Remote Sensing Applications in Agricultural Statistics at China NBS

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Outline

01 Introduction

02 Remote Sensing Measurement

03 Area Frame Survey

04 Software & IT Infrastructure

05 Challenges & Development
The new requirements of agricultural statistics in 21th century.

- **Provide relevant data for policy making to ensure national food security.**
  - Food security has the highest priority for the development of modern agriculture.
  - Agricultural statistics are vital information for grain development strategy.
  - The international situation, the rapid development and profound change of agriculture and rural area in China brings up the new requirement.

- **Meet the data gap for modern agricultural development.**
  - Grain Production Counties Development Strategy has implemented, which requires to set up statistical monitoring and evaluation system.
  - The strategy of developing facility-based agriculture and standardizing horticulture production was set up, which requires corresponding statistics.
  - The innovation of agricultural technology integration, mechanizing and informatization, new survey tools should be applied for these new farming.
  - To enhance the agricultural production with social services supporting, agricultural statistics should be service-oriented, providing more relevant information to producers.

- **To meet the needs of multi-dimension services.**
  - Markets need timely, accurate, transparent information.
  - Large and small area statistics are all needed.
  - The data are needed for all major crops, include commodity crops and minor crops.
  - Information for food quality, its production and marketing are all needed.
The new requirements of agricultural statistics in 21st century.

- Food security
- Agriculture modernization
- Service-oriental

New goals
- More information
- Advanced vehicles
- Reliable data
- Better services

New requirements
- Data collection capacity
- Data processing capacity
- Data analytical capacity
- Data delivery capacity

Can the traditional agriculture statistical system meet the new requirements of 21st Century?
Traditional agricultural statistics become unadapted

<table>
<thead>
<tr>
<th>Survey schemes</th>
<th>Counting units</th>
<th>Survey tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>The merging of sample</td>
<td>Mobility of sample farmers.</td>
<td>Mainly traditional tool, such as self-report, compass and rope.</td>
</tr>
<tr>
<td>survey and complete</td>
<td>Rapid change of Land tenure.</td>
<td>Cannot efficiently deal with estimation under disaster or other rapid change</td>
</tr>
<tr>
<td>reporting.</td>
<td>Impact of sample farmer’s subjectivity.</td>
<td>Lack of necessary supervision and management.</td>
</tr>
</tbody>
</table>
The support of new technologies

- Computer, network
- Geospatial information technologies
- Big data

Technologies

- Deepening reform
- Agriculture and rural policy
- Scientific outlook on development

Policies

- Best practices of peers
- Experience of other industries

Experiences

Importing new technologies, improving agricultural statistics.
Geospatial information technologies

Geospatial information technologies (3S) include Remote Sensing (RS), Geography Information System (GIS) and Global Positioning System (GPS), combined with computer and network, applied for measurement, collection, storage, management, display, analysis, spreading and application of geospatial data. In USA, Geo-IT has become one of the three hottest occupations (with Biotechnology and Nanotechnology).

The ability of earth observation
- Big range
- High resolution
- Timeliness

The ability of geospatial data management
- Huge volume data
- Visualization

The ability of positioning
- Location
- Navigation
- Measurement and mapping

Geo-IT and agricultural statistics can be naturally integrated.
中国农业统计遥感发展历程

Technical Maturity → Pilot → Implementation

- **Starting phase**
  - 863 project -- The research of norm and application of remote sensing for agricultural surveys 2003年

- **Research phase**
  - 863 project -- The research of key technologies for statistical surveys 2006年
  - Industry project -- Data source pilot of remote sensing for agricultural surveys 2009年
  - Earth observation project -- Pilot of high resolution remote sensing for statistical surveys 2011年

- **Pilot phase**
  - Crop area frame survey 2009年
  - Xinjiang cotton remote sensing measurement 2010年
  - Crop area remote sensing measurement pilot 2009年

- **Operation phase**
  - 863 project -- The research of norm and application of remote sensing for agricultural surveys 2003年
The research of key technologies for operational implementation of agricultural statistical remote sensing

- National research project to produce of key technologies
  Crop remote sensing identification methodology.
  Using geo-spatial technology to build area sampling frame for agricultural surveys. ...

- Using pilot to promote the transformation of research results of key technologies
  Crop area remote sensing measurement pilot will improve crop identification methods with the terrain characters and imagery availability for different regions, and develop methodology operational for specific region. ...

- Use demonstration application to break through the nexus of operational application of key technologies
  Crop area frame sampling survey will integrate the geo-spatial frame building, geospatial sampling, and other new technology. ...
Building two major agricultural statistical surveys system with remote sensing.

