The agricultural survey improvement program in Islamic Republic of Iran.

Mehrdad, Nematzadeh Alidash
Center for Information & Communication Technology, Ministry of Jihad-e-Agriculture
Taleghani St., Valiasr St. Crossing, Tehran, Iran
mnematzadeh@yahoo.com, mnematzadeh@gmail.com

ABSTRACT

To improve agricultural statistics in Iran, the Ministry of Jihad-e-Agriculture (MOJA) requested assistance from FAO in order to improve agricultural statistics programs which is practical and can produce reliable, timely and cost effective information. The development objective of the project was to establish a methodology for a new National Program of Agricultural Surveys that would produce twice a year the basic national and provincial level data for the agricultural sector.

The immediate objectives of the project was to design and implement an Annual Agricultural Survey in the Hama dan Province, using a multiple frame survey design with two survey rounds per year. The statistical design procedure has been based on Cochran (Sampling Techniques, third edition 1977) and the Multiple Frame Agriculture Surveys (volumes 1 and 2; FAO Statistical Development Series number, 7 and 10). Remote sensing (RS), Geographical Information Systems (GIS) & Global Positioning System (GPS) Technologies have been used to implement the project.

The main objective of the project was design, demonstration and applicability of more advanced methods of producing reliable, timely and cost effective agricultural statistics, as well as training the required staff and providing training material for its implementation. Although the agricultural statistics produced in the course of the project was not timely and therefore could not be effectively used in the management process, the technology that was used to produce it was well demonstrated. The project demonstrated that the new design is capable of producing more reliable, cost-effective and timely agricultural statistics in Islamic Republic of Iran.

Key Terminology application of Remote Sensing, GIS & GPS Technology in agricultural statistics, Multiple Frame Agricultural survey, crop monitoring

1. Background:

Iran adopts a decentralized system in agricultural statistics. Different governmental departments undertake statistical activities individually in the areas of which they are responsible. The Ministry of Jihad-e-Agriculture (MOJA) and the Statistical Centre of Iran (SCI) were the two major organizations for agricultural statistics.
The SCI is responsible for the Agricultural Census and national aggregates. The Bureau of Statistics & Information Technology (BSIT) is responsible for crop & its cost of production, livestock, fishery and forestry surveys.

The MOJA obtains its primary data on crop areas and yields through three major activities:

- Production forecasts
- Agriculture data assessments
- Crop monitoring and direct measurements

Every year through the above activities the MOJA forecasts crop and fruit production levels early spring. Later, in the fall the actual production levels are assessed and if more accurate data are needed, direct measurements and remote sensing techniques are applied.

Production forecasts: By mid spring the Ministry reports its forecasts on production levels for decisions to be taken on food-balance, import-export policies, guaranteed price policies etc. The forecasting is based mainly on time-series analysis and expert’s observations throughout the country at provincial level. Observational reports on areas planted weather reports and input distribution reports are main sources of information for these forecasts. There is no standard procedure and guideline for provincial Agricultural Departments to carry out this task. Each province reaches a conclusion based upon its experts and managerial perceptions. By the end of March all provinces send their reports to the relevant organisation or deputy in the MOJA in Tehran. All the provincial forecasts are then aggregated in collaboration with the relevant experts to derive the national figures. Since there is no coherent procedure written and implemented for deriving this forecast, the figures reflect compromise rather than reality; therefore the figures are not reliable and usually are highly misleading. There is no specific budget allocated for this forecast and it does not involve any kind of formal data acquisition. This process takes between two to three months each year.

Agriculture Data Assessment: Detail agricultural statistics are produced through sampling surveys every year after harvest in fall. Four data collection projects are carried out all through the country in this respect. Each project has its information system with well-defined procedures and manuals. Three projects are designed to assess productions and the fourth one for detailed farming system data. These projects are:

- Wheat and barley sampling project
- Rice & certain crop sampling project
- Other crops sampling project
- Detailed farming system sampling project, called “Cost of Production” system.

In addition, occasionally, BSIT is conducting case specific surveys for particular items, such as potatoes and orchards in some parts of the country. Agricultural statistics is also generated through the reporting systems, which is mainly based on local statistics and expert judgments.

