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# AGRICULTURE STATISTICAL ANALYSIS BASED ON SATELLITE IMAGERY

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## ABSTRACT

Increasing agricultural production has long been a strategic goal of the Egyptian Government. The Ministry of Agriculture and Land Reclamation has a mandate to increase agricultural yields, bring new reclaimed land, monitor and protect existing agricultural land. Thus a better information concerning all agriculture land must be collected to improve land management. Remote Sensing satellite images is the best tool for many applications such as production of topographic mapping, exploration, generation of land use, soil and geological maps , as well as monitoring of variations & land cover over a certain period of time. A new system for collecting agricultural information is established, which is called ALIS (Agricultural Land Information System). It can be used efficiently for land cover determination on the national level. It has been tested for a case study area in Fayoum and proved to be efficient and satisfying the surveying accuracy standards in various check points. In addition, valuable products have been developed, including TIN and orthophotos.

## INTRODUCTION

Remote sensing images are utilized for many applications such as generation of land use maps and monitoring of variations and land cover over a certain period of time. Many researches have been made in this area in Egypt for the Ministry of Agriculture. Ismail (1998) evaluated the remote sensing classification techniques on Abu Hammad district, Sharkia governorate, detected the changes in land reclamation from 1964 to 1997 for the same area and utilized the change detection for updating GIS database using different techniques. Khalil *et al.* (1998) and Fahim *et al.* (1998) determined the urban encroachment at Tanta and El-Mahalla El-Kubra cities. This research focuses on crop area estimation using the statistical parameters in the main administrative entities. The treated area must be homogenous with the same type of land use, resulting from zoning process, and then segments are created. The segment sampling entities are composed of the polygon intersection between administrative entities layer and the zoning layer, FAO (1996). These entities are named strata, Fig. (1).

## EXPERIMENTAL WORK
## EXPERIMENT SETUP

The study area is chosen in El-Fayoum governorate. The data used in this study are SPOT XS and SPOT Panchromatic scenes acquired in summer 2002 (111-291,111-292).

Utilized hardware includes HP workstation, PC's, scanner, a printer, and a plotter. Software includes ARC/Info, PCI, Java and Oracle.

## PROCEDURE

The proposed technique is carried out through the following procedure:

- -Read the digital satellite data (SPOT) using remote sensing software.
- -Apply the geometric correction to the images using the corrected images (level 2B) acquired from SPOT and registering all other images to it using the 2nd order polynomial model.
- -Merge the adjacent SPOT scenes with the same acquisition date and the same view angle into a mosaic in order to obtain a larger image that cover the pilot area.
- -Create the vector coverage, which contains the administrative boundary of pilot area in EL Fayoum Governorate.
- -Divide the area into Homogenous areas (Zones). The aim of zoning is to define homogenous areas, to be used as a basis for the random selection of the segment. The description of various zones is described in Table (1)
- -Digitize Zoning layer as polygon coverage.
- -Overlay the Governorate boundaries with the zones in order to define homogenous area (strata), Fig. (2).
- -Determine the excluded zones such as water and urban.

**Table (1): Zones Description**

| Zone name | Description |
|---|---|
| Zone 0 | Urban and rural housing |
| Zone 1 | Desert , water and salt affected soils near lakes. |
| Zone Z3B | The field crops are cultivated in clay soil. Fruit and vegetables are cultivated in loamy soils close to the Nile stream. |
| Zone Z7A | New cultivated areas West-Delta, fruit trees, vegetables and water melon, soil type is sandy soils |

## SAMPLE SELECTION

The sample design is done by selecting stratified samples of holding, selected with probability proportional to their area. In this case a grid is overlaid on the strata and sample points are selected. These points are then identified. The ground and the corresponding holding are selected for the area sample.

The segment sampling process provides a random position of segments. Fig. (3), Tables (2) and (3) illustrate the agricultural strata and define the segment sample.

