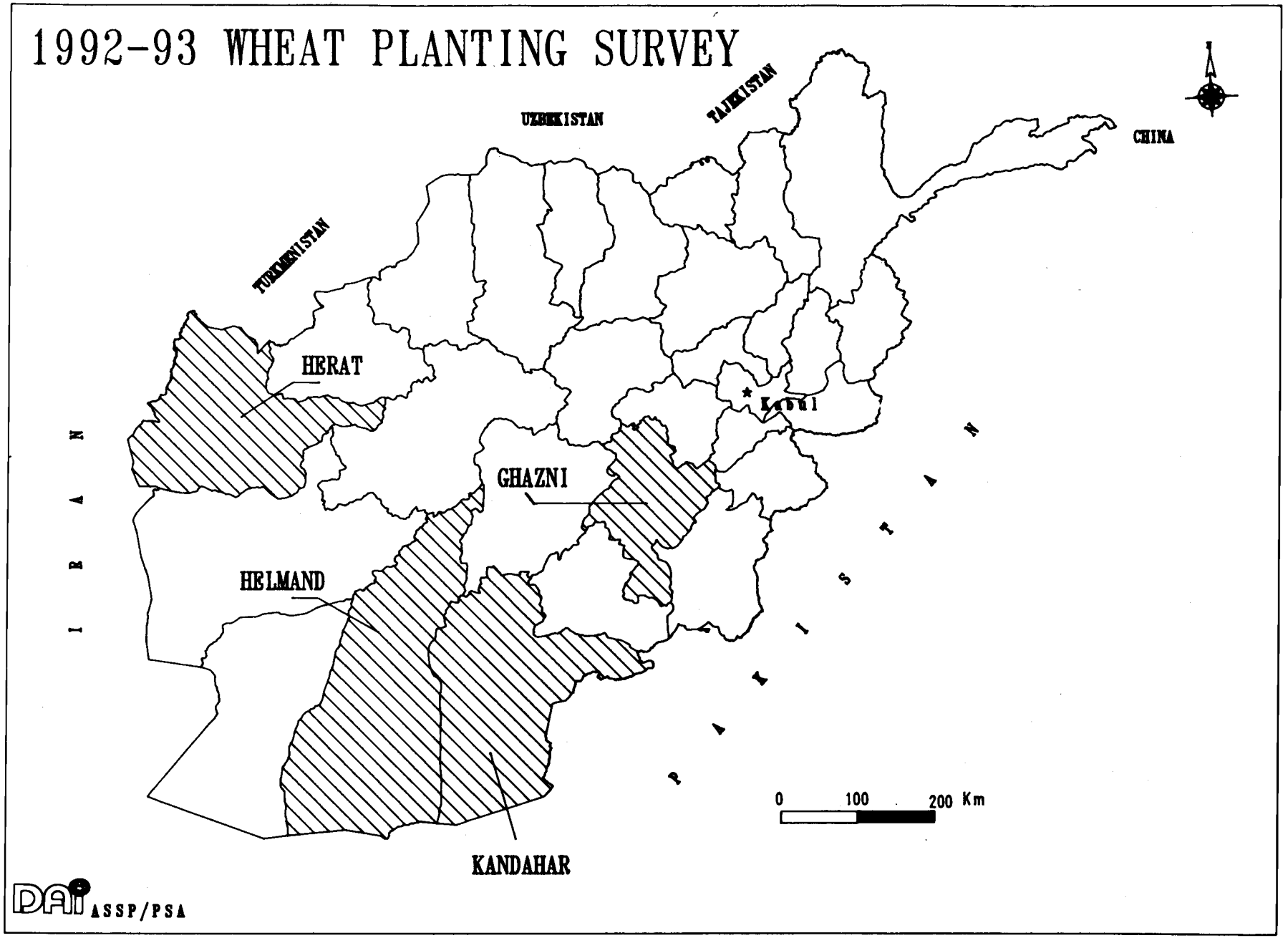
1992-93 WHEAT PLANTING SURVEY
UZBEKISTAN
TAJIKISTAN
CHINA
TURKMENISTAN
HERAT
Kabul
GHAZNI
HELMAND
KANDAHAR
I R A N
P A K I S T A N
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ASSP/PSA

1. INTRODUCTION

Since its inception, the Afghanistan Agricultural Sector Support Project (ASSP), has been involved in an ongoing assessment of cereals production for Afghanistan. This assessment has been motivated by a lack of reliable information on domestic food production and the concern that large sections of the population in Afghanistan are vulnerable to food shortages. Recent official food production statistics are considered unreliable because the government did not physically control many parts of the country since hostilities began in 1978. Other estimates produced by various agencies differ substantially both from official data and each other, and are difficult to evaluate because they are based on non-comparable methodologies.

To overcome this information deficiency, the project has mobilized resources to monitor food prices through regular market surveys and estimate foodgrain production based on satellite imagery interpretation, the development of mathematical models, and ground surveys. The primary focus for the food availability assessment has been wheat, a staple food in Afghanistan, accounting for over two-thirds of total foodgrain production.

The methodology used by the project to estimate wheat production has evolved over time partly in response to opportunities arising from changing conditions in Afghanistan. Earlier estimates were based largely on satellite imagery and mathematical models[1] with minimal ground truthing because of the difficulty in physically accessing many parts of the country. More recently, as physical access has improved, estimates have been based on a combination of satellite imagery and more conventional ground probability surveys. The 1992 wheat production survey for Balkh and Jawzjan Provinces, for example, was the first attempt by the project to obtain statistically rigorous wheat acreage, yield, and production estimates using such a methodology.

Based on the experience of the production survey, it was decided to undertake a wheat planting survey during the fall of 1992. This decision was influenced by two main considerations. First, although yield measurements would not be possible, the survey would provide an indication of the area planted to wheat and allow preliminary production estimates for 1993 to be derived well in advance of the actual harvest. The next complete wheat production survey could not be carried out before the crop was mature in May or June 1993, and its results would therefore not be available before August next year at the earliest.

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[1] An example is CROPCAST, a crop estimation model developed to estimate wheat production by the Earth Satellite Corporation, a U.S. based subcontractor to DAI/ASSP.

Second, the survey would provide information on several important wheat producing provinces which were not covered in the 1992 wheat production survey. This information would be used to check the accuracy of the satellite imagery interpretation showing agricultural areas for those provinces as well as the validity of the assumptions used in earlier mathematical models to estimate wheat production. A secondary consideration was that the survey would enable the project's surveyors to acquire more field experience in the methodology developed to estimate crop area for Afghanistan.

2. METHODOLOGY

The survey methodology is best described as a modified area frame sampling technique. Sample points were selected at random from areas identified as "agricultural" from satellite imagery. The procedure then required that survey teams go to the sample points using a geographic positioning device (GPS), and record the land use along a 500 meter survey line. The teams were also instructed to interview farmers, where available, about their cultural practices. The findings of the survey with respect to the information on cultural practices will be presented in a subsequent report. The survey methodology is discussed in greater detail below.

2.1 Province Selection Criteria

As in the case of the 1992 wheat production survey, nation-wide coverage was not considered feasible due to time constraints and limited manpower and equipment resources. Like the previous survey, the wheat planting survey was extremely time sensitive. The former had to be scheduled as close as possible to the harvest, but not later, so that yield and area measurements could be obtained. The more recent attempt suffered from a different but equally limiting time constraint: the survey had to be undertaken as late as possible in the year to ensure that farmers had planted the wheat but before the onset of winter which would make many parts of the country inaccessible because of snow and rain. Because most rainfed wheat was planted early in the new year, the survey was restricted to irrigated areas.

The basic criterion for selecting provinces for this survey remained their share of the total land under cultivation as identified through satellite imagery interpretation by the Earth Satellite Corporation (EarthSat). It was assumed that provinces with more land under cultivation were likely to be major wheat producing areas. Irrigated areas were given twice the weight of

rainfed areas to reflect their higher productivity.[2] Provinces were ranked on the basis of their total cultivated area and the eleven highest ranked selected initially for the survey. Total rather than irrigated land was used to rank the provinces because of the possibility of surveying the rainfed areas in these provinces during the spring of 1993. With few exceptions, the list of provinces remains the same regardless of whether total or irrigated agricultural land is used as a ranking criterion: the top ranked provinces are also the ones with the largest irrigated areas. The provinces selected are listed below in Table 2.1:

TABLE 2.1 PROVINCES SELECTED FOR FALL WHEAT PLANTING SURVEY, 1992/93

Region	Province
South-west	Kandahar
	Helmand
North-west	Farah
	Herat
Central	Ghazni
North-central	Balkh
	Jowzjan
	Faryab
North-east	Kunduz
	Baghlan
	Takhar

Based on ASSP's earlier experience, it was considered that this number of provinces could be covered with the project's 9 survey teams in the available time given the requirements of the survey method. Taken together, these provinces are thought to account for over two-thirds of the total agricultural land in Afghanistan and further have the advantage that they represent all the historically important agricultural regions in the country.

[2] Wheat yields in irrigated areas are reported to be 2 to 2.5 times higher than in rainfed areas (Swedish Committee for Afghanistan, Twelfth Report, 1990 Survey, p. 12-13).

The only notable exclusion from the list is Badghis Province, which although it ranked high was omitted on account of its inaccessibility and uncertain security status. Badghis's high ranking was mainly due to the large rainfed area reported for that province.

2.2 Sample Plan

The sample frame for the survey was the area identified as "irrigated agriculture" by EarthSat. The sample plan considered that while the agricultural areas delineated from satellite imagery may include large areas of uncultivated/uncultivable land, any cultivated land has probably not been omitted. This conclusion was based on two factors. First, EarthSat qualified its estimates as representing upper limits of agricultural areas, possibly including significant uncultivated and/or non-agricultural lands; second, the estimates included areas which appear to have been under irrigation in the recent past. These estimates may more accurately represent the available supply of traditionally arable irrigated land in Afghanistan than that actually being cultivated at the time of imaging.[3] The exception to this observation is the northern portions of Faryab, Jawzjan, and Balkh provinces for which satellite imagery was not available.

A simple random sample was selected with equal probabilities in each province (see Section 2.3). This sampling system has two advantages:

(1) Because the sample points for each province are selected with equal probabilities, the calculations for computing survey expanded estimates are much simplified.

(2) Assuming that any incompleteness in the survey is not associated with the proportion of wheat, or other crop, at the survey point, then any such incompleteness can be taken as no more than the effect of a random deletion of sample points. Therefore, the lack of bias in the survey results is maintained and the only effect of the smaller sample size is a slightly larger variance of the estimate.

For each province, fifty samples were drawn at random from the areas identified as comprising irrigated agriculture. The accuracy from the survey was expected to vary according to the number of samples observed and the actual proportion of wheat to total land in the agricultural areas delineated from satellite imagery. It was estimated that 50 observations per province would result in

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[3] See Appendix A for a more detailed discussion of the definitions for "irrigated" and "rainfed" agricultural areas.

relative sampling errors from 15 to 20 percent if the actual proportion of wheat to total land is between 0.3-0.5. as estimated for Balkh and Jawzjan Provinces.[4] Then, assuming that the observed proportions of wheat to total land were reasonably consistent from province to province, the sampling errors for the 11 province total were expected to be between 4 and 7 percent.

2.3 Sampling Procedure

The sample was drawn separately for each province in the following manner. First, a computer file was prepared of all latitude-longitude coordinate intersections located in a province based on an arbitrary beginning point and sampling interval. Second, 5,000 random numbers were generated and assigned unique geographic coordinates corresponding with each grid point (agricultural and non-agricultural) for that province. This quantity of random numbers was chosen to ensure that sufficient points fell within the areas identified as "irrigated agriculture" for each province. Finally, the first 50 points located in irrigated agricultural areas were selected as the sample.[5]

Table 2.2 presents the sampling intervals used and points generated for each province (see Appendix B for a more detailed technical description of the sampling procedure).

The sampling procedure differed from the one employed for the 1992 Balkh and Jawzjan wheat production survey. For the latter survey, a two-stage sampling procedure was adopted in which first the number of grid points which fell in agricultural areas were generated from which the desired number of random samples were

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[4] Relative sampling errors (or cv) are computed as:

$$se = \sqrt{\frac{p(1-p)}{n}}$$

$$cv = \frac{se}{p}$$

where se is the sampling error, p is the actual proportion of wheat to EarthSat classifications of agricultural lands, and n is the sample size.

[5] Based on the project's previous experience, the actual number of sample points selected was higher to ensure that the surveyors would complete at least 50 observations per province. The additional samples were regarded as contingency points.

selected. The sequence was reversed for the fall wheat planting survey in that the random numbers were generated first followed by the selection of the first 50 plus points which fell in areas identified as agricultural. This procedure reduced computer processing time considerably while maintaining the randomness of the sample.

TABLE 2.2 SAMPLING INTERVAL AND POINTS GENERATED BY PROVINCE
WHEAT PLANTING SURVEY 1992/93 - AFGHANISTAN

Province	Sampling Interval		Total Grid Points [1]	Random Points	
	(min./sec.)	(degree)		Total [2]	In Irrigated Areas [3]
Baghlan	1, 00	0.017	21,626	5,000	90
Balkh	1, 00	0.017	10,381	5,000	242
Farah	1, 00	0.017	54,498	5,000	83
Faryab	1, 00	0.017	21,626	5,000	74
Ghazni	1, 00	0.017	21,626	5,000	114
Helmand	1, 00	0.017	51,903	5,000	81
Herat	1, 00	0.017	41,522	5,000	100
Jawzjan	1, 00	0.017	24,221	5,000	91
Kandahar	1, 00	0.017	48,443	5,000	99
Kunduz	1, 00	0.017	7,785	5,000	328
Takhar	1, 00	0.017	12,976	5,000	120

[1] Includes points in both agricultural and non-agricultural areas.
[2] Arbitrarily selected to ensure sufficient number fall in irrigated areas.
[3] Number of total random points falling in irrigated agricultural areas.