In 1995, a research contract was signed between the BSIT and the International Institute for Aerospace Survey and Earth Sciences (ITC) of The Netherlands to design and develop a proper method which can generate timely and reliable information on the area and production of the major agricultural commodities in the selected province. Such methods could be later upgraded to cover the entire national territory. The project was called “Development of crop inventory and forecasting system for the major agricultural commodities in Hamadan province, Islamic Republic of Iran”. The project activities have been started in March 1995 and were completed by May 1998. The main objectives of the project were formulated as follows:
- Development of crop inventory methods and procedures
- Development of yield forecasting method
- Development of a crop forecasting method
- Development of a conceptual model for the crop forecasting system

Crop area estimation was making use of area frame sampling (square segments) and remote sensing techniques. The area frame sampling performed quite well in all aspects e.g., it cost less; it is more timely and produces a better results. As it is based on measurements rather than interviews; technically it was also well understood and could be easily operationalized at different extent.

The yield estimate was making use of crop growth simulation models which make use of extensive data sets on crop phonology, physiology, soil, weather and management practices. In the absence of the real data for many of the required parameters a reasonable estimates as a default value was applied in the simulation procedures.

The yield components due to its detailed information requirements did not produce a satisfactory forecast of the production of the major agricultural commodities. So BSIT continue crop forecasting concept by using crop growth simulation based on new satellite technology which is Called “Surface Energy Balance Algorithm for Land” (SEBAL). The SEBAL is an image-processing model comprised of 25 computational steps that calculate the actual (ET\textsubscript{act}) and potential evapotranspiration rates (ET\textsubscript{pot}) as well as other energy exchanges between land and atmosphere. This methodology is under examination & the result would be presented later.

In 2000, based on BSIT's request, FAO sent a mission to Iran in order to advise on the establishment of a new national program to improve agricultural statistics based on more advanced survey methods to be installed through a pilot test in Hamadan Province. In this context, an agreement between the government of the Islamic Republic of Iran and the United Nation Organization for Food and Agriculture concerning technical assistance services for the agricultural survey improvement program has been prepared and signed in 2004. The project has been called “Agricultural Survey Improvement Programme (ASIP)”. This time combination of Area Sampling Frame (ASF) & List Sampling Frame (LSF) which is called Multiple Frame sample surveys (MFS), has been used. This paper describes implementation MFS Methodology.

2. Study Area:

The study area was the province of Hamadan, Islamic Republic of Iran. It is located in the Western part of the country and covers 2,021,426 hectares(Figure 1). The area consists of high (3500 m.) mountains, hilly areas and plains. In the plains irrigated agriculture is predominant, though there are substantial salinised areas. In the hilly areas dry farming (mainly wheat and barley) is practiced and also grassland and natural vegetation is present. The mountains are mainly covered by natural vegetation and grassland with (small) valleys where agriculture is practiced (mostly irrigated). The area has a semiarid climate with mild summers and very cold winters. The mean annual rainfall ranges between 320 and 350mm, and mean monthly temperature varies from –5oC in January to 24oC in July. The soils of Hamadan province are predominantly of clayey texture and the litology is determined by calcareous schist, limestone. The major crops in the area are wheat, barley, alfalfa, potato and beans. Wheat and barley that cover 80% of the area are considered as the major crops in the region.
3. Methodology used

The statistical design procedure has been based on Cochran (Sampling Techniques, third edition 1977) and the Multiple Frame Agriculture Surveys (volumes 1 and 2; FAO Statistical Development Series number, 7 and 10). Conceptual presentation of the survey design is shown in figure 1.

![Figure 1: Location of study area](image)

![Figure 2: Conceptual presentation of the survey design](image)
In the course of the design the following activities have been carried out:

- Establishment of a stratified map of the province. Considering the existing land use maps and manual photo interpretation of recent satellite images (IRS-WIF, 180 meter resolution acquired on September 2005, and 2005 SPOT -5 images) the project area has been stratified in, Irrigated agriculture, Rain fed agriculture, Orchards, Range land, Non-agriculture, and Urban. Next the area of each stratum has been measured.

- Selection of sample size and sampling rate in each stratum: Sample size and rate in each stratum has been selected based on the importance and variability within each stratum, tradeoffs (ratio) between input (cost, and resources) and output (accuracy). In this process first the sample size for each stratum had been selected and then based on the required sampling rates the number of samples so called “Secondary Sampling Units (SSU)” in each stratum had been identified. As a result, 181 “SSU” had been selected (Table 1).

- PSU and SSUs sizes had been decided as following: for range land stratum, a SSU equal to100 ha, and PSUs from 1000 to 2000 ha. For rainfed land the average size for SSUs 50 ha and PSUs from 500 to 1000 ha. In the irrigated land, SSUs has been around 25 ha and PSUs from 250 to 500 ha. Finally the average SSUs for orchards 20 ha and PSUs average size varying from 200 to 400 ha.