**Table (2): Agricultural Strata**

| Stratum name | Acreage (feddan) | Sample rate | No. of segments |
|---|---|---|---|
| G06-Z3B | 365802.2449 | 2.52 | 79 |
| G06-Z7A | 17908.92 | 1.95 | 3 |
| G06-Z0 | 9321.164 | 0 | 0 |
| G06-Z1 | 142096.12 | 0 | 0 |

**Table (3): The Segment Sample (Size and Scale)**

| Segment size x(M) | Segment size y(M) | Scale |
|---|---|---|
| 700 | 700 | 1:7500 |

The land survey document is composed of:

- A printout of the portion of a multi-spectral image is plotted , including the segment at a scale 1:7500 with a transparent film attached on a paper (A4) size, Fig. (4).
- A print out of the portion of a panchromatic image is plotted , including the segment at a scale 1:50000 to be used as a localization document on a paper (A4) size, Fig. (5).
- An assembly board of the localization documents is prepared.

## GROUND TRUTH

Many field trips are carried out to the study area to collect the required ground truth information, necessary for the classification process. Each team includes four specialists, in addition to a car driver. It includes a GPS operator, two surveyors for collecting surveying measurements, as well as for specifying different locations at the ground that match certain regions in the image (segment) with a scale of 1:7500, and an agricultural researcher from the surveying and land classification department for gathering different information related to land cover and crop specifications.

Different surveying instruments are utilized during these missions, including GPS receivers, compass, tapes, in addition to existing panchromatic maps of the regions with a scale of 1:50000.

Land surveyors draw the boundaries of the parcels inside the segment on the transparent film and register the land use and crops of each parcel, Table (4). Then the transparent film is transformed to digital format. The ground survey must represent the whole territory and thus a sampling rate of 2% is chosen in order to characterize the land use of each stratum properly for the success of the system.

The operators input the land use information for each parcel of each segment. These data are processed and extrapolated to give the statistical results depending on strata and administrative entity.

**Table (4): The Crop Nomenclature For Noting The Land Use**

| MAIN CROP | |
|---|---|
| COTTON | 10 |
| MAIZE | 20 |
| RICE | 30 |
| SUGARCANE | 40 |
| PEANUT | 50 |
| SOYABEAN | 60 |
| SESAM | 70 |
| SUNFLOWER | 80 |

| TREES | |
|---|---|
| CITRUS FRUIT | 220 |
| MANGO | 221 |
| DATETREE | 222 |
| BANANE | 223 |
| OTHER FRUIT TREES | 225 |
| OTHEETREE | 230 |

| VEGETABLES | |
|---|---|
| CUCUMBER | 200 |
| EGG PLANT | 201 |
| TOMATO | 202 |
| OKRA | 203 |
| CABBAGE | 204 |
| WATERMELON | 205 |
| SWEETMELON | 206 |
| OTHER | 216 |

| | |
|---|---|
| AGRICULT.BARE SOIL | 235 |
| FALLOW LAND | 240 |
| WASTE LAND | 245 |
| ROADS & RURAL HOUSING | 250 |
| WATER | 256 |

| LEGEND | | | |
|---|---|---|---|
| ST=CROP STAGE | 1=SOWING/FLOWERING<br>2=FLOWERING/MATURATION<br>3=MATURATION/HARVESTING<br>4=HARVESTED | H0=HOMOGENUS | 1=YES<br>2=NO:DISEASE,SALINITY<br>3=NO:DIFFERENT STAGES<br>4=NO:CROP PATCHES<br>5=NO:MIXED CROPS |

| PARC. | LANDUSE | CODE | ST | H0 | SA | OBSERVATIONS |
|---|---|---|---|---|---|---|
| A | | | | | | |
| B | | | | | | |
| C | | | | | | |
| D | | | | | | |
| E | | | | | | |
| F | | | | | | |
| G | | | | | | |
| H | | | | | | |
| I | | | | | | |
| J | | | | | | |
| K | | | | | | |
| L | | | | | | |
| M | | | | | | |
| N | | | | | | |
| O | | | | | | |
| P | | | | | | |
| Q | | | | | | |
| R | | | | | | |
| S | | | | | | |
| I | | | | | | |
| U | | | | | | |
| V | | | | | | |
| X | | | | | | |
| Y | | | | | | |
| Z | | | | | | |