The location of each sample point was then plotted on the appropriate 1:100,000 topographical map to assist the survey teams in locating the selected points.

2.4 Field Procedures

The surveyors were given extensive training by ASSP staff in field procedures before the survey was launched. The training, given in Peshawar, Pakistan, focused on the explanation of the objectives of the survey, discussion of the survey instruments and field procedures, map reading, GPS operation, field exercises, and contingency plans for handling a wide range of situations. An important aspect of the training involved how to identify and differentiate among land recently planted in wheat, poppy and other crops.

2.4.1 Locating Sample Points

Topographic maps were used to guide the survey teams to the vicinity of each sample point. GPS units were then used to find the exact location to within +/- 20 meters.

2.4.2 Direction of Survey Line

The direction of the survey line was determined as follows:

- If the sample point were in a cultivated area along a stream or contained in a narrow valley, the survey line was parallel (down valley) to the stream.

- Otherwise, the direction of the survey line was a continuation of the direction of travel away from the survey vehicle.

2.4.3 Data Collection

Data on land use and cultural practices were recorded on forms developed for the survey. These forms, whose Dari translations were printed on the opposite side of each page, are shown in Appendix C. Form A was used to enter the land use measurements, and Form B to interview farmers about cultural practices. Each team was also provided with an instructions manual (see Appendix D) which explained the field procedures in detail and served as a reference guide. This manual was the same as that used for the ASSP 1992 wheat production survey. For the current survey, the surveyors were directed to disregard the instructions relating to the crop cut samples. The field data collection procedures are summarized below:

Area by Type of Crop and Land Use: If the sample point were not in a cultivated area and there were no cultivated land along the direction of travel, only the type of land use and terrain at the sample point was recorded. Otherwise, data collected from each survey line was the number of meters through each crop or land use, and whether the crop was irrigated. Different crops and types of land-use which could be recorded included:

- Crops: wheat, other cereals, poppy, horticultural crops, other crops, and fallow for cultivable areas;

- Non-crop: roads, habitations and other buildings, grassland and brush, rivers and canals, mountains or rocky areas, desert, and other (specify).

Cultural Practices: When available, information on cultural practices was obtained from farmers present during the land measurement.

3. RESULTS AND ANALYSIS

3.1 Implementation of Survey Method

The survey was carried out during November and December 1992. However, because of poor security conditions in northern and other parts of Afghanistan, the survey was limited to four provinces: Kandahar, Helmand, Ghazni, and Herat. The likelihood that the survey teams would have been unable to return to Pakistan before the project completion date of 31 December 1992 was another consideration to exclude the northern provinces from the survey. The teams which surveyed Kandahar, Helmand and Ghazni returned to Islamabad in mid December and those that covered Herat in the first week of January. All teams were extensively debriefed in Peshawar and Islamabad in order to understand their experience in carrying out the survey and to clarify questions which arose during the editing and coding of the survey forms.

The teams completed 52 sample points in Helmand, 48 in Kandahar, 41 in Ghazni, and 49 in Herat Province. The additional observations for Helmand were due to faulty communications between different survey teams in the field. Fewer observations were completed for Ghazni because poor security conditions made sample points in the western half of the province inaccessible.[6] In particular, sample points falling in Navor and Malestan areas in Ghazni and Musa Qala and Baghran in Helmand were excluded from the survey because of security considerations based on ethnic tension or reported fighting among different Afghan factions.

For each sample point excluded, the surveyors substituted the first contingency point available from the numbered list provided to them. In a few cases, the contingency point closest to the original point was selected if located nearby. The largest number of contingency points were completed for Ghazni Province because of the surveyor's inability to reach the original sample points.

During the process of overlaying the random points with irrigated agricultural areas, the ARC-INFO software sorted the randomly numbered sample points by latitude. This had the effect of numbering the sample points in ascending order starting from the top left hand corner of the grid. Because the first fifty numbers were designated as primary sample points, a proportion of the total irrigated area in each province - by definition in the bottom half - was excluded from the survey. This proportion depended upon the number of total points falling in irrigated areas for each province.

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[6] The western half of the province is populated by Hazaras, an ethnic group in Afghanistan, and characterized by lawlessness, banditry, and kidnapping in recent months due to tension among different ethnic groups.

Since the surveyors substituted contingency points for sample units they could not cover, the actual coverage of a province is based on the number of alternate points selected. The surveyors were instructed to pick the contingency points in ascending order from a numbered list when they were unable to complete a primary sample point. A rough approximation of the physical coverage of irrigated areas for each province is therefore indicated by the ratio of the last numbered point completed to the total number of points. According to this indicator, the survey covered 69% of the irrigated area in Kandahar, 68% in Herat, 87% on Ghazni, and 94% in Helmand Province. For Ghazni Province, the surveyors sampled all the points, including contingency points, in the eastern half of the province because the western Hazara half was inaccessible.

It is not known whether land use patterns in areas the surveyors failed to reach were different in any way from those they surveyed. It is difficult, therefore, to draw any conclusion about whether the results were biased in any way, nor about the direction and magnitude of the bias, if any. It is assumed, in computing the provincial estimates, that the areas excluded due to security reasons and the sample numbering error are similar in terms of land use patterns to the ones covered by the survey.

In some cases, the surveyors reached the sample points before the winter crop had been planted. This was due to inaccurate information about planting times in different areas; although the existence of a long planting season made it difficult to identify precisely the dates by which most of the area would have been planted in winter crops. It is also possible that planting dates have changed in recent years so that pre-war conventional wisdom about when farmers sow their crops is no longer valid. In the cases where they were early, the surveyors interviewed farmers to ascertain what, if any, crop the latter planned to grow on specific plots, and recorded the responses accordingly. This occurred at several sample points in Helmand, Kandahar and Herat, but not in Ghazni where the fall planting is completed earlier before the arrival of the winter snow. Farmers were also interviewed in cases where the surveyors could not identify the crop planted with certainty.

One implication of combining direct observations with farmer interviews is that the results should be interpreted as including <u>planned</u> as well as <u>actual</u> cropped area although the distinction between the two may not be important in practice as discussed below.

The fact that the sample is based on a mixed methodology tends to impart both upward and downward biases to the crop area estimates. The upward bias occurs because some of the observations recorded planting plans which may not have been realized due to a number of reasons including the non-availability of labor, water and seed. Also, farmers are likely, while reporting planned crop area, to

ignore small tracts which could not be cultivated because of, for example, the field gradient or poor soils. The downward bias occurs in cases where the farmers were not available for interview and the surveyors recorded the area as "fallow" or "uncultivated" although it may have been subsequently planted.

These biases are not thought to have substantially affected the results for the following reasons. First, in many cases the land for which interview responses were recorded had been prepared for planting. It is unlikely that farmers would have ploughed land if they were not reasonably confident that they could plant a crop on it. Second, the measurements were recorded on a plot-by-plot basis even where the information was obtained through an interview. This reduced the likelihood of farmers over estimating crop area by ignoring small non-cultivable patches. Finally, farmers were interviewed in almost all cases where the winter crop had not yet been sown, which reduced the possibility of erroneously classifying cropped area as fallow or uncultivated.

It was not possible to quantify these non-sampling errors because of the inability to distinguish between information from direct observation and farmer interviews for comparable provinces.[7] It is assumed in calculating the areas estimates, therefore, that the upward and downward biases offset each other.

The data was edited, pre-coded, and entered into dBase IV, and the results analyzed using Lotus 1-2-3 computer software.

3.2 Irrigated Wheat Area Estimates - 1992/93

Estimates of the average proportion of area under different land use categories for Helmand, Kandahar, Ghazni and Herat Provinces are shown in Figure 3.1 and its related table.[8] These estimates refer to land use patterns in areas classified as "irrigated agriculture" from satellite imagery. The latter classification does not necessarily indicate actual irrigated status.

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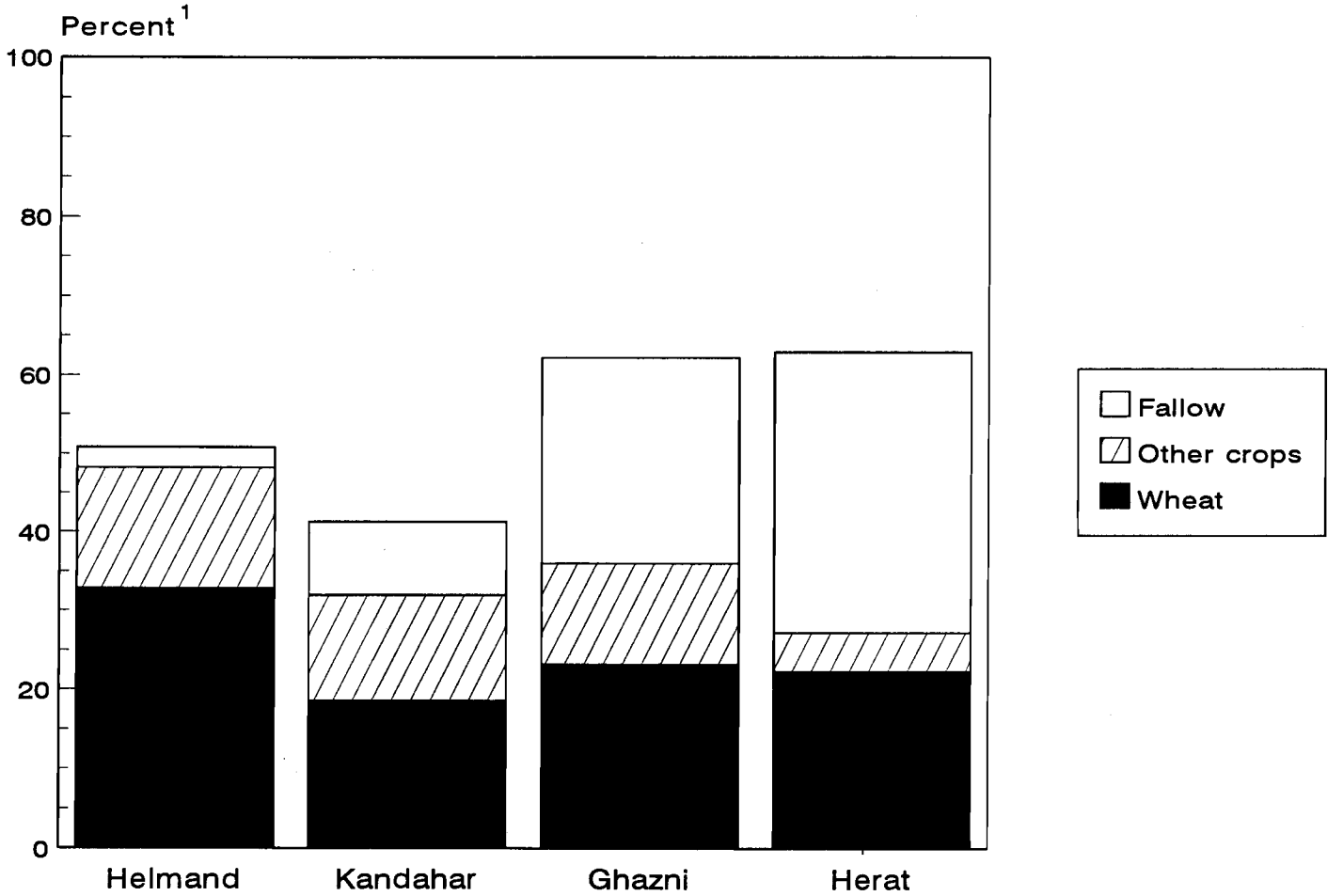
[7] Measurement and interview response biases are referred to as "non-sampling" errors. They are distinguished from sampling errors which occur because only a proportion of the population has been sampled, and which can be computed precisely. The total error of a sample estimate is the sum of sampling and non-sampling errors.

[8] See Appendix E for details of how the estimates and sampling errors were calculated.

Figure 3.1 Irrigated Agriculture Land Use Patterns, 1992/93

Selected Provinces, Afghanistan



1. Of area identifed as irrigated agriculture from satellite imagery

Table 3.1 LAND USE PATTERNS IN IRRIGATED AGRICULTURAL AREAS - SELECTED PROVINCES, AFGHANISTAN

	Helmand		Kandahar		Ghazni		Herat	
	[1]	c.v. [2]	[1]	c.v.	[1]	c.v.	[1]	c.v.
Proportion under:								
Irrigated Wheat	0.32	14	0.19	24	0.23	16	0.22	20
Rainfed Wheat	0.01	100	0.00	-	0.00	-	0.01	75
Total Wheat	0.33	14	0.19	24	0.23	16	0.23	19
Poppy	0.12	21	0.00	-	0.00	-	0.00	-
All Crops	0.48	11	0.32	18	0.36	13	0.27	17
Fallow	0.03	53	0.09	37	0.26	17	0.36	15
Total Cultivable [3]	0.51	11	0.41	16	0.62	10	0.63	9
Wheat as % of all crops	0.68	-	0.58	-	0.64	-	0.85	-

[1] Proportion of satellite imagery defined irrigated agricultural area.
[2] Coefficient of variation expressed as a percentage of the estimate.
[3] Total cultivable area = area under all crops + fallow.