- Establishing Prime Sampling Unites: The sample units “SSU’s” in different strata have been distributed over each stratum through larger units so called “Primary Sampling Units (PSU). Each PSU, contains10-20 SSU’s. Next PSU’s has been manually delineated on Land Sat-ETM Ortho-photomap containing the stratified boundaries as well as administration boundaries. Delineation has been carried out by local experts after proper training, based on natural and physical boundaries. PSU boundaries has been entered into a GIS (digital database) and prepared for sample selection.

- Identification of the selected prime sampling units. To distribute the selected number of samples in the study area, a replicate sampling method has been applied. The replicate number has been coordinated with the desired sample rotation. The samples were

### Table 1: The area of each Stratum and its related total and sampled number of SSU’s

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Area( ha)</th>
<th>Number of SSU’s</th>
<th>SSU size (ha)</th>
<th>Sample rate</th>
<th>Number of selected SSU’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>428085</td>
<td>4281</td>
<td>100</td>
<td>0.004</td>
<td>16</td>
</tr>
<tr>
<td>Rainfed</td>
<td>814256</td>
<td>16285</td>
<td>50</td>
<td>0.005</td>
<td>81</td>
</tr>
<tr>
<td>Irrigated</td>
<td>376137</td>
<td>15045</td>
<td>25</td>
<td>0.004</td>
<td>64</td>
</tr>
<tr>
<td>Orchards</td>
<td>50498</td>
<td>2520</td>
<td>20</td>
<td>0.008</td>
<td>20</td>
</tr>
<tr>
<td>Non agriculture</td>
<td>352450</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2021426</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>181</strong></td>
</tr>
</tbody>
</table>
drawn in a way that is evenly distributed over the stratum. After selection of PSU’s in each stratum, their boundaries have been transferred into a geometrically corrected (1/10,000 scale) 2005 Spot-5 images with 10 meter resolution. For orchards the 1/5000 enlargement of IRS-Pan image (with 6 meters resolutions) has been used. In this process the boundaries have been adjusted to natural and physical boundaries (figure 3).

Figure 3: selected PSUs of Hamedan Province

- Identification of Second Sampling Units "SSU’s". In this process, each selected PSU has been divided into 10-20 SSU’s, (the size of SSU’s for different strata). Delineation of SSU’s in each PSU has been carried out considering the size and natural boundaries. Next SSU’s have been numbered and a sample has been randomly drawn. The SSU's are units that have been used for field-work; therefore they have been well defined and documented.
- Definition of selected SSU samples: The boundaries of selected SSU’s have been transferred to existing IRS 1-D, 1-C, Pan Images, and printed on the 1/5000 scale paper (Figure 4). Using the hard copies, the boundaries of the SSU were further adjusted to the natural boundaries. For orchard, to achieve better visibility it had been decided to use the enlarged 1996 aerial photographs. The aerial photographs have been first scanned, geometrically corrected and used for the process.

![Figure 4: selected SSU ortho-photomap (IRS 1c panchromatic image, scale 1:5000)](image)

- A complete kit per enumerator had been prepared containing, maps and images of different scales, instruction for finding, establishing, and completing questionnaires and data collection and finally a hand held GPS for navigating & locating the segments. To facilitate the data collection process, the kit also included, an enlarged colour-composite spot image, map showing the distribution of SSU’s, map of selected PSU, plus the 1/10,000 colour image and 1/5000 scale black and white images of a selected SSU.

The area frame have been used for different items; mainly annual crops, orchards, and livestock. However, area frame alone could not ensure good results for livestock or for rare and concentrated items. Therefore for some of the items, such as livestock a mixed frame (list + area) has been applied. In order to combine both frames, a list of large livestock holders had been prepared and a decision has been made to interview all farmers who own more than 100 heads of cow and calf or more than 500 heads of lamb, sheep and goats. A separate list of names had been prepared and given to the enumerators to check during the survey to identify those holders that are on the list and operating in the sample units. Clear instruction had been given to remove all the large farmers from the area frame since they will be enumerated exhaustively while the small holders will remain related to the sample units where they
operate. According to the importance of livestock in the country and the accuracy requirement, the weighted segment has been preferred for use instead of open segment.

All the above processes have been mainly carried-out by the local experts after short face-to-face training and on the job training.