| | |
|---|---|
| STRATUM: | |
| SEGMENET NO.: | |

| |
|---|
| SURVEY DATE: |

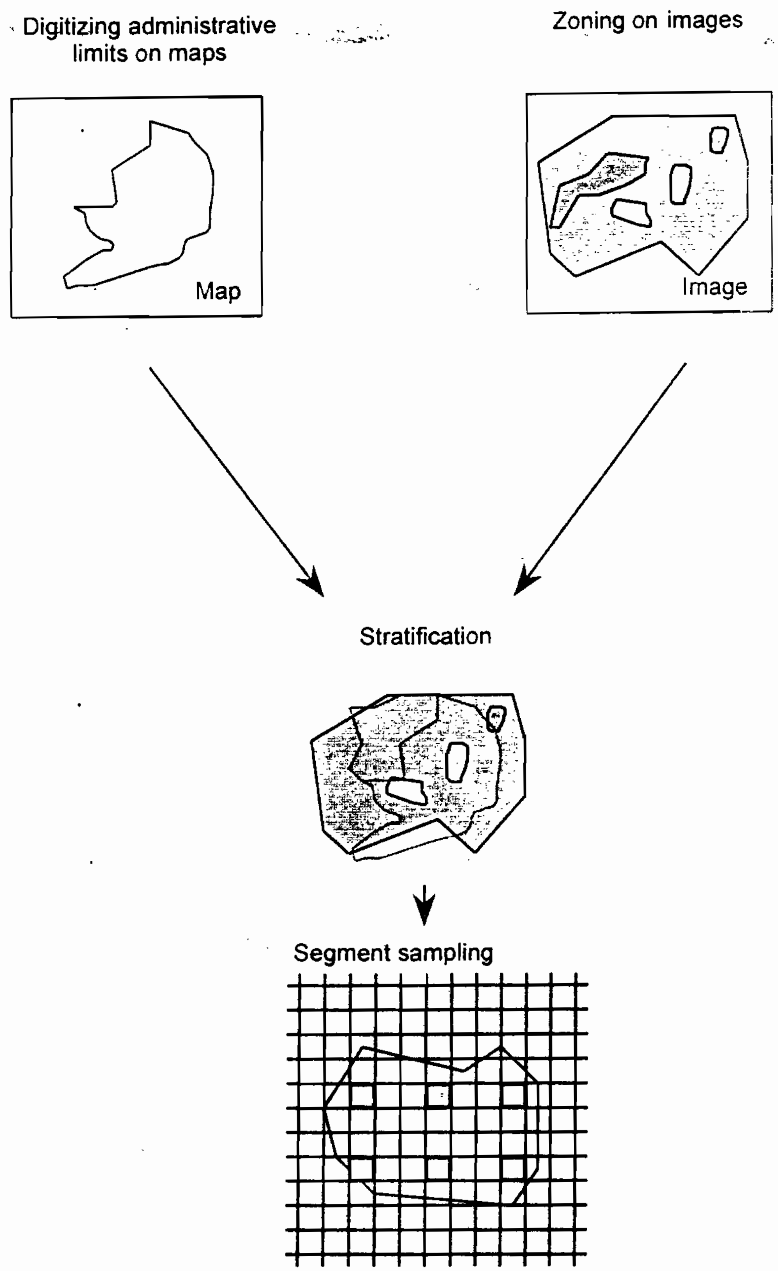



**Fig. (1): Overlaying Of The Administrative Boundary And