Source: ASSP 1992 Wheat Planting Survey

The proportion of area under wheat varies considerably among provinces. It accounted for a third of the total area in Helmand, about a quarter in Ghazni and Herat, and only 19% in Kandahar province. The coefficient of variation which indicates the statistical reliability of the estimates is 14% for Helmand, 24% for Kandahar, 16% for Ghazni, and 19% for Herat.[9] The higher coefficient of variation for Kandahar reflects the lower overall proportion of wheat area in the province as well as the greater variability in wheat area along the sample survey lines.

In comparison, about a third of the total area was estimated as planted in wheat by a previous ASSP survey for both Balkh and Jawzjan Provinces - although for Jawzjan it included both rainfed and irrigated wheat area.[10] The proportion of land under wheat for Ghazni and Herat is likely to be higher when spring planting is

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9 The higher the coefficient of variation or standard deviation of the estimate, the larger the confidence interval around the mean, and the lower the probability that the sample estimate approximates the true population mean.

10 This survey was carried out in June 1992 (see Afghanistan 1992 Wheat Production Survey - Balkh and Jawzjan Provinces. ASSP/DAI. Islamabad. October 1992).

accounted for since a part of the irrigated area in those provinces is sown after the winter snows melt. This implies that, with the exception of Kandahar, for which estimates are less reliable, the wheat area is fairly consistent across all the provinces surveyed - at one-fourth to one-third of the total satellite imagery identified agricultural area. Also, the land planted in wheat varied between one-half to two-thirds of the total crop area in all the provinces surveyed except in Herat where it was much higher. Only at a few sample points in Herat, and one point in Helmand, was rainfed crop land found in areas classified as irrigated agriculture from satellite imagery.

The survey found that poppy accounted for nearly 12% of the total irrigated agricultural area and about a third of the wheat area, in Helmand province. The latter province is reported to be one of the largest producers of poppy in Afghanistan. The coefficient of variation for the proportion estimate is 21%. In contrast to wheat, for which information was derived from a combination of observation and interviews, the poppy estimate is based entirely on farmer interviews. This is because the crop had not been planted at any of the sample points at the time the survey was carried out. As a result, the poppy area proportion estimate for Helmand more accurately represents planned rather than actual area. Surprisingly, no poppy was reported for Kandahar which is also regarded a major opium producing province. The reasons for this are not known.[11]

Fallow land accounted for 3% of the total area in Helmand, 9% in Kandahar, 26% in Ghazni, and 36% in Herat. The lower estimates for Helmand and Ghazni are in part due to definitional problems resulting from the time of year the survey was carried out. Unlike Ghazni, the winter crop had not yet been planted at many sample points in these provinces. As a result, fallow land was reported to be for the winter crop or classified as uncultivated if no winter crop was planned. On the other hand for Ghazni and Herat, the fallow proportion estimates include land which would be planted in spring.

The distinction between different "non-crop" land use categories was not adequately explained or defined during the training of surveyors. As a result, the surveyors used a variety of terms to describe non-crop land use categories, sometimes inconsistently. The inconsistent interpretation of these land use categories does

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[11] During the debriefing, the surveyors confirmed that they observed cannabis and poppy plots in some areas in the province, but that these crops did not fall along the survey line at the sample points. The surveyors also reported that they did not observe any poppy in Herat which they attributed to the discouragement of poppy cultivation by the provincial authorities.

not affect the crop area estimates. The more important terms include "shudyar", "kasht-na-shuda", "bura", "alafchar" and "la-mazruh".

Most surveyors understood "shudyar" to mean land that had been ploughed but would not be planted. "Kasht-na-shuda" literally means uncultivated or, more precisely, "not cultivated". The majority of surveyors used this term to refer to agricultural land on which a crop had been grown in the past but which had not been recently ploughed. A few surveyors used "kasht-na-shuda" synonymously with "shudyar". Some surveyors also distinguished between "kasht-na-shuda" and "matruka" land where the latter referred to agricultural area that had been abandoned. "Bura" was another term sometimes used interchangeably with "kasht-na-shuda", but in other cases, it referred to agricultural land that had been harvested but not ploughed for the next crop. Finally, "alafchar" was used to describe pastures, and "la-mazruh", barren or uncultivable land.

In coding the plot measurements, the main concern centered on defining "fallow land" in a way which would not be distorted by the inconsistent interpretation and use of different terms for non-crop land use categories. For the purpose of this report, fallow land is assumed to comprise land which is not uncultivable ("alafchar" and "la-mazruh") or has not been planted with crops. Therefore, "shudyar", "bura", "kasht-na-shuda" and "matruka" land are all classified as fallow.

"Fallow land" plus "crop area" then provides a rough estimate of cultivable or potential agricultural land - although the concept may not be very meaningful in Afghanistan where water, not land, is the binding constraint to agricultural production.

For Balkh and Jawzjan Provinces, the earlier ASSP survey estimated the fallow land in irrigated areas as varying between 3-5% of the total area, but was defined as including only "shudyar" land (area ploughed but not planted).

Cultivable area, defined as "crop area" plus "fallow", accounted for about 40-60% of the total satellite imagery defined agricultural area in all provinces.[12] Unless it reflects more recent changes, the difference in the proportion of cultivable (and crop) area between Kandahar and Helmand is surprising. Since the two provinces have similar topographic and agricultural system characteristics, the satellite imagery based classification of agricultural areas is expected to be fairly consistent. Nevertheless a substantial number of sample points for Kandahar were found to be uncultivable and comprising water-logged land

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[12] Cultivated area for Balkh and Jowzjan Provinces was estimated by the earlier ASSP survey to vary between a half to two-thirds of total area.

covered with reeds. It is possible that these reeds were picked up as vegetation and the areas erroneously classified as agricultural in the process of interpreting the satellite imagery.

Wheat (and poppy) acreage was calculated by multiplying the total irrigated agricultural area by the estimated proportion of land under that crop. The assumptions and the resulting estimates are shown in Table 3.2. The coefficients of variation for the area estimates are the same as those reported for the underlying proportion estimates in Table 3.1.

TABLE 3.2 ESTIMATED WHEAT AREA 1992/93 - SELECTED PROVINCES, AFGHANISTAN

	Helmand	Kandahar	Ghazni	Herat
Irrigated area (hectares) [1]	228,532	239,510	141,830	233,235
Proportion under Wheat [2]				
actual irrigated	0.32	0.19	0.23	0.22
actual rainfed	0.01	0.00	0.00	0.01
Wheat Area (hectares) [3]				
actual irrigated	73,587	44,573	32,961	52,105
actual rainfed	1,325	0	0	2,169
total	74,913	44,573	32,961	54,274

[1] Earthsat estimate based on satellite imagery interpretation.
[2] Computed from 1992 wheat planting survey.
[3] 1*2.

Source: DAI/ASSP

For 1992/93, the total wheat area is estimated at 73,587 hectares for Helmand, 39,232 ha for Kandahar, 32,961 ha for Ghazni, and 52,105 ha for Herat. These estimates refer to land under fall planted wheat in areas classified as irrigated agriculture from satellite imagery. They exclude spring planted irrigated wheat (where present) as well as irrigated wheat in satellite imagery defined rainfed agricultural areas. Also, the land under rainfed wheat in "irrigated" areas may be underestimated where it is planted in the spring.

Among the provinces surveyed, only farmers in Ghazni and Herat plant a part of irrigated wheat in spring. In Kandahar and Helmand, all of the irrigated wheat is planted between November and January. Consequently, the wheat area estimates for these two provinces are thought to better represent the total irrigated wheat acreage.

The possibility of substantial land being under irrigated wheat in "rainfed" areas is considered remote given the satellite imagery interpretation process by which agricultural areas are classified by irrigation status. No irrigated wheat was found in areas classified as rainfed in the spring 1992 ASSP wheat survey of Balkh and Jawzjan Provinces, where most of the sample points were in rainfed areas. Areas classified as irrigated in Jawzjan, however, often contained rainfed wheat.

The area under poppy for Helmand Province is estimated to be about 26,000 ha based on calculations similar for wheat. This estimate may be somewhat high since it is entirely based on the planting plans of farmers rather than actual cultivation.

3.3 Comparison with Other Crop Area Estimates

The irrigated wheat area survey estimates for Helmand, Kandahar, Ghazni and Herat are compared with other official and non-official estimates for those provinces in this section. The latter estimates are based on different methodologies and provide a context in which the wheat planting survey figures can be placed.

Table 3.3 presents alternative estimates for the surveyed provinces. It should be kept in mind that the wheat planting survey estimates for Ghazni and Herat understates the actual irrigated wheat area because it does not include spring planted wheat. Approximately 5-10% of the total irrigated wheat in those provinces is thought to be planted in spring. Also, the survey estimates understate the total irrigated wheat area to the extent that irrigated wheat exists in areas classified as rainfed from satellite imagery. As discussed earlier, this is not considered likely.

The EarthSat irrigated wheat estimates are based on agricultural areas identified from satellite imagery, to which reduction factors are applied to account for non-wheat crops and fallow land. The Government of Afghanistan (GOA) wheat area estimates for 1992 are derived from information provided by Ministry of Agriculture's extension agents and past data. The GOA/FAO Agricultural Survey, 1966/67, is reported to have been based on a probability survey but information on its methodology, coverage, or accuracy is not available. Also, the estimates from this survey refer to area under cereal crops which include maize, barley and rice in addition to wheat. The UNIDATA wheat area estimates appear to be based on a rapid appraisal non-probability survey.

Except for Helmand Province, ASSP survey estimates of the wheat area are substantially lower than those reported by EarthSat and the GOA/FAO Agricultural Survey. The difference with the GOA/FAO figures is less when the latter are adjusted to account for double cropping.

TABLE 3.3 IRRIGATED WHEAT AREA ESTIMATES - SELECTED PROVINCES, AFGHANISTAN

(hectares)

	Helmand	Kandahar	Ghazni	Herat
ASSP Wheat Planting Survey 1992/93	73,587	44,573	32,961	52,105
EarthSat, 1990 [1]	69,260	106,310	161,200	126,070
Government of Afghanistan, 1991/92 [2]	52,000	50,000	31,000	103,000
UNIDATA, 1991 [3]	na	78,000	41,422	na
GOA/FAO Agricultural Survey, 1966/67 [4]	119,180	103,880	96,760	136,340
Adjusted for double cropping [5]	79,453	69,253	64,507	90,893

[1] "Final Report: Summary of Developments for Cropcast 1990 Afghanistan Wheat Production Assessment", Earth Satellite Corporation, 1991.
[2] Unpublished estimates obtained from Ministry of Agriculture, GOA, Kabul.
[3] Socio-Economic Profiles for Kandahar and Ghazni Provinces, UNIDATA.
[4] "Afghan Agriculture in Figures", Central Planning, Government of Afghanistan.
[5] Assuming a cropping intensity of 150%.

na = not available

Note: Agricultural Survey, 1966/67 figures refer to area under cereal crops including maize, rice, and barley.

There could be a number of reasons why the wheat area survey estimate for Helmand is higher than that of EarthSat. First, EarthSat used a larger reduction factor to derive wheat from total agricultural area for this province. As a result, the Earthsat wheat area estimate for Helmand is much lower than that for Kandahar even though the total irrigated agricultural area for both provinces is approximately equal. Second, the survey estimate possibly overstates somewhat the actual wheat area in Helmand (and Kandahar) Province because it may have attributed land which would have been left fallow to wheat.

Interestingly, the wheat planting survey estimates seem to be fairly consistent with GOA's 1991/92 estimates, even though the latter are thought to be "guesstimates" because the government's authority has extended only to the urban areas in recent years. The exception to this statement is Herat for which the survey estimate is much lower than the figure reported by GOA.

Assuming that the survey estimates are basically accurate, and that the difference in pre and post-war wheat area reflects the impact of the civil war on agricultural production, Herat, Ghazni and Kandahar seem to have been more affected by the war than Helmand Province.

The survey estimate of 26,000 ha under poppy in Helmand Province is substantially higher than the 3,600 ha indicated by Nathan-Berger

for the same province for 1991.[13] The latter estimate is reported to be based on a variety of sources using undefined methodologies. The ASSP survey estimate, however, seems to be consistent with the 20,800 ha poppy area for Helmand in 1990-91 estimated by the USAID-financed Narcotics Awareness and Control Project (NACP).[14] Ironically, the NACP figures are regarded as unreliable because they differ substantially from other sources.

3.4 Preliminary Wheat Production Projections for 1992/93

In this section, the survey acreage estimates are used to develop irrigated wheat production projections for 1992/93. In developing these projections, a high, medium and low case scenario is laid out for each province based on assumptions about wheat yields. The yield assumptions are in turn based on recent estimates made by the Swedish Committee for Afghanistan's (SCA), EarthSat, the GOA's Ministry of Agriculture, and ASSP.[15] These estimates are shown below in Table 3.4.

The SCA's yield estimates are based on farmer interviews obtained from non-probability surveys. EarthSat uses a more sophisticated model to develop wheat yield estimates, incorporating historical data as well as current meteorological information on variables such as rainfall and temperature. The GOA yield statistics seem to be "guesstimates" derived from reports by agricultural officials. The highest yields for the surveyed provinces are reported by the SCA and the lowest by the GOA. Some of the SCA estimates seem implausibly high.

For the wheat production projections, the high yield case is largely based on EarthSats's estimates for 1991, the medium case on GOA 1992 estimates, and the low case on the ASSP 1992 wheat production survey for Balkh and Jawzjan Province.

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13 "Opium Subsector Survey". Draft Final Report. Nathan Associates Inc. and Louis Berger International Inc. August 1992. p.18.

14 Ibid. p.23.

15 The ASSP estimates are actually for Balkh and Jawzjan Provinces, and are based on the crop cut results of an earlier survey for those provinces. For 1992, ASSP estimated the irrigated yield as 1.28 metric ton per hectare for Balkh and 1.16 for Jawzjan.