- **Crop area frame surveys**
  Beginning from year 2010, crop area frame survey has been carried out at Jiangsu, Henan, Liaoning, Jilin Hubei, Anhui with county-level as population, which has replaced the traditional list-based crop survey. The building of work base for survey have completed and seasonal survey has been carried normally.

- **Remote sensing measurement**
  Beginning from year 2010, remote sensing measurements have been implemented at Beijing, Jiangsu, Henan, Hubei, Jinlin, Liaoning, Ningxia, East part of Inner Mongolia for summer and autumn grain crops. Unmanned aircrafts(drones) and other new survey tools were used for survey and a technical system was built for operational field survey.
Improving the survey tools for agricultural surveys

The first agricultural survey vehicle was developed, which integrated satellite imagery, aero-photography, field observation. So high resolution images, roadside picture and video, field agro-parameters will be collected and combined together to distill useful data for estimation. The data collection capacity of geospatial samples for crop area, growing condition and yield was formed, which provide a solution for completely, rapidly and accurately data collection for estimation of crop area, crop condition and total production.
Crop area remote sensing methodology was developed, which includes data collection and processing, remote sensing classification, field survey, validation, error correction and producing ASCDL as major functions.
Technical procedures

1. Remote sensing identification
2. Classification
3. Change detection
4. Geometric correction
5. Remote sensing image
6. Field work and land use mapping
7. Remote sensing area correction
8. Accuracy assessment

1. 标准化处理
2. 分类
3. 变化检测
4. 几何校正
5. 遥感影像
6. 根据野外样方，优化精度
7. CDL、精度评估
8. 天-地现场一体化调查

作物面积遥感测量校正

海安县冬小麦测量结果
Remote sensing identification

Based on the current multi-phase remote sensing data, land cover (arable land included) were extracted and crop identification were made and finally ASCDL was produced.

**ASCDL**

- County-level knowledge base for identification
- Crop data layers
- Agricultural statistical land cover data layer
- Error analytical layers
- Description of county-level products.

**Production flow of ASCDL**

- 数据准备情况确认
- 测量区县基本知识库建立
- 土地覆盖数据层生产
- 耕地范围提取
- 作物数据层生产
- 样本集建立
- 误差统计分析层生产
- 测量区县产品描述表建立
Field survey and sample interpretation (1)

For the selected field sample, with the support of region office, UAV field survey was carried and aero-photography was captured and crop plots were delineated.

Field work photos

Vectorization of sample land

UAV photo mosaic
Field survey and sample interpretation (2)

- **Photo Captures by RPV or Mobile Devices (Tablets, smartphones)**
- **Area measurement by photos**
Results of remote sensing identification
Area frame was built with 2\textsuperscript{nd} agricultural census data and 2\textsuperscript{nd} land use census data. Cropland segments were created as sampling unit and enough segments were sampled to meet the precision requirement. Several direct interviews of segment planting were carried by interviewer to estimate the crop area. According to the harvest season of crops, certain planting plots were selected for crop-cutting and then the yield of specific crop was collected and estimated. Finally, the crop production was estimated.
Crop area frame survey system

A primary system for crop area frame survey was developed, which includes geospatial sampling frame, segment sampling, field survey, survey data submit, estimation, quality evaluation. Detailed data on fields are collected and measuring precision is improved. The goals to change the counting unit from list to spatial fields were realized.

crop planting area estimates and variances of the Pilot counties in 2009

<table>
<thead>
<tr>
<th>Pilot county name</th>
<th>辽宁法库县</th>
<th>河南濮阳市</th>
<th>江苏溧阳市</th>
<th>吉林德惠市</th>
<th>安徽凤台县</th>
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</thead>
<tbody>
<tr>
<td>对地抽样方法</td>
<td>空间随机抽样</td>
<td>空间随机抽样</td>
<td>空间随机抽样</td>
<td>以规则网格为初级抽样单元的分层两阶段抽样</td>
<td>农普与土地利用数据相结合的两阶段抽样</td>
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<td>标准地块面积（ha）</td>
<td>6.0</td>
<td>5.0</td>
<td>2.0</td>
<td>7.0</td>
<td>2.0</td>
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<td>标准地块数量（总体）</td>
<td>25658</td>
<td>20421</td>
<td>87103</td>
<td>30442</td>
<td>33850</td>
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<tr>
<td>行政村数量（总体）</td>
<td>334</td>
<td>1033</td>
<td>360</td>
<td>285</td>
<td>282</td>
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<tr>
<td>标准地块数量（样本）</td>
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<td>204</td>
<td>871</td>
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<tr>
<td>行政村数量（样本）</td>
<td>159</td>
<td>170</td>
<td>258</td>
<td>80</td>
<td>60</td>
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<tr>
<td>作物名称</td>
<td>玉米</td>
<td>玉米</td>
<td>水稻</td>
<td>玉米</td>
<td>水稻</td>
</tr>
<