Zones To Produce Segment Sampling**

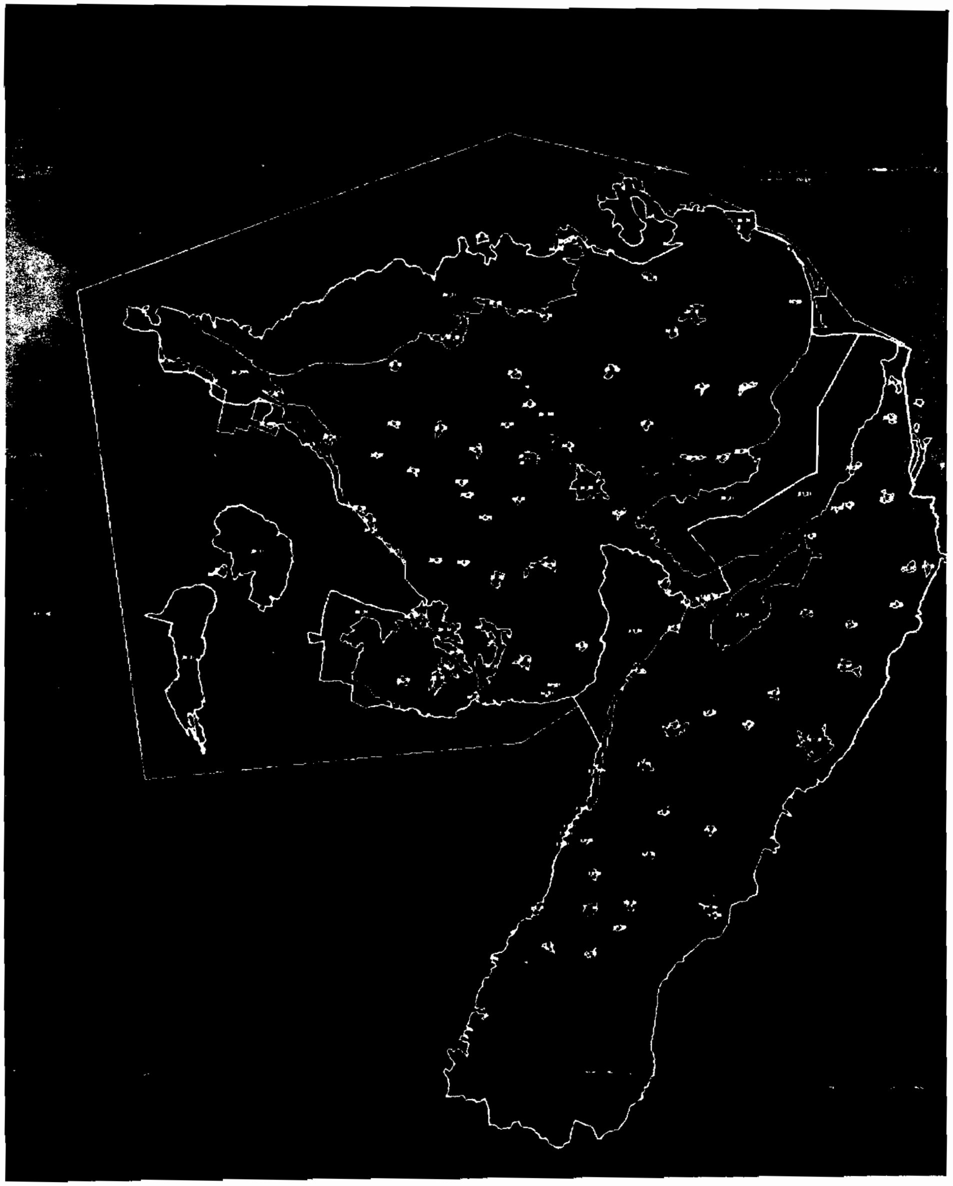


Fig. (2): Location Of Zones

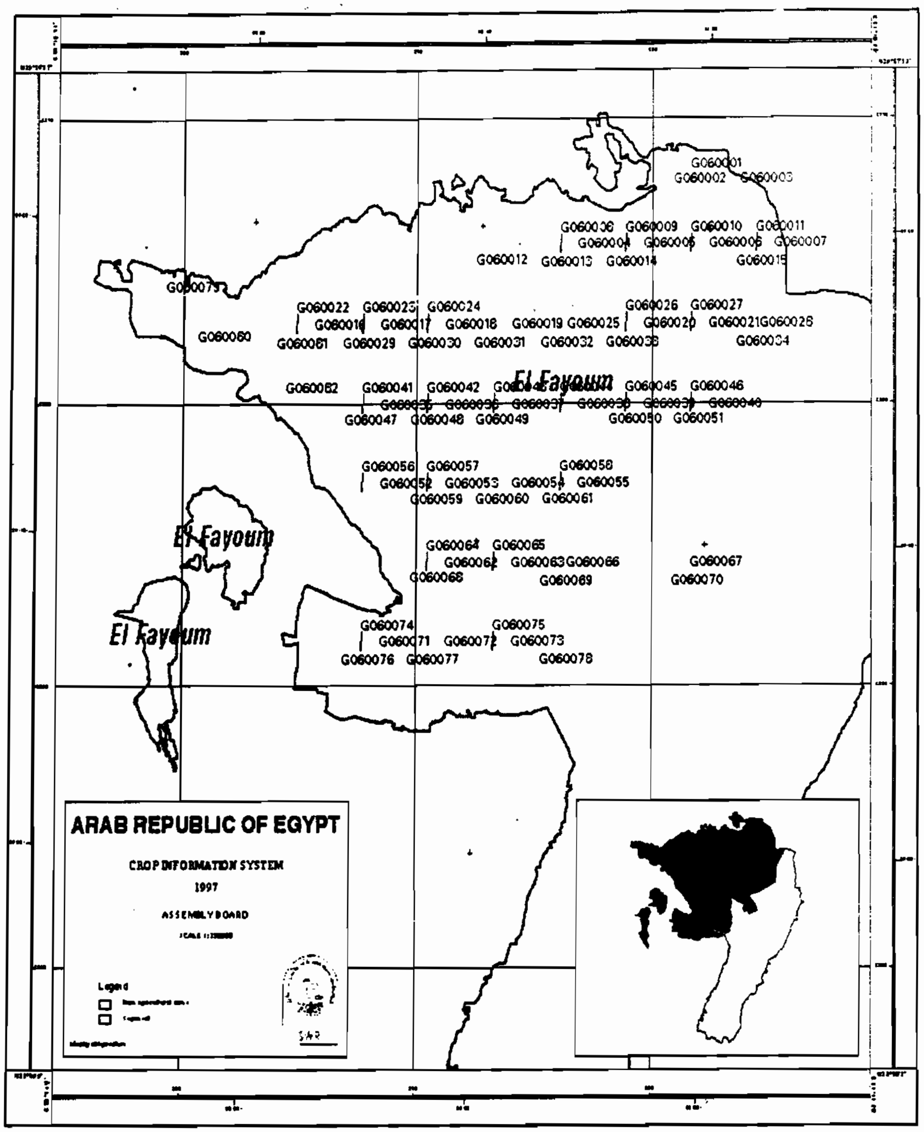
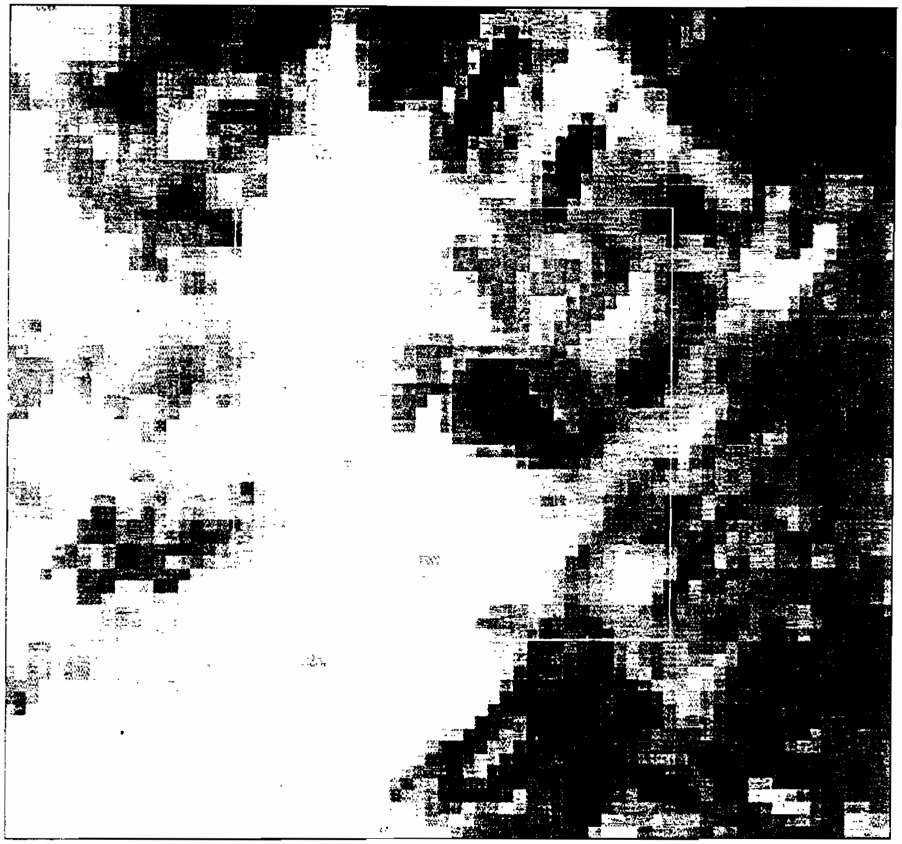



Fig. (3): An Assembly Board Of The Localization

*Ministry of Agriculture*



**G060082**

SEG N° ..........    SURVEYOR : ..........................    DATE : ................