TABLE 3.4 IRRIGATED WHEAT YIELDS - SELECTED PROVINCES, AFGHANISTAN

(metric tons per hectare)

	Helmand	Kandahar	Ghazni	Herat
Swedish Committee for Afghanistan [1]				
1988	1.99	1.74	1.72	2.05
1989	2.27	1.36	1.75	na
1990	1.85	1.89	2.10	3.04
1991	2.52	1.36	1.89	1.82
Average (1988-91)	2.16	1.59	1.87	2.30
EarthSat [2]				
Base	1.71	1.65	1.48	1.67
Forecast 1991	1.80	1.82	1.55	1.59
Government of Afghanistan, 1992 [3]	1.56	1.44	1.23	1.33

[1] "The Agricultural Survey of Afghanistan", SCA, various reports.
[2] "Final Report: Summary of Developments for Cropcast 1990 Afghanistan Wheat Production Assessment" Earth Satellite Corporation, 1991.
[3] Unpublished statistics obtained from the Ministry of Agriculture, GOA, Kabul.

Source: DAI/ASSP

Table 3.5 shows the yield assumptions used and the resulting production projections from the survey area estimates for each province. Irrigated wheat production is projected to range from 91,984 MT to 128,777 MT in Helmand Province, 49,040 MT to 68,666 MT in Kandahar, 39,533 MT to 52,738 MT in Ghazni, and from 62,526 MT to 83,368 MT in Herat.

Except for Helmand Province, the wheat production projections are considerably lower than previous estimates made for these provinces by EarthSat. The 1992/93 projections seem to be generally in line with the Nathan Berger estimates for Kandahar and Helmand Provinces, but not for Ghazni and Herat where the former are much lower.[16] The projections also appear to be consistent with GOA wheat production statistics for 1992 with the exception of Herat where the projection is again lower.

Two points need to kept in mind about these projections. First, for Ghazni and Herat Provinces, they represent the lower bound of irrigated wheat production since they exclude spring planted irrigated wheat, and possibly irrigated wheat in "rainfed" classified areas. Second, in other provinces such as Helmand and Kandahar they reflect a mix of actual area planted and farmers

16 The Nathan Berger estimates are based on a Lotus 1-2-3 spreadsheet model called AFGRAIN which integrates farm production data from SCA's non-probability surveys with estimates of in-country population.

intention to plant. To the extent that the latter is not realized, the projections would tend to overestimate the 1992/93 irrigated wheat production for those provinces.

TABLE 3.5 IRRIGATED WHEAT PRODUCTION PROJECTIONS 1992/93 - SELECTED PROVINCES, AFGHANISTAN

	Helmand	Kandahar	Ghazni	Herat
Irrigated wheat area (hectares) [1]	73,587	44,573	32,961	52,105
Yield (metric tons per hectare) [2]				
High	1.75	1.75	1.60	1.60
Medium	1.50	1.50	1.40	1.40
Low	1.25	1.25	1.20	1.20
Wheat Production (metric tons)				
High	128,777	78,003	52,738	83,368
Medium	110,381	66,860	46,145	72,947
Low	91,984	55,716	39,553	62,526
Other Wheat Production Estimates (metric tons)				
EarthSat, 1990 [3]	124,356	192,953	250,505	200,010
Nathan Berger, 1989 [4]	73,000	87,000	227,000	129,000
Government of Afghanistan, 1992 [5]	81,000	72,000	38,000	137,000

[1] Wheat Planting Survey estimate.
[2] Based on past yield estimates reported by the Swedish Committee for Afghanistan, EarthSat, the Government of Afghanistan, and ASSP.
[3] "Final Report: Summary of Developments for Cropcast 1990 Afghanistan Wheat Production Assessment", Earth Satellite Corporation, 1991.
[4] "AFGRAIN - Afghanistan Regional Foodgrain Situation", Nathan Associates Inc. and Louis Berger International Inc., 1990.
[5] Unpublished estimates obtained from GOA, Kabul.

Source: DAI/ASSP

4. CONCLUSIONS AND ISSUES

4.1 Wheat Area Estimates and Production Projections

Because the survey was limited to four provinces and irrigated areas, it is not possible to project 1992/93 national wheat acreage (or production) with any reasonable degree of confidence. Provincial irrigated wheat area estimates have been made, although since no statistics based on a comparable methodology are available, it is difficult to infer whether area under wheat for 1992/93 is higher or lower than in recent years.

Wheat accounts for between one-fourth to one-third of the satellite imagery defined irrigated agricultural area with the exception of Kandahar Province, where the proportion of wheat to total area is lower. Further, wheat accounts for between 50-65% of the total crop

area in all provinces except Herat where the proportion is much higher.

A comparison with other estimates suggests that, with the exception of Helmand Province, the irrigated wheat area for 1992/93 is lower than what it was in pre-war years, and substantially lower than recent estimates obtained from satellite imagery.

Preliminary projections of irrigated wheat production have also been made for each province. These projections are extremely tentative because they depend upon uncertain assumptions about yields per unit of land.

4.2 Accuracy of Estimates

With the exception of Kandahar Province, the survey wheat area estimates are more accurate in terms of relative sampling errors than the 1992 wheat production estimates for Balkh and Jawzjan Provinces. This is because the surveyors completed more observations per province than in the earlier survey. However, the non-sampling errors may be higher for the wheat planting survey because many samples were based on a combination of observation and interview which could have biased the estimates. Also, the coverage of surveyed provinces was incomplete due to the approach taken in numbering the sample points, and because the surveyors could not cover specific areas where security was poor.

Despite these limitations, the survey demonstrates that the methodology to estimate crop area is practical in the unique set of circumstances that exist in Afghanistan. This methodology can provide objective and reliable estimates of crop area (and production when combined with crop cut samples) with a relatively modest outlay of resources.

4.3 Timing of Wheat Planting Survey

The appropriate timing for a wheat planting survey poses a dilemma. If the survey is done in the fall three consequences ensue: First, rainfed areas cannot be surveyed since most non-irrigated wheat is planted during the early part of the following year. Second, the survey cannot capture spring planted irrigated wheat which exists at higher elevations. Third, one runs the risk, as experienced in this survey, that the winter wheat crop may not yet have been planted. As a result, the survey has to rely on a methodology which mixes direct observation with farmer interviews leading to possible biases and estimates which more accurately reflect planting plans as well as actual crop area. Also, it causes definitional problems relating to land use categories such as "fallow" since the latter is difficult to define or identify precisely when no crop has been sown. On the other hand, the onset of winter makes it difficult to

delay the survey any later than early December because snow and rain make many parts of the country inaccessible.

A better alternative may be to carry out the survey after the spring planted irrigated and rainfed wheat has been sown. Because of the long winter season in Afghanistan, the earliest this can be considered in many provinces is perhaps March. This implies that the advantage in terms of advance information, compared to a wheat production survey in June, is reduced to three months - with the results for the planting survey becoming available in May rather than August for the production survey. The production survey also has the benefit that it can obtain reliable information on wheat yields because the crop has either matured or is near maturity.

The three month time advantage, even though fairly small, seems important enough to warrant such a wheat planting survey to be carried out. May is the beginning of the wheat harvest season in Afghanistan which extends until September, and a March/April wheat survey would provide additional time for GOA and donors to programme imports and food assistance.

4.4 Improving Survey Methodology and Procedures

The experience gained in executing the wheat survey suggests a number of areas to which greater attention should be given to improve the survey methodology and procedures, and, hence the quality of the estimates. These include training of surveyors, field supervision and communication, and specification of contingency points.

Although, the surveyors were given intensive training in GPS use and survey methods, the training did not fully anticipate the problems they eventually faced in the field. Most of these problems resulted from the timing of the survey which was too early in many provinces. In particular, the failure during training to standardize and explain the terminology to be used for non-crop land use categories, resulted in inconsistent interpretation and classification of such categories by the surveyors.

The lack of radio communication facilities between the field supervisors and the head office, and the supervisors and the survey teams, created a number of difficulties. The most important of which was the inability to respond immediately to logistic and methodology problems as they arose during the implementation of the survey. The availability of radio communications would considerably facilitate more effective supervision of surveyors. Improvements in communication and supervision notwithstanding, the survey methodology requires a trained and dedicated team of surveyors.

The specification of the contingency points was, in retrospect, a mistake. Even though, the points themselves were randomly selected

and the procedure for substituting them for the original sample points clearly laid out, their very existence raised the possibility that surveyors would tend to choose sample points which were easier to reach. Examination of the completed points did not indicate any deviation from specified procedures except in a few instances. However, it is recommended that contingency points should not be provided in future surveys. The sample size itself can be increased to ensure that a sufficient number of observations are completed for each province.

Definition Of Agricultural Areas.

A1 **Irrigated Agriculture.** Areas of agricultural activity dominated by artificial water sources, e.g., karés, areas with visible canals, and areas within river valleys. Generally speaking, on imagery acquired during the growing season, areas of active irrigated agriculture will appear on TM 3-7-4(B-G-R) imagery with significantly more red color than areas of rainfed agriculture , indicating the presence of mere absolute biomass, either due to closer spacing of plants, or to better plant vigor from more frequent and/or timely watering. Field sizes of irrigated vs. rainfed agriculture in Afghanistan tend to be smaller, except in some of the larger areas of project irrigation (the Helmand and Arghandab valleys, for example). Irrigated agriculture includes those areas of horticulture which, under a more traditional classification system employing ground truth and/or aerial photos, would have been classified separately. **Note:** during the mapping for this program, areas which appeared to have possibly been under irrigated cultivation in the recent past, but which lacked an infrared (red) appearance, were categorized as **A1.** The purpose for this classification was to achieve the goal of accounting for the **available** supply of traditionally arable land in Afghanistan, rather than to provide a measure of agricultural activity at the time of imaging. It was felt that at a later date, active irrigated agriculture could be separated from fallow irrigated land in a straightforward fashion.

Irrigated agriculture is found in all parts of Afghanistan, along river courses, and along alluvial fans at the bases of mountain blocks, where ground water is tapped through underground tunnels(kares). The presence of visible canal networks are not necessary, as many of the canals are very small, and may not be detectable by the TM sensor.

A2 **Rainfed Agriculture.** Areas of cultivation characterized by a lack of artificial water supply, and generally with a larger field size than nearby irrigated agricultural areas. Active rainfed agriculture generally has a less intense red appearance than active irrigated agriculture, due to lesser amounts of biomass, wider spacing of crops, and generally lower crop vigor. Areas of non-active rainfed agriculture are distinguished from surrounding non-agricultural land (rangelands) by the presence of field patterns superimposed upon the land surface, and by a generally lighter appearance, indicating that the natural cover has been removed for cultivation at some point.

Rainfed agriculture is found in large quantity on the northern flank of the Hindu Kush mountains, where rain shadow effects of topography allow sufficient rainfall to support a crop. Smaller areas of rainfed agriculture are visible within the Hindu Kush and Safed Kuh, and in limited areas of the southeast (Gazni, Paktya, and northern Kandahar provinces). Generally, the rainfed crops are grain crops capable of tolerating dry conditions, including spring wheat, barley, etc.

As with irrigated agriculture, the total area exhibiting evidence of rainfed agricultural activity was delineated under category A2 for the purposes of this evaluation. There were large areas in the northern tier of provinces in which field patterns were visible, but no infrared signature was evidenced during the peak of the growing season (April to early May). It was felt that to exclude these areas (apparently affected by pestilence) would be to understate the total area available for agriculture. As with A1, a later separation of active from non-active rainfed agriculture was envisioned.

Additionally, literature sources, most notably the Swedish Committee for Afghanistan, indicated that generally speaking, only one-third of all rainfed land is cultivated in any given year, with two-thirds allowed to lie fallow. Given the small mapping scale (1:250,000), it was felt that it would be impossible to map each and every active rainfed field as a distinct unit. Thus, it was decided to map the outer limits of rainfed areas, as evidenced by either activity or the lighter appearance when compared to surrounding lands as described above. Areas of large non-disturbed inclusions of non-agricultural lands could be and were separated out and categorized according to their appearance. Reduction factors could then be applied to digital evaluations of area as calculated by the GIS apparatus. These reduction factors could be developed based on an overview of an entire province or region.

SAMPLE SELECTION PROCEDURES

ASSUMPTIONS

In the process of generating sample points for the survey, the following assumptions were made:

1. Selecting the first fifty points from a set of random points maintains the randomness of these points.

2. Multiplying a random number with a constant value results in a random number.

3. Dropping off the fraction part from a random number has no effect on the randomness of the number.

PARAMETERS

The following parameters were defined for the sample point generation process:

1. To provide a sample frame of possible points for a province, a box encasing the province was drawn. Coordinates of the upper left and lower right corners were used to calculate coordinates of all points lying in the box.

2. Interval of 0.017 decimal degrees (DD) was selected as displacement (horizontal and vertical) between adjacent points. This interval was used in the first ASSP wheat production survey with positive results. The size was selected to allow a dense enough grid from which the required number of random points (50 per province) may be extracted.

3. Five thousand (5,000) random points per province were generated. This number was large enough to provide sufficient (over 50 per province) points falling in irrigated areas. It also provided enough contingency points. These were required in case the sample size per province needed to be increased.

4. The landuse database was used to extract irrigated areas of the provinces. The landuse database is the spatial data provided by Earth Satellite Corporation as a result of visually interpreting satellite imagery of Afghanistan. Thus the sample points to be surveyed were the first fifty random points that fell in areas defined as irrigated by the landuse database.

5. Maximum number of grid points was generated per province. The number depends upon the size of box encasing the particular province and the interval between points.