**Field work and data collection**

The field data collection had started after control of SSU, PSU, definition, documentation and preparation of questioners, forms, codes, and instructions. That had included the following main activities:

- Filed work training: A period of 5 days field work has been carried-out to verify and improve the given training to the field crews; to make sure that the field organization can carry out the data collection and data quality assessment, and validate and improve the instructions, forms, and developed procedure.

- In the survey design two rounds of data collection had been foreseen. One for collecting data on areas and livestock and one for production and other economical items. Since the first round had been delayed due to none availability of new satellite data, it had been decided to carry out the two rounds as follows:

  **First round:**
  - Postpone the field data collection of orchards stratum for one month,
  - Collect data on area for all holders
  - Collect data on production just for holders who have harvested their fields before the survey day,
  - Collect data on livestock for the holders who operate within the unit and having less than 100 heads of cows or less than 300 of sheep/goats.

  **Second round:**
  - Concentrate on larger operators which have more than 100 heads of cows or 300 heads of sheep/goats.
  - Collect data on production for the remaining holders who had not harvested their fields during the first round.

**Data processing quality assessment**

According to the original plan, the data processing should have been completed by December 2006, which should have allowed quality assessment and documentation to be finalized by January February 2007. Due to some administration problem the links between FAO experts and project implementation was cut until April 2009. Naturally this delay had caused significant impacts on the effectiveness and efficiency of the project. As organization, quality control, and processing of the collected data had been disturbed. The FAO experts in their last mission (April 2009), had reviewed the design and implementation of sampling ASF including data collection, data entry and processing, survey results and had made an overall assessment of the project, with special attention to the documentation of processes by the Iranian counterparts.

**Documentation**

One important element of the project has been documentation, which includes basic theory and principles, development of proper manual for sampling design, field work and data processing. In addition to provided text book, a manual has been developed by the Iranian experts. This has been considered important as it documented the process as has been understood by the Iranian experts.
3. Results obtained

Estimates were made for each stratum. Some strata give more accurate results because of variations in sample rate. Here only the combined estimate for the province is given.

Three main results were expected: Crop areas estimates, Crop productions estimates and livestock estimates.

To estimate crop areas and crop productions, closed segment method was used due to the precision provided at different levels (stratum, province). However, for livestock estimates weighted segment method was preferred because the reporting unit here is the holding.

The outcome of data analysis doesn’t include the crop production estimates according to the difficulty found in processing data section to supply data on the crop production estimates. The same for the orchards stratum either for areas nor crop production estimates as well data were not processed. So, the outcome can be divided into two sections accordingly: area estimates and animal husbandry estimates.

3.1-Crop areas estimates

The total area for all strata considered under the present study in Hamadan province are estimated to 697 307 hectares where the cereals represent a major proportion (74%). Table 2 shows details of area estimates by crop in Hamadan

<table>
<thead>
<tr>
<th>crops</th>
<th>Total In irrigated land</th>
<th>Total In rainfed land</th>
<th>Total In range land</th>
<th>Total in province</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat rainfed</td>
<td>34622</td>
<td>261957</td>
<td>47941</td>
<td>344521</td>
</tr>
<tr>
<td>Wheat irrigated</td>
<td>77186</td>
<td>19278</td>
<td>1838</td>
<td>98302</td>
</tr>
<tr>
<td>Barley rainfed</td>
<td>11824</td>
<td>12840</td>
<td>14852</td>
<td>39516</td>
</tr>
<tr>
<td>barley irrigated</td>
<td>25395</td>
<td>5417</td>
<td>171</td>
<td>30983</td>
</tr>
<tr>
<td>Maize</td>
<td>3060</td>
<td>965</td>
<td>0</td>
<td>4025</td>
</tr>
<tr>
<td>potato</td>
<td>17965</td>
<td>348</td>
<td>166</td>
<td>18479</td>
</tr>
<tr>
<td>Beans</td>
<td>784</td>
<td>84</td>
<td>0</td>
<td>869</td>
</tr>
<tr>
<td>alfalfa</td>
<td>50137</td>
<td>5919</td>
<td>3644</td>
<td>59701</td>
</tr>
<tr>
<td>other silage</td>
<td>4274.38</td>
<td>4607</td>
<td>8147</td>
<td>17029</td>
</tr>
<tr>
<td>other crops</td>
<td>25719</td>
<td>30431</td>
<td>27733</td>
<td>83883</td>
</tr>
<tr>
<td>Total</td>
<td>250 958</td>
<td>341 847</td>
<td>104 493</td>
<td>697 307</td>
</tr>
</tbody>
</table>