COMMENT :

SCALE : 1/7500

**Fig. (4): A Multi-spectral Segment**

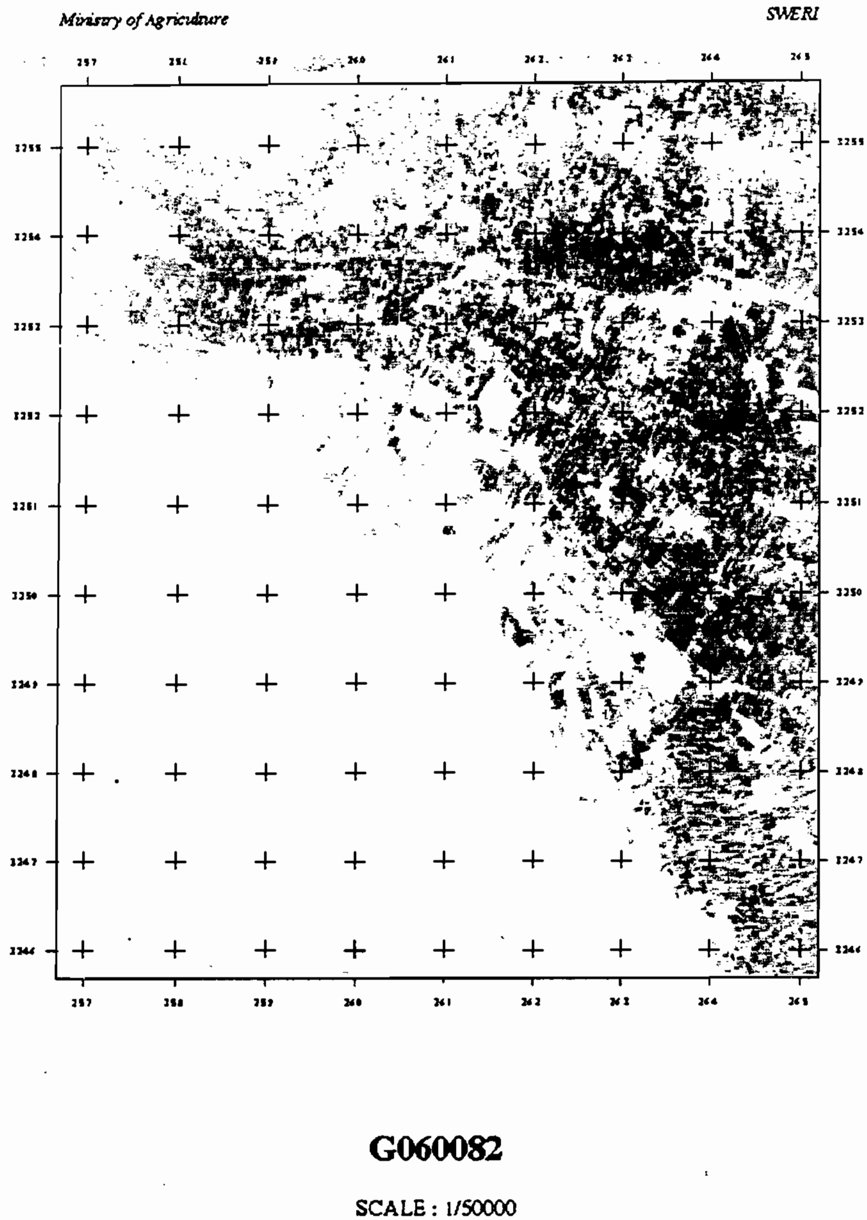



**Fig. (5): A Panchromatic Image Including The Segment (Localization Map)**

## LAND STATISTICAL ANALYSIS

Six land classes (Rice, Trees, Vegetables, Cotton, Other Crops, Non-Agriculture) are considered. There are two stages of statistical analysis, primary statistics and final statistics

## PRIMARY STATISTICS

For a group of crops and a stratum or zone, the following statistical parameters are considered.

**Mean**

$Xs = 1/n \Sigma X$

**Variance**

$Vs = 1/n*1/(n-1) \Sigma(X-Xs)^2$

**Deviation**

$Ds = sqrt(Vs)$

**Variation**

$Cs = Ds/Xs$

Where

(n) represents the number of segments of a stratum or a zone.

($\Sigma$) is the summation of every valid segment of the stratum or zone .

(X) is the total area of a group of crops in a segment.

The primary statistics results for the pilot area(strata and admin are given in tables 5,6).