6. The total number of random points falling in irrigated areas varied per province, and depended upon (a) the size of province and (b) the proportion of total area comprising irrigated agriculture.

Table 1.

Province	upper left corner longitude X1 00	upper left corner latitude Y1 00	lower right corner longitude X2 00	lower right corner latitude Y2 00	Interval 00	X2-X1 00	Y2-Y1 00	cols	rows	total grid points	total random points
BAGHLAN	67.30	34.30	70.00	37.00	0.017	2.5	2.5	147	147	21,626	5,000
BALKH	66.00	35.30	67.30	37.30	0.017	1.5	2	88	118	10,381	5,000
FARAH	60.30	31.00	65.00	34.30	0.017	4.5	3.5	265	206	54,498	5,000
FARYAB	63.30	35.00	66.00	37.30	0.017	2.5	2.5	147	147	21,626	5,000
GHAZNI	66.30	32.00	69.00	34.30	0.017	2.5	2.5	147	147	21,626	5,000
HELMAND	62.00	29.00	65.30	34.00	0.017	3	5	176	294	51,903	5,000
HERAT	60.30	33.00	64.30	36.00	0.017	4	3	235	176	41,522	5,000
JAWZJAN	65.00	34.30	67.00	38.00	0.017	2	3.5	118	206	24,221	5,000
KANDAHAR	64.30	29.00	68.00	33.00	0.017	3.5	4	206	235	48,443	5,000
KUNDUZ	68.00	36.00	69.30	37.30	0.017	1.5	1.5	88	88	7,785	5,000
TAKHAR	69.00	35.30	70.30	38.00	0.017	1.5	2.5	88	147	12,976	5,000

Total grid points = interval * cols * rows

PROCEDURE

1. Generate Random Numbers

A box was drawn encasing each province. The upper left and lower right corners of the box were selected and an interval of 0.017 DD was defined between the rows and columns (longitude & latitude). The corner values in longitude and latitude for each province is given in Table 1.

Random numbers were generated using a dBase program. Utilizing the RND function of dBase, a random number between 0.99999 and 0.9 was generated. This was multiplied by 100,000. The integer value of the result was the required random number. If the number was less or equal to the maximum number of grid points, it was recorded as a random number. Otherwise, the number was rejected and the process repeated. The process continued till 5,000 points were obtained. The process was repeated for each province.

* Random. prg

2. Compute coordinates

The random numbers obtained from step 1 were mere numbers and had no geographic coordinates. The numbers were assumed to be points on a grid encasing each province. For example random number one is point one on the grid. Similarly, random number 300 is point number 300 on the grid. The corresponding coordinates were calculated by traversing the grid starting from upper left corner towards lower right corner, increasing the latitude/longitude by the given interval per point. This procedure was carried out by executing another dBase program. The program computed x and y coordinates (longitude, latitude) for these points.

* Actuals.prg

3. Import Points to GIS

Step 2 produced points with coordinates in dBase format. These points had to be converted to an ARC/INFO file for spatial overlaying with irrigated areas of the province. Using the x and y coordinates generated in step 2, ARC/INFO programs (SMLs) were prepared. Each province had an exclusive program which consisted of 5,000 commands. The format of these commands was :

ADD [x-coordinate] [y-coordinate]

* {province}.sml

Before points can be incorporated to a ARC/INFO coverage (file), the coverage boundaries need to be defined. Boundary coverages (files) for each province were created from existing boundary coverages. The command used was:

CREATE [new-cover] [province-cover]

* Make.sml

In the ARCEDIT module of Arcinfo, the random points were imported to the coverage by executing each province program. The result of this execution was that each province coverage had 5,000 random points.

* Pointgen.sml

4. Extract Irrigated Areas from Landuse Database

Before the random points could be overlayed with satellite data, the irrigated areas were extracted to separate coverages. This was done by applying the RESELECT command of

the ARC/INFO Overlay module. This resulted in eleven coverages, one per province. Command format is:

RESELECT [in-cover] [out-cover] poly {sml file}

5. Projection Conformation

The landuse data was in UTM projection while the random point data was in geographic projection. To combine these two databases, they had to be in the same projection. Therefore the landuse database was converted to geographic projection (the choice of projection to work in depends entirely on the user). Commands used were :

```
PROJECT COVER [in-cover] [out-cover] {sml file}
CLEAN [in-cover] # 0.00 0.0002
BUILD [in-cover] poly
```

6. Overlay with Satellite Data

The point coverages were finally overlayed with the irrigated area coverages to obtain only those random points that fell in irrigated areas. The command applied was:

INTERSECT [in-cover] [intersect-cover] [out-cover] point

The result was 11 coverages, one per province. Depending upon the province size and proportion of irrigated areas, the number of obtained random points varied between provinces (see Table 2).

Table 2.

Province	Total random points in irrigated areas
BAGHLAN	90
BALKH	242
FARAH	83
FARYAB	74
GHAZNI	114
HELMAND	81
HERAT	100
JAWZJAN	91
KANDAHAR	99
KUNDUZ	328
TAKHAR	120

6. Compute Coordinates in Decimal Degrees

The coverages produced contained the final random sample points to be surveyed. Since the Intersect command generates new IDs for the points in the coverages, these codes cannot be used for retrieving the x and y coordinates of the points. So the coordinates were recomputed in decimal degrees using the command:

```
     ADDXY [cover]
* pointfnl.sml
```

7. Compute Coordinates in DMS

Geo Positioning Systems (survey devices) to be used by survey teams require input in DMS (degrees, minutes, seconds) format. Therefore the DMS equivalent of the coordinates were computed. The conversion formula is as follows:

Let random number = x.ab

degrees = integer value of x.ab
= x

minutes = fraction value of x.ab multiplied by 60
= ab * 60
= cd.ef (suppose)
= cd

seconds = fraction value of minutes multiplied by 60
= ef * 60

The above procedure was applied on both x and y coordinates for each point and for every province. To implement it a program in dBase was executed.

* dd_dms.Prg

```
* PROGRAM : RANDOM2
* FOR : WHEAT SURVEY 1992; GENERATION OF RANDOM POINTS
*       FOR 11 PROVINCES
* DATE : OCT 12, 92
*
USE BALKH
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 10381
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
USE KANDAHAR
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 48443
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
USE HELMAND
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 51903
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
USE FARAH
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 54498
      APPE BLANK
      REPL RANDOM WITH M
```

```
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
USE HERAT
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 41522
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
USE FARYAB
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 21626
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
USE BAGHLAN
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 21626
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
USE KUNDUZ
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 7785
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
```

```
USE TAKHAR
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 12976
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
*
USE GHAZNI
COUNTER = 1
do while COUNTER <= 5000
   M = RAND() * 100000
   M = INT(M)
   IF M <= 21626
      APPE BLANK
      REPL RANDOM WITH M
      COUNTER = COUNTER + 1
   ENDIF
enddo
```

ACTUALS.PRG

```
* PROGRAM : CALCULATE ACTUAL LAT/LON COORDINATES OF EACH RANDOM
POINT.
*           5,000 POINTS PER PROVINCE.  11 PROVINCES.
*           PROVINCE.DBF LISTS PROVINCE NAMES; INTERVAL, COLUMNS
*           JAWZJAN.DBF LISTS RANDOM POINTS FOR JAWZJAN AND
*           WILL STORE CALCULATED X Y COORDINATES
*           DBF FOR EACH PROVINCE.
* FOR   :  WHEAT SURVEY II
* DATE : OCT 13, 92
SELE 1
USE PROVINCE
SKIP
DO WHILE .NOT. EOF()
   MPROV = PROVINCE
   SELE 2
   USE &MPROV
   DO WHILE .NOT. EOF()
      IF RANDOM <= A->COLUMNS
         REPL X WITH A->X1 + RANDOM * A->INTERVAL
         REPL Y WITH A->Y1
      ENDIF
      IF RANDOM > A->COLUMNS
         ROW = INT(RANDOM/A->COLUMNS)
         REPL Y WITH A->Y1 + ROW * A->INTERVAL
         REPL X WITH A->X1 + (RANDOM-ROW*A->COLUMNS)*A->INTERVAL
      ENDIF
      SKIP
   ENDDO
   SELE 1
   SKIP
ENDDO
```

MAKE.SML

```
&rem This program creates empty coverges of each province by
&rem duplicating the corner point coordinates (tic values)

CREATE E:\BOUNDARY\PROVBDRY\JAWZJAN        JAWZJAN
CREATE E:\BOUNDARY\PROVBDRY\BALKH          BALKH
CREATE E:\BOUNDARY\PROVBDRY\KANDAHAR       KANDAHAR
CREATE E:\BOUNDARY\PROVBDRY\HELMAND        HELMAND
CREATE E:\BOUNDARY\PROVBDRY\HERAT          HERAT
CREATE E:\BOUNDARY\PROVBDRY\FARAH          FARAH
CREATE E:\BOUNDARY\PROVBDRY\FARYAB         FARYAB
CREATE E:\BOUNDARY\PROVBDRY\BAGHLAN        BAGHLAN
CREATE E:\BOUNDARY\PROVBDRY\KONDUZ         KONDUZ
CREATE E:\BOUNDARY\PROVBDRY\TAKHAR         TAKHAR
CREATE E:\BOUNDARY\PROVBDRY\GHAZNI         GHAZNI
```

{province}.sml
FARYAB.SML

```
ADD 64.078 36.615
ADD 64.197 37.380
ADD 65.489 36.445
ADD 64.316 35.204
ADD 64.707 36.683
ADD 64.112 35.595
ADD 63.755 35.391
ADD 64.877 35.782
ADD 64.554 37.023
ADD 65.217 35.051
ADD 63.891 36.224
ADD 64.537 37.414
ADD 65.693 36.938
ADD 65.506 36.258
ADD 65.319 36.870
ADD 65.319 35.408
ADD 64.622 36.054
ADD 63.704 35.731
ADD 65.472 36.734
```

continued for 5,000 points

POINTGEN.SML

```
&REM This program imports the randomly generated points to ARC/INFO

&REM (spatial software) using the Arcedit module. Result of the
program
&REM is eleven coverages (files) showing the random points for all
the provinces

MAPE JAWZPOIN
EDITC JAWZPOIN
DRAWE TIC ID
MAP TIC JAWZPOIN
DRAW
EDITF LABEL
COOR KEYB
@JAWZJAN.SML
SAVE

REMOVEE ALL
Y

MAPE BALKPOIN
EDITC BALKPOIN
DRAWE TIC ID
MAP TIC BALKPOIN
DRAW
EDITF LABEL
COOR KEYB
@BALKH.SML
SAVE

REMOVEE ALL
Y

MAPE KANDPOIN
EDITC KANDPOIN
DRAWE TIC ID
MAP TIC KANDPOIN
DRAW
EDITF LABEL
COOR KEYB
@KANDAHAR.SML
SAVE

REMOVEE ALL
Y

MAPE HELMPOIN
EDITC HELMPOIN
```

```
DRAWE TIC ID
MAP TIC HELMPOIN
DRAW
EDITF LABEL
COOR KEYB
@HELMAND.SML
SAVE

REMOVEE ALL
Y

MAPE FARAPOIN
EDITC FARAPOIN
DRAWE TIC ID
MAP TIC FARAPOIN
DRAW
EDITF LABEL
COOR KEYB
@FARAH.SML
SAVE

REMOVEE ALL
Y

MAPE HERAPOIN
EDITC HERAPOIN
DRAWE TIC ID
MAP TIC HERAPOIN
DRAW
EDITF LABEL
COOR KEYB
@HERAT.SML
SAVE

REMOVEE ALL
Y

MAPE FARYOIN
EDITC FARYPOIN
DRAWE TIC ID
MAP TIC FARYPOIN
DRAW
EDITF LABEL
COOR KEYB
@FARYAB.SML
SAVE

REMOVEE ALL
Y

MAPE BAGHPOIN
EDITC BAGHPOIN
```

```
DRAWE TIC ID
MAP TIC BAGHPOIN
DRAW
EDITF LABEL
COOR KEYB
@BAGHLAN.SML
SAVE

REMOVEE ALL
Y

MAPE KONDPOIN
EDITC KONDPOIN
DRAWE TIC ID
MAP TIC KONDPOIN
DRAW
EDITF LABEL
COOR KEYB
@KUNDUZ.SML
SAVE

REMOVEE ALL
Y

MAPE TAKHPOIN
EDITC TAKHPOIN
DRAWE TIC ID
MAP TIC TAKHPOIN
DRAW
EDITF LABEL
COOR KEYB
@TAKHAR.SML
SAVE

REMOVEE ALL
Y

MAPE GHAZPOIN
EDITC GHAZPOIN
DRAWE TIC ID
MAP TIC GHAZPOIN
DRAW
EDITF LABEL
COOR KEYB
@GHAZNI.SML
SAVE
```