3.2- Animal husbandry estimates

The total of all animals (for all strata) actually counted is given in Table 3, Cattle, sheep and goats were counted in all strata but the major proportion is represented by sheep (86%) while the cows and goats both don’t exceed 14%.
Table 3: Results of animal husbandry survey (Hamadan province AFS 2006)

<table>
<thead>
<tr>
<th>Strata</th>
<th>Cow</th>
<th>Sheep</th>
<th>goat</th>
</tr>
</thead>
<tbody>
<tr>
<td>irrigated agriculture</td>
<td>62060</td>
<td>597231</td>
<td>40568</td>
</tr>
<tr>
<td>rainfed agriculture</td>
<td>52863</td>
<td>1210020</td>
<td>117183</td>
</tr>
<tr>
<td>range lands</td>
<td>22475</td>
<td>377795</td>
<td>44147</td>
</tr>
<tr>
<td>orchard</td>
<td>12941</td>
<td>94372</td>
<td>9942</td>
</tr>
<tr>
<td>large holders</td>
<td>5020</td>
<td>3807</td>
<td>65</td>
</tr>
<tr>
<td><strong>Total in Hamadan province</strong></td>
<td><strong>155,359</strong></td>
<td><strong>2,283,225</strong></td>
<td><strong>211,905</strong></td>
</tr>
</tbody>
</table>

since it’s the first application of the weighted segment, regarding the way data has been processed and the no availability of some input about number of strata, number of households interviewed before stratification, the limit of cut off of each stratum etc., we could not ensure if the results are correct enough unless we reprocess all the data, do their checking again and having all input missed to do the analysis. It should be understood that particularly for livestock it was no way to check data as it should be according to the number of mistakes related to shared production system, the data processing system and the data base system.

4. Conclusions

The evaluation of the whole survey work in Hamedan province through the final survey findings were good enough ensuring technically that the extension of this new methodology to other regions would be without any risk and particular problems. However, decision makers have to determine when and where the extension of this new methodology should be and make sure to have the necessary facilities and staff competency for processing data and building a good data base system.

The working team has got a good methodological knowledge even though, there is still a need for technical assistance to supervise different activities. The project has achieved its objectives despite the use of old materials such as satellite data acquisition, aerial photography during the preparation phase.

Based on the information collected during the survey, data analysis of the field samples and evaluation of the current stratification, it’s highly recommended that a complete stratification may become necessary which can be achieved through application of new satellite data. This shall help establishing a better frame and land use strata.

As due to lack of time was not possible to control the production and orchard data there is no estimates for crop production estimates and orchards area estimates. This means that the final results will be underestimated even for crop areas and livestock, as the cropped area in the orchard strata is not included.

Considering the BSIT’s and regional field office competences the test had met its objectives and the new survey sampling system (dual frame) can be expanded to other provinces as well as to the national level in the future. The results will be more satisfactory
for the users since the areas will be assessed through measurement procedures instead of the household declarations and the productions will be based on the weight from selected plot cutting crops. The new survey’s system will provide means to the BSIT to have areas and productions precisely measured and good statistics on livestock as well.

5. Issues in application of RS, GIS & GPS Technologies in agricultural statistics and proposed solutions

A. The most important issue is availability & accessibility of remotely sensed data. Because of international sanction against Iran, ordering & purchasing satellite data is very difficult. So we need to list & organize existing data & apply them for similar projects in the MOJA. In this regards two main activity have been done:

1. Activating council of RS & GIS users of the MOJA in order to coordinating RS-GIS activities & decreasing implementation of parallel projects.
2. Design & development of spatial data clearing house the MOJA in order to inform data users of existing data like satellite data, aerial photograph, topographic maps in different scales, thematic maps, GIS information layer & so on.

B. Regarding international sanctions against Iran purchasing RS/GIS software is very difficult so council of RS & GIS users of the MOJA in coordination with the national council of GIS Users decided to change to open source RS & GIS software.

C. To support decision makers & planners, establishment of a system for crop monitoring & forecasting is essential. Dual frame sampling surveys is capable to produce reliable information on area and production but doesn’t produce any map, so combination of DSF with modern digital image processing for producing precise spatial statistics is a filed for future research. Also application of RS, GIS & Crop growth simulation models to monitor & forecast of crop production is a field for future research. As mentioned before, the MOJA is testing use of SEBAL model & will report the results soon.

6. References


FAO (1996) Multiple Frame Agriculture Surveys volumes 1 ; FAO Statistical Development Series number 7

FAO (1998) Multiple Frame Agriculture Surveys volumes 2 ; FAO Statistical Development Series number 10