**Table (5): Primary Statistics For A Zone Or A Strata**

| Group of Crops | Mean (%) | Variance (%) | Variation (%) |
|---|---|---|---|
| Rice | 13.020 | 6.780 | 19.999 |
| Trees | 5.970 | 4.230 | 34.451 |
| Vegetables | 0.170 | 0.020 | 83.189 |
| Cotton | 9.660 | 1.930 | 14.381 |
| Other crops | 59.450 | 11.530 | 5.712 |
| Non-agri | 10.470 | 3.460 | 17.766 |

For a group of crops and an administrative entity, the following statistical parameters are calculated:

**Mean**

$Xa = \Sigma Ss*Xs$

**Variance**

$Va = \Sigma Ss^2*Vs/ns$

**Deviation**
Da = sqrt(Va)

**Variation**
Ca = Da/Xa

The primary statistics results are given in table ( 5 )

**Table (6): Areas And Primary Statistics For Different Classes At Administrative Entity Level**

| Crops | Mean (%) | Variance (%) | Variation (%) |
|---|---|---|---|
| Rice | 12.410 | 6.160 | 19.999 |
| Trees | 5.690 | 3.840 | 34.439 |
| Cotton | 9.210 | 1.750 | 14.363 |
| Other crops | 56.680 | 10.480 | 5.712 |
| Non-agriculture | 9.980 | 3.140 | 17.756 |

## FINAL STATISTICS

Final statistics rely on a set of segments that may be different from the segments used for land survey statistics. In order to produce final statistics, the images must be classified using image processing software using the maximum likelihood classifier technique and then importing` the classification results from image processing software to exclude urban area from zoning.
The final statistical results for the pilot area are given in table (7).

**Table (7): Areas And Final Statistics For Different Classes At Administrative Entity Level**

| Crops | Mean (%) | Variance (%) | Variation (%) |
|---|---|---|---|
| Rice | 13.410 | 7.580 | 21.843 |
| Trees | 5.170 | 5.350 | 44.739 |
| Cotton | 9.460 | 2.440 | 16.512 |
| Other crops | 60.260 | 14.590 | 6.339 |
| Non-agriculture | 11.700 | 4.380 | 17.888 |

## CONCLUSIONS

1- Many advantages are considered when using the proposed technique, including:

- The training area is taken randomly from homogenous zones (strata).

- The training area (segment) was controlled by a ratio of (1%, 1.5%) of the total area and also number of replicate of the segments.
- The segments are good representative samples because they are chosen from homogenous area
- The user can exclude the non-agriculture zones from the sample such as urban and water.

2- Two factors affect the results, which are zones and sample ratio.

3- To determine the primary statistics, the old documents and old data can be used because the primary statistics depend on the number of segments in the strata and the strata area and no relation exist between the computation and the image characteristics .

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## تحليل احصائى زراعى باستخدام صور الاقمار الصناعية

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تعد زيادة الإنتاج الزراعي هدف استراتيجى للحكومة المصرية وتهدف استراتيجية وزارة الزراعة واستصلاح الاراضى الى زيادة الانتاج الزراعى واستصلاح اراضى جديدة ومراقبة وحماية الاراضى الزراعية الحالية.

ولهذا فإن تجميع بيانات كاملة عن كافة الاراضى الزراعية هدف هام جدا لتحسين ادارة الاراضى. وتعد صور اقمار الاستشعار عن بعد الوسيلة المثلى لعدة تطبيقات مثل انتاج الخرائط الطبوغرافية والاستكشاف وانتاج خرائط استخدامات الاراضى وخرائط التربة والخرائط الجيولوجية ومراقبة التغيرات فى استخدام الاراضى والغطاء الارضى فى المدد الزمنية المختلفة.

ويستعرض هذا البحث انشاء نظام جديد فى تجميع البيانات الزراعية يسمى (نظام معلومات الاراضى الزراعية) والذى يمكن استخدامه بكفاءة فى تحديد الغطاء الارضى على المستوى القومي وقد تم اختبار النظام بمنطقة دراسة بالفيوم وأثبت كفاءة عاليه مع تحقيقه للدقة المساحية المطلوبة عند نقاط التحقق الارضية بالاضافة الى انتاجه عدة مخرجات رقمية قيمة مثل نموذج الارضى الرقمى والصور العمودية الجوية