POINTFNL.SML

```
&REM  This program (i) selects the irrigated agriculture from the
&REM  landuse (ii) overlays it with the points generated
&REM  (iii) extractsthe points falling inside the irrigated areas
&REM   (iv) and finally assigns latitude and longitude values to
these points
&REM  There are six lines of SML code per province

RESELECT E:\LAND\JAWZJAN JAWZIRRI POLY IRRI.SML
PROJECT COVER JAWZIRRI JAWZLAND PROJ2.SML
CLEAN JAWZLAND # 0.00 0.0002
BUILD JAWZLAND POLY
INTERSECT JAWZPOIN JAWZLAND JAWZFINL POINT
ADDXY JAWZFINL

RESELECT E:\LAND\BALKH BALKIRRI POLY IRRI.SML
PROJECT COVER BALKIRRI BALKLAND PROJ2.SML
CLEAN BALKLAND # 0.00 0.0002
BUILD BALKLAND POLY
INTERSECT BALKPOIN BALKLAND BALKFINL POINT
ADDXY BALKFINL

RESELECT E:\LAND\KANDAHAR KANDIRRI POLY IRRI.SML
PROJECT COVER KANDIRRI KANDLAND PROJ2.SML
CLEAN KANDLAND # 0.00 0.0002
BUILD KANDLAND POLY
INTERSECT KANDPOIN KANDLAND KANDFINL POINT
ADDXY KANDFINL

RESELECT E:\LAND\HELMAND HELMIRRI POLY IRRI.SML
PROJECT COVER HELMIRRI HELMLAND PROJ2.SML
CLEAN HELMLAND # 0.00 0.0002
BUILD HELMLAND POLY
INTERSECT HELMPOIN HELMLAND HELMFINL POINT
ADDXY HELMFINL

RESELECT E:\LAND\FARAH FARAIRRI POLY IRRI.SML
PROJECT COVER FARAIRRI FARALAND PROJ2.SML
CLEAN FARALAND # 0.00 0.0002
BUILD FARALAND POLY
INTERSECT FARAPOIN FARALAND FARAFINL POINT
ADDXY FARAFINL

RESELECT E:\LAND\HERAT HERAIRRI POLY IRRI.SML
PROJECT COVER HERAIRRI HERALAND PROJ2.SML
CLEAN HERALAND # 0.00 0.0002
BUILD HERALAND POLY
INTERSECT HERAPOIN HERALAND HERAFINL POINT
ADDXY HERAFINL
```

```
RESELECT E:\LAND\FARYAB FARYIRRI POLY IRRI.SML
PROJECT COVER FARYIRRI FARYLAND PROJ2.SML
CLEAN FARYLAND # 0.00 0.0002
BUILD FARYLAND POLY
INTERSECT FARYPOIN FARYLAND FARYFINL POINT
ADDXY FARYFINL

RESELECT E:\LAND\BAGHLAN BAGHIRRI POLY IRRI.SML
PROJECT COVER BAGHIRRI BAGHLAND PROJ2.SML
CLEAN BAGHLAND # 0.00 0.0002
BUILD BAGHLAND POLY
INTERSECT BAGHPOIN BAGHLAND BAGHFINL POINT
ADDXY BAGHFINL

RESELECT E:\LAND\KONDUZ KONDIRRI POLY IRRI.SML
PROJECT COVER KONDIRRI KONDLAND PROJ2.SML
CLEAN KUNDLAND # 0.00 0.0002
BUILD KUNDLAND POLY
INTERSECT KONDPOIN KONDLAND KONDFINL POINT
ADDXY KONDFINL

RESELECT E:\LAND\TAKHAR TAKHIRRI POLY IRRI.SML
PROJECT COVER TAKHIRRI TAKHLAND PROJ2.SML
CLEAN TAKHLAND # 0.00 0.0002
BUILD TAKHLAND POLY
INTERSECT TAKHPOIN TAKHLAND TAKHFINL POINT
ADDXY TAKHFINL

RESELECT E:\LAND\GHAZNI GHAZIRRI POLY IRRI.SML
PROJECT COVER GHAZIRRI GHAZLAND PROJ2.SML
CLEAN GHAZLAND # 0.00 0.0002
BUILD GHAZLAND POLY
INTERSECT GHAZPOIN GHAZLAND GHAZFINL POINT
ADDXY GHAZFINL
```

DD_DMS.PRG

```
* This program converts values in decimal degrees (DD) to decimal
* minutes and seconds (DMS).
* For : Wheat Survey 1992

        DO WHILE .NOT. EOF()
        FRACTION = X_COORD  - INT(X_COORD)
        DEGREES = INT(X_COORD)
        FRACTION= X_COORD - DEGREES
        MINUTES = FRACTION*60
        SECONDS = (MINUTES - INT(MINUTES)) * 60
        REPL LOND WITH DEGREES
        REPL LONM WITH INT(MINUTES)
        REPL LONS WITH SECONDS

        FRACTION = Y_COORD  - INT(Y_COORD)
        DEGREES = INT(Y_COORD)
        FRACTION= Y_COORD - DEGREES
        MINUTES = FRACTION*60
        SECONDS = (MINUTES - INT(MINUTES)) * 60
        REPL LATD WITH DEGREES
        REPL LATM WITH INT(MINUTES)
        REPL LATS WITH SECONDS
        SKIP
        ENDDO
```

APPENDIX C

SURVEY INSTRUMENTS

1992 WHEAT PLANTING SURVEY
FORM A

Province_____ Sample number_____ _____

Coordinates: Latitude ____ ____ ____

Longitude ____ ____ ____

Names of surveyors _____

Date: (day/month/year) _____/_____/_____

Beginning time _____

1. After reaching these coordinates, mark the beginning point with the range pole. Take a reading with the GPS (see Appendix A1 in the instructions manual) and record the location and altitude below.

   Coordinates: Latitude ____ ____ ____

   Longitude ____ ____ ____

   Altitude _____

   Also record the satellite information from the GPS below (see Appendix 1.A in the instructions manual).

	PDOP			
SAT				
SQ				

2. Indicate what type of area the beginning point is located in by circling the appropriate category below:

   (a) Cultivated area
   (b) Mixed cultivated and non-cultivated area
   (c) Uncultivated area

3.1 If area type is (a) or (b), lay out a 500 meter transect line according to the guidelines in the instructions manual. As you lay out the line, record the number of meters in each crop or land use in the table provided on the next page.

3.2 If area type is (c), and no agricultural land is within 500 meters on all sides then take a GPS position fix and note your observations. If you see that that there is irrigated land within "500" meters in any direction then proceed with the normal procedure.

Sample Number_____ _____

LAND USE TABLE

Plot [1]	Land Use* [2]	Meters [3]	Running totals		Irrigated Yes or No [6]
			Wheat [4]	Total [5]	
1.					
2.					
3.					
4.					
5.					
6.					
7					
8.					
9					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					

* Land use types include: wheat, vegetables, fruits, other crops and fallow for cultivated areas; and roads, dwelling places and other buildings, grassland, rivers and canals, mountain/rock, and desert for uncultivated areas.

Sample Number_____ _____

4. At the 500 meter mark, use the GPS to record the location and altitude of the ending point below:

Coordinates: Latitude ____ ____ ____

Longitude ____ ____ ____

Altitude _____

1992 FALL WHEAT PLANTING SURVEY
FARMER QUESTIONNAIRE
FORM B

Name of Surveyor_____ Date_____ Province_____

1 - How much irrigated land did you plant with wheat this fall?

_____ jeribs

2 - When did you plant this wheat crop?
(circle appropriate time and specify month)

(a) beginning
(b) middle
(c) end

_____
(month)

3 - How much wheat seed did you plant on your irrigated land this fall?

_____ kgs

(a) - How much of this total was improved seed?

_____ kgs

(b) - How much of this total was local seed?

_____ kgs

4 - How much fertilizer did you use on your present wheat crop?

(a) - Urea (white fertilizer): _____ bags _____Kgs/bag.

(b) - Phosphate (black fertilizer): _____ bags_____Kgs/bag.

5 - Did you use tractors in your field operations this year?

Yes _____ No _____

- If yes, were the tractors:

_____ owned.
_____ rented (hired).
_____ shared.
_____ borrowed.

- Specify the operations in which tractors were used?

_____ Plowing/Planting.
_____ Scraping/Leveling.
_____ Hauling.
_____ Discing

- Make of tractor: _____ Horse Power _____

6 - Did you use oxen in your field operations this year?

Yes _____ No _____

- If Yes, were the oxen:

_____ owned.
_____ rented (hired)
_____ shared/paired
_____ borrowed

7 - Any other source of animal power used?

_____

8 - How much spring wheat do you plan to grow next year?

_____ jeribs.

9 - How much total land did you cultivate this fall and plan to cultivate next spring?

_____ jeribs

10 - In how many separate plots is your total irrigated land divided?

_____ numbers.

سروی کشت گندم خزانی سال ۱۹۹۲

فورمه A

ولایت _____ نمبر سمپل _____.

کواردنات: عرض البلد _____ _____ _____.

طول البلد _____ _____ _____

اسمای سرویران _____

تاریخ : (روز-ماه-سال) _____ _____ _____.

وقت آغاز کار _____.

۱- بعد از رسیدن به این کواردینات، نمبر نقطه آغاز را توسط رینج پول نشانی کرده و موقعیت آنرا توسط GPS ثبت نماید (در مینول هدایات ضمیمه A را ملاحظه نمایید) و موقعیت نقطه را با ارتفاع آن در ذیل تحریر نمایید.

کواردنات: عرض البلد _____ _____ _____

طول البلد _____ _____ _____

ارتفاع _____ _____ _____

همچنان معلومات قمر مصنوعی را از GPS ذیلا درج نمایید. (در مینول هدایات ضمیمه A را ملاحظه نمایید)

	PDOP			
SAT				
SQ				

۲- موقعیت نقطه آغاز را نظر به نوعیت زمین از جمله سه کنگوری ذیل با کشیدن دایره بدور یکی از آنها انتخاب نماید.

(A) زمین کشت شده

(B) قسما کشت شده و قسما کشت نا شده.

(C) زمین کشت نا شده.

۳,۱ اگر نوعیت ساحه (a) یا (b) باشد،سروی لاین را به طریق که در منول هدایات تشریح شده بطول ۵۰۰ متر خط اندازی کنید. در جریان کار خط اندازی سروی لاین طول خط را که در نباتات مختلفه قرار دارد به متر در جدول صفحه بعدی ریکارد کنید.

۳,۲ اگر نوعیت ساحه (c) باشد و در اطراف در حدود پنج صد متر زمین زراعتی دیده نمیشود ، پوزیشن را توسط GPS بگیرید و مشاهدات خویش را تحریر نماید-اگر درهر سمت در حدود پنج صد متری در زمین زراعتی را می بینید، لازم است ، عملیه سروی را بطریق نورمال اجرا کنید.

نمبر سمبل_____ .

جدول اســـــتعمال زمـــين

پلات [1]	استعمال زمین [2]	متر [3]	مجموع		آبی است بلی - نی [6]
			مجموع کل [4]	مجموع گندم [5]	

نوع استعمال زمین مشتمل است بر : گندم،سبزیجات ، میوه جات ، نباتات دیکر و شدیار برایی زمین کشت شده . و همچنان سرك ها ، محل زیست و تعمیرات دیکر سبزه زارها ، دریا ها ،کوها، سنکلاخ و صحرا برائي زمین کشت ناشده.

٤ - با استفاده GPS موقعیت و ارتفاع نقطه انجام سروي لاین را که به آخر 500 متر قرار خواهد داشت ثبت نموده در ذیل درج نمایید.

کواردینات: عرض البلد _____ _____ _____

طول البلد _____ _____ _____

ارتفاع _____.

سروی کشت گندم خزانی در افغانستان ۱۹۹۲
پرسش نامه زارعین
فورم "B".

اسم سرویر _____ تاریخ _____ ولایت _____

۱ ـ چه اندازه زمین آبی را در موسم خزان امسال گندم کاشته اید ؟

_____ جریب

۲ ـ چه وقت گندم خزانی آبی امسال خود را کشت نموده اید؟
(a) شروع
(b) وسط برج _____
(c) آخر

۳ ـ چه مقدار تخم گندم آبی را در خزان امسال کشت کردید ؟

مجموع _____ کیلو گرام

اصلاح شده _____ کیلو گرام

محلی _____ کیلو گرام

۴ ـ در گندم کشت تیر ماهی آبی خود چه مقدار کود را استعمال نموده اید ؟

(a) یوریا (کود سفید) _____ بوری _____ کیلو گرام

(b) فاسفیت (کود سیاه) _____ بوری _____ کیلو گرام

۵ ـ آیا در کشت خزانی امسال خود از تراکتور استفاده نموده اید ؟

بلی _____ نه _____

اگر جواب بلی باشد در آنصورت اشاره نماید.

از تراکتورشخصی استفاده نموده ا ید. _____

از تراکتور کرائی استفاده نموده اید. _____

از تراکتور شریکی استفاده نموده اید. _____

از تراکتور به شکل کمکی استفاده نموده اید. _____

عملیات را که در آن از تراکتور استفاده به عمل آورده اید مشخص نماید.

قلبه کردن و کشت _____

هموار کاری زمین _____

انتقالات _____

دسك کردن زمین _____

ساخت تراکتور(نام کشور یا کمپنی) _____

قوه تراکتور _____ هارس پاور

۶ ـ آیا از قلبه گاو در کشت خزانی خود استفاده نموده اید ؟

بلی _____ نه _____

اگر جواب بلی باشد در آنصورت اشاره نماید.

از قلبه گاو شخصی استفاده نموده اید _____

از قلبه گاو کرائی استفاده نموده اید _____

از قلبه گاو شریکی استفاده نموده اید _____

از قلبه گاو به شکل کمکی استفاده نموده اید _____

۷ ـ آیا در کشت خزانی امسال خود از حیوانات دیگر هم استفاده نموده اید ؟

نام حیوان _____

۸ ـ پلا ن شما برای کشت گندم بهاری در سال آینده چه اندازه زمین است ؟

_____ جریب

۹ ـ جنابه شمول همه محصولات آبی چه اندازه زمین را در خزان امسال و بهارسال آینده تحت کشت خواهید داشت ؟

_____ جریب

۱۰ ـ ساحه مجموعی زمین آبی شما (تحت کنترول شما) به چند قسمت جدا گانه تقسیم شده است

به _____ قسمت

Field Instruction Manual.

The Wheat Production Survey is the first major survey undertaken by PPA component of the Afghanistan Agricultural Sector Support Project (AASSP) for this year. Its main objective is to improve wheat production estimates for Afghanistan for the coming year. The survey aims to do this by providing independent estimates of acreage under different crops and wheat yields for selected provinces of the country. In total ten provinces have been selected for survey and these fall into three distinct harvesting periods beginning in June through to mid August.

Due to the time and distance away from the Pakistan duty station the success of the survey requires guidelines to provide advice and direction. The Surveyors Instruction Manual (SIM) has been written for this purpose and serves a an aid for surveyors working cross border in Afghanistan. The SIM has three basic aims. The first is to set out in a concise, step by step manner the survey methodology including locating the survey point and carrying out the survey procedure. Secondly it hopes to anticipate any problems that may arise with the survey and explain the solution in a precise and orderly manner which can be understood easily by the surveyor, and thirdly it outlines action to be taken in emergency situations.

The SIM has been organized into two sections, The first contains the procedures for locating the survey point and includes setting a course and navigating with the GPS. The second outlines the survey methodology once the point is located. In this latter section we deal with laying out the line and acquiring the wheat yield data.

SECTION 1: LOCATING THIS SURVEY POINT.

Each survey point has been predetermined by using satellite imagery, and a coordinate in latitude and longitude obtained. Prior to your departure you will have entered these points into your GPS units in the form of waypoints. If by any mischance your unit loses this coordinates you can reenter them by using the procedure outlined in Appendix.la.

In order to reach the survey point to carry out the survey you will need to use the Course and Navigation mode on your GPS. Before using the GPS you should get as close as possible to the intended survey site by using the topographical maps which have the survey points located, and the relevant road information.

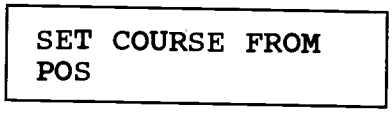
*NOTE The coordinates you have been given as survey points have been chosen with specific design of the survey in mind . By no means are you to adapt or change the locations of these points for any reason. It is imperative that you locate these points by using the maps and GPS and report the situation that you find.

The following is the approach you should use to determine the location of the survey line.

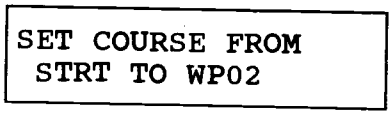
01. Before using the Course and Navigation modes amend the following functions on the GPS; in Auxiliary 1 set the TERRAIN SETTING to INTERRUPTED; in Auxiliary 2 set CONTINUOUS OPERATION to ON.

02. Take a position fix using the GPS unit (See Appendix.1A).This point becomes the POS on the GPS display.

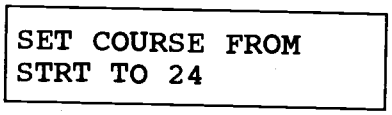
03. Press the COURSE key followed by the CLEAR key on the GPS unit.



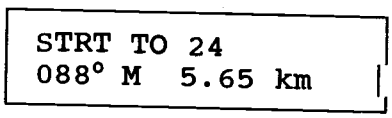
04. Press ENTER. Note that the POS on the GPS display becomes STRT.



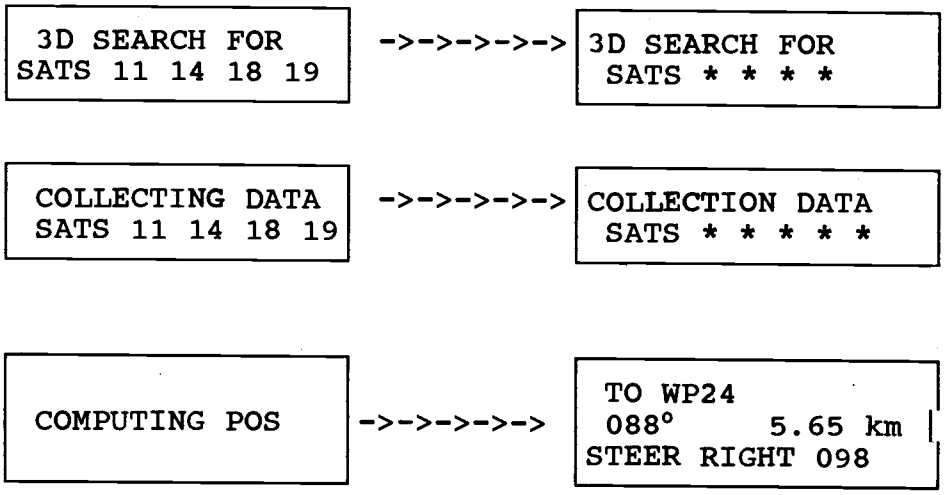
05. With the -> key scroll until you obtain the waypoint which displays the intended destination. In this example let that be waypoint 24.



06. Press ENTER. The screen will display the compass bearing (088°), which is the direction and the distance (5.65km). to your destination.



07. Once you have set the Course, stand in a clear place, point the antenna up and press the NAV key on the GPS unit. The following screens will appear in the order below.



08. At the appearance of the final screen you can start to travel. As the appearance the information on the screen will be updated every 10 seconds, it is important that you keep an eye on these changes and adjust your course accordingly.

It should be noted at this point that once you are within 20 meters of your destination point, the GPS will no longer give you bearing and steering information. You must therefore pace out these last few meters based on the direction of the last bearing. The last step of your pace will become the starting point of the survey line.

SECTION 2: THE SURVEY METHODOLOGY

The following sequence of events numbered 01-15 begin after you have arrived at the survey site using the Course and Navigation mode of the GPS and have located the start point of the survey line.

Please note that once you reach the survey point it is advisable to seek permission from the local inhabitants before preceding with the survey. Try and send a message to those concerned explaining exactly who you are and what you are doing. Only proceed when you have received the necessary blessing.

PART ONE

01. Mark the point of your last step, the start point of the survey line, with the ranging pole.

02. Fill in the blank spaces on the top of the survey form A;
- names of surveyors
- date
- beginning time

03. Take a position fix using the GPS unit (see Appendix 1A.),and note this position on the survey form a. Note also the PDOP, the satellites (SAT) and the signal quality (SQ) (see Appendix 1A. Point 5.).

04. At site you will find yourself in one of three situation; (a) on cultivated land, (b) on mixed cultivated and uncultivated land and (c) uncultivated land.

If you find yourself in an area comprising (c) uncultivated land and no agricultural land is within 500 meters on all sides then take a GPS position fix and note your observations on the survey from A. There is no need to lay out a survey line in this case.

05. If you find yourself in an area comprising (a) cultivated land or (b) mixed cultivated and uncultivated land then you will be required to lay out a survey line. The direction of the survey line will be determined by whether your start point is in a valley or on a plain. The two possible scenarios that you will come across are outlined below.

A. If the start point is in a valley and you can see a river or stream then lay out the survey line parallel to the river or stream, down valley for 500 meters. If the river or stream changes direction, you should continue the survey line in the direction you started with.

B. If the start point is on a plain then lay out the survey line by lining up the vehicle with the start point and extending it 500 meters.

C. If the start point falls in a river then you should start the survey line along the bank down stream for 500 meters.

D. If your start point falls on a minefield then do not under any circumstances enter this area. Note your observation and proceed to the next point.

06. Once the alignment of the survey line has been determined a compass bearing of the direction should be obtained. The team leader and surveyor 1 should stand at the start point and direct surveyor 2 to the right alignment. Surveyor 2 should measure out 30 meters or to the boundary of the next plot and mark this position with a second ranging pole.

07. The team leader should then fill in the survey form A on the following for each field;
- type of crop/crops or land use (column 2)
- the ground distance of the crop/crop or land use along the survey line (column 3)
- the total ground distance (column 5)
- irrigated - yes or no (column 6)

*NOTE: Each 100 metes or so interval should be marked with a ranging pole, which will serve as a reference point. These should be collected on your return.

08. Repeat steps 06-07 until 500 meters have been marked out .

09. At the end of the survey line (500 meters)take a position fix using the GPS and note the coordinates on the survey form A (Q4).

PROBLEMS

A. UNCROSSABLE BARRIER. If the survey line passes through barrier which cannot be crossed such as a water body, abyss or minefild, the following action should be taken.

i The type of barrier and its approximate width along the survey line should be noted on the survey form in column 1.

ii. As you can not cross the barrier an assessment of what lies on the other side should be made by noting it on the survey form in column 1.

B. CROSSABLE BARRIER. If the survey line passes through a barrier which can be crossed, for example a house, then the following procedure should be followed (see figure 1. below)

i. You should walk either right or left, right angles (90)to the survey line until you are past the barrier making a note of this distance as D1.

ii. Walk at right angles (90°) to this diversion line (in the same direction as the survey line) until you are past the barrier making a note of the distance covered as D2. Note the distance (D2) that you measure on the survey form (column 3) indicating the type of barrier negotiated (column 2).

iii. In order to return to the correct position of the survey line,

walk at right angles to D2 for a distance equal to D1. continue survey as before.

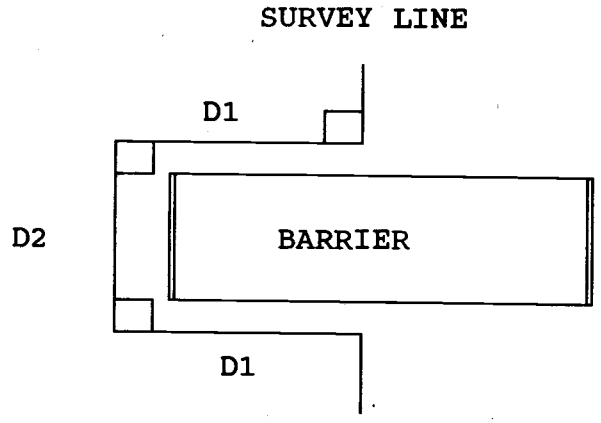


Figure 1. Negotiating a crossable barrier

C. INACCESSIBLE AREAS. If the survey point is inaccessible for example on a mountain, then get as close as possible and enquire from the local inhabitants as to the type of land where the point is located. Note the observation on the survey form A in the land use table. Also indicate that the information recorded is obtained from local enquiry rather than direct observation.

PART TWO

After you have taken a position fix at the end of the survey line you are ready to begin part two of the survey.

10 Add up the total number of meters that were under wheat, column 4 of the Land Use Table on the survey form A and note the total at the bottom of the column. Let us call this number TW.

11 Turn to the Table of Random numbers and pick the first two numbers which are both less than TW. Make a note of these numbers on the survey from A in the space provided (Q:5.1).

*NOTE When a random number has been used you should cross it and all the numbers rejected because they were too large from the table and be sure not to use them again. When you run out of numbers on your table then start again by using a second table.

12. From the end point begin your return to the start point walking along the survey line. As you walk, measure with the tape the amount of land under wheat until you attain the distance signified by the first random number.

*NOTE

A. If there is only one plot of wheat with a distance of less than 50 meters on the survey line, take only one crop cut sample from this survey point.

B. Remember you should only measure this distance on wheat fields.

C. If the wheat field determined by the random number has already been harvested but there are unharvested wheat fields within 100 meters in any direction then go to the nearest field, walk in 5 meters and take the crop cut at

this point. Also carry out the farmer survey at this point.

D. If the clip point determined from the random table number falls on the border between a wheat field and other land use categories including other crops, then back up 1 meter and take the crop cut.

E. If the clip point falls on a border within what you classified as a wheat field- for example between wheat and an irrigation ditch/track- then take the cut at the same point even if part of the circle does not contain any wheat.

13. Mark this point by pushing the ranging pole, with the chain attached, into the ground. Make sure the chain can be freely rotated around the ranging pole.

14. The chain when rotated forms a circle, this circle is the area where you should clip the heads of all the wheat crop you find. The wheat head should be clipped close to the junction of the head and stalk. As you cut the wheat heads lay them at the side of the circle on some paper or a plastic sheet.

*NOTE Only cut wheat heads that come into contact with the chain. If the wheat stalk does not touch the chain then this should not be cut.

15 Once you have finished cutting fill out form C making a note of the sample number, the clip unit number and the number of wheat heads. Place the clip unit number and form C in the envelope and staple the envelope shut. On the front of the envelope record this information with a marker pen.

16. During the crop cut or immediately afterwards the farmer whose land you took the wheat cut from should be interviewed using the questions in survey form B.

17. Now proceed to the distance of the second random number, remembering that it is the distance from the end point. When you reach this point repeat steps 14-17 above.

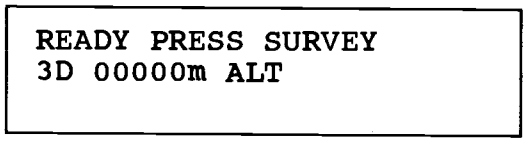
18. After completing these steps go back to the start point and record the ending time on the form. You are now ready to go to the next survey point.

APPENDIX 1.

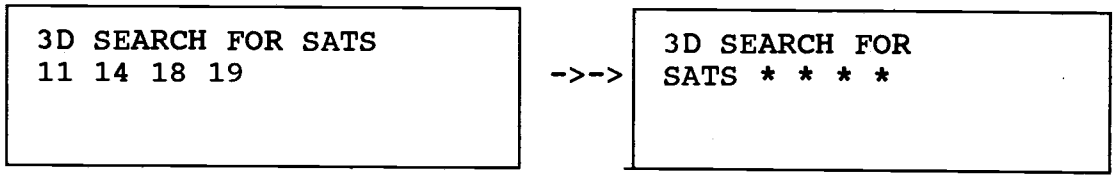
A. TAKING A POSITION FIX

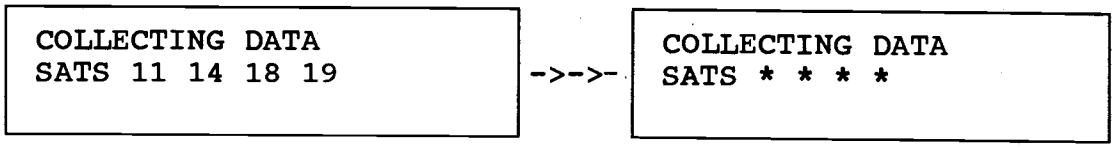
01. Stand in clear open space and point the antenna of the GPS vertically.

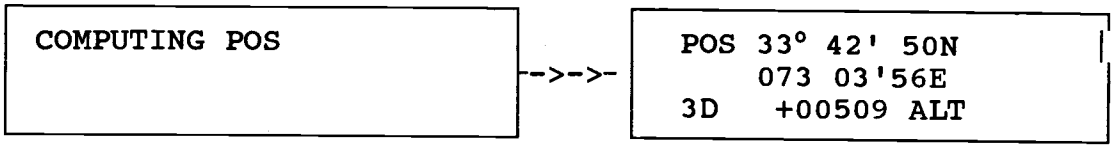
02. Turn the GPS unit on.



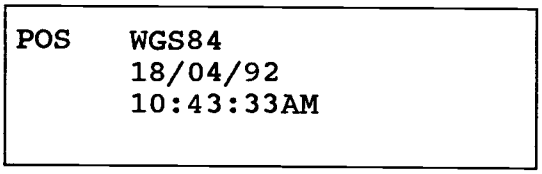
03 Press the SURV key on the GPS. The following screens will appear in the order shown below.







04. Press ! (down arrow). The screen will show the datum (WGS84), the date (18/05/92) and the time (10:43 33 AM) of the reading.



05. PRESS ! (DOWN ARROW). The screen will show the PDOP (1.6), The satellites used (02 11 16 20) and the signal quality (SQ) of each satellite (9 3 7 9).

```
POS  PDOP 1.6
SAT 02 11 16 20
SQ 9 3 7 9
```

B: ENTERING WAY POINTS

Example: Point 23
Latitude: 34° 26'10"
Longitude; 072° 54'23"
Altitude; 500 meters

01. Turn the GPS unit on

02. Press the WPT key.

```
SELECT WPT WITH
OR PRESS ENTER
```

03. Press ENTER

```
ENTER WPT NAME
```

04. Press ABC
2

Scroll with -- until 2

05. Press DEF
3

Scroll with -- until 3

06. Press ENTER

```
23      -  °  '  N
```

07. Enter latitude - 342610 using numeric keypad.

08. Press ENTER

```
23       34°  26' 10N
         -      ,   W
```

09. Enter longitude - 0725423E using numeric keypad. *NOTE in order to change from W to E you should use the right arrow.

10. Press ENTER

```
23       34° 26' 10N
         072 54' 23E
         +00000m ALT
```

11. In order to enter the altitude if you know it press CLEAR

```
23  34° 26' 10N
    072 54' 23E
    +_      m ALT
```

12. Enter Altitude -00500 using numeric keypad

13. Press ENTER

```
23       34° 26' 10N
         072 54 '23E
         +00500m ALT
```

C: INITIAL GPS SETTINGS

The following list contains the settings for the GPS unit in normal use. It is important that you have these settings when using the unit. When alternative settings are required they will be mentioned in the instruction manual. After any alteration the settings should be reset in accordance to the list below.

Auxiliary 1.

01.	TERRAIN SETTING	OBSCURED
02.	COORDINATES	LAT/LON
03.	LAT/LON DISPLAY	DEG/MIN/SEC (1.)
04.	MAP DATUM	WGS84
05.	MAGNETIC VAR	AUTO MAG (M)
06.	DIST, SPEED UNITS	Km; Km/HR
07.	ALTITUDE UNITS	meters
08.	TIME DISPLAY	LOCAL AM/PM
09.	BEEPER	ON
10.	DATE ORDER	DAY/MONTH/YEAR
11.	RESET FACTORY DEFAULTS	ON

Auxiliary 2.

01.	CONTINUOUS OPER	OFF

APPENDIX 2.

Emergencies

1/ **Vehicle breakdown:** If the vehicle is repairable, have it repaired. In case it is not repairable , arrange for its removal to the nearest ADT, VITA, CCSC, UN office or the office of an international NGO working in that area, and arrange for the safe storage of the vehicle. If possible, hire a vehicle and continue the survey. If not, return to the nearest field office in Pakistan and await further instructions.

2/ **Vehicle hijack and robbery:** If adequate funds and a hired vehicle can be arranged, continue your survey , otherwise return to your duty station. However make every effort to get wheat samples, equipment, and survey forms back from the robbers.

3/ **Illness or injury of surveyor:** In this case, if the surveyor can recover after a few days rest, arrange a place for him to rest in , proceed wit your survey after arranging a meeting point for him to reach on his recovery. In case the illness or injury is of a serious nature and cannot be treated locally or in Kabul, arrange for him to be sent to Pakistan by the fastest means and continue with the survey.

4/ **Sample point located in insecure area:** In case the sample point is located in an area where there is a security risk or a minefield and waiting for a few hours will not improve the situation go to the next point and continue with the survey.

5/ **Local authorities refuse permission for survey:** If after persuasion they are still adamant, go to the authorities of the province and try to arrange permission and protection

6/ **Shortage of money:** Try to arrange adequate funds locally, or get in touch with other team/field supervisors for assistance.

7/ **Threats from inhabitants of area:** If the threats are of a serious nature, and there is no way of improving the situation, go to the next point and continue with the survey.

8/ **Kidnapping:** Immediately inform field supervisors, if possible, otherwise inform UNDP/UNOCA office in Kabul. If it is the field supervisors who have been kidnapped, inform UNDP/UNOCA office in Kabul, and ask them to send message to DAI Islamabad.

9/ **Loss or theft of maps/Gps:** Get in touch with the field

supervisors who will be carrying spare sets of maps and GPS units.

APPENDIX.
CONTACT ADDRESSES

ADT offices:

01. Ezatullah / Mohd. Tahir
Village Qala Nasera
Kolangar
LOGAR

02. S. Akbar Seeloos
Miana Deh office
Khoshi
LOGAR

03 Rafiullah
Village Garmaba
Charak
LOGAR

04. Suleman Shah
Said Abad District
Said Abad
WARDAK

05. Mohd Nasir
Zaman Khel Village
Chuck
WARDAK

06. Abdul Jabar
Abdul Jabar's House
Ander
GHAZNI

07. Payenda Mohd
Village Asfandee
Asfandee
GHAZNI

08. Amruddin
Old Woleswal Residence,
Waleswali Campus
GHAZNI

09. Abdul Jabar
Sharan, Qallah Wazir mohd
Sharan
PAKTIKA

10. Wali Mohd
Village Khogyani
Maroof
KANDAHAR

11. Said Mohmood
Village Zangi Abad
Panjwaee
KANDAHAR

12. Mohd Arif
Near to Khwaja Mulk Bazaar
Khwaja Mulk
KANDAHAR

13. Bashar Khan
Village khalaj
Shamalan
HELMAND

14. Abdul Karim
Village Dewala
Darweshan
HELMAND

15. Mohd Hasan
Qala Shahi Village
Dari noor
NANGARHAR

16. Latifurrahman
Qala Shahi
NANGARHAR

17. Mohd Taher
c / o Bismillah, SCA
BAMYAN

VITA offices:

CCSC offices:

RANDOM NUMBERS FOR 1992 AFGHAN WHEAT SURVEY

231	55	148	389	473	117	433	438
495	367	70	433	115	313	70	92
479	437	226	110	478	391	259	314
113	147	103	210	100	373	478	380
235	326	475	240	67	498	435	166
485	467	389	279	179	440	474	478
76	83	258	55	160	174	261	269
128	120	13	372	252	1	6	283
386	344	35	259	111	74	485	97
188	331	254	83	252	294	255	94
487	42	330	346	199	231	426	49
489	379	269	154	361	381	328	185
60	146	134	92	90	431	3	19
189	314	91	283	310	333	422	314
100	491	262	6	184	204	250	184
243	422	206	190	314	358	397	455
58	64	13	376	88	248	493	55
73	85	472	146	56	423	8	442
152	280	295	385	39	46	337	37
404	51	255	339	16	268	429	448
127	363	173	279	295	221	394	281
422	371	55	232	371	49	362	122
436	308	410	161	91	167	54	61
130	290	351	331	378	325	322	316
357	225	86	318	230	492	298	252
99	350	122	85	87	87	62	449
418	156	260	30	377	394	368	213
332	388	326	79	171	63	426	480
438	91	443	37	487	280	227	457
7	432	10	198	1	199	167	130
374	123	178	58	377	449	341	243
201	161	262	406	499	288	442	327
430	57	195	419	65	25	131	315
405	307	22	66	356	459	454	350
28	246	86	176	381	165	296	482
106	393	366	206	120	162	409	85
2	357	314	482	234	10	26	410
143	406	103	71	470	183	100	90
125	333	400	118	329	468	354	16
395	476	456	475	82	166	159	237
354	45	352	7	497	115	249	102
90	464	112	349	430	337	492	424
133	326	150	283	180	138	412	301
185	410	285	417	79	379	369	441
221	443	415	182	494	325	117	204
446	488	233	486	464	60	212	269
347	169	442	398	128	176	174	59

170	375	197	54	223	248	455	193
259	159	246	229	439	367	373	22
133	206	146	318	172	201	156	75

CALCULATION OF ESTIMATES AND SAMPLING ERRORS

1. Estimated Areas:

The observations taken along the survey line are a series of measured distances which were assigned codes during the edit process.

If an individual distance is defined as

$$d_{hijkl}$$

where the different subscripts represent the following:

h = the code for the province in which the sample is located;

i = 1 or 2, depending on whether the sample is selected from areas (strata) defined by EarthSat as irrigated cropland (1), or rainfed cropland (2);

j = 1,2...., n_{hi}, where n_{hi} is the total number of completed (area) reports from province 'h', domain 'i';

k = 0,1,2,3, or 4, is the landuse code assigned the individual measurement during the edit process; and

l = 1,2...m_{hij}, where m_{hij} is the number of individual landuse measurements recorded on the form for sample 'j', and 'l' represents a single measurement;

then d_{hijk} is the total of all measurements for landuse code k in sample i,j, and d_{hij} is the total of all the d_{hijk} quantities.

Therefore, the proportion of land in each landuse category on the sample transect, p_{hijk} is computed as

$$p_{hijk}=\frac{d_{hijk}}{d_{hij}}$$

Similarly, the average proportion of land in each landuse category for domain 'i' in province 'h' is computed as

$$p_{hik}=\frac{\sum_{j=1}^{n_{hi}} p_{hijk}}{n_{hi}}$$

Then, the estimated area of land in each landuse category within EarthSat domain 'i', province 'h', is computed as

$$a_{hik}=A_{hi}*p_{hik}$$

where A_{hi} is the Earthsat estimate of acreage in province h, strata i.

Survey estimates of the total area of irrigated (k=1) or rainfed (k=2) wheat in each province are then computed as

$$A_{hk}=\sum_{i=1}^{2} A_{hik}$$

Finally, the A_{hk} are totaled to create provincial estimates of the area in wheat.

2. Variances of Estimated Areas:

Basic principles: Let the characters 'a' and 'b' represent arbitrary constants, and the characters 'x' and 'y' represent values of random variables from a simple random sample.

Then, the variance of the survey average of 'x' is computed as

$$[1]\quad s_{\bar{x}}^2=\frac{\sum_{i=1}^{n} x_i^2-\frac{(\sum x_i)^2}{n}}{n*(n-1)}$$

If the ratio of the number of observations in the sample (n) to the total possible number of sample units (N) is greater than 0.1, then the variance computed as in [1] should be adjusted (reduced) by the fraction (N-n)/N.

Other basic principles are as follows:

a. The variance of a linear combination of random variables is the sum of the variances of the individual variables. That is

$$[2]\quad z=x+y,\ then\ s_z^2=s_x^2+s_y^2.$$

b. The variance of the product of a random variable multiplied by a constant value is the square of the constant value times the variance of the random variable.

$$[3]\quad If\ z=a*x,\ then\ s_z^2=a^2*s_x^2.$$

c. The variance of the product of two stochastically independent random variables is the square of the first times the variance of the second plus the square of the second times the variance of the first.

$$[4]\ \textit{If } z=x*y, \textit{ then } s_z^2=x^2*s_y^2+y^2*s_x^2.$$

d. If the two variables are not stochastically independent, then the variance of the product [4] must also include the additional term,

$$+2*s_{xy}$$

where s_{xy} represents the covariance between x and y.

The survey estimate for the area of wheat at the lowest level of aggregation is computed as the product of a constant, the EarthSat acreage for strata i, and a random variable: the survey-estimated average proportion of irrigated (k=1) or rainfed (k=2) for strata i in province h. Therefore the variance is computed as in [3].

$$s_{a_{hik}}^2=A_{hi}^2*s_{p_{hik}}^2, \textit{ where } s_{p_{hik}}^2 \textit{ is computed as in } [1].$$

The variance of the estimated area of wheat for any combination of the estimated acreages is the sum of the variances of the acreages being added.

The standard error (in hectares) of any acreage estimate is the square root of the variance. Also, the relative standard error (or coefficient of variation (CV) expressed as a percentage of the estimate) is computed as

$$CV = 100 * \text{standard error} / \text{estimate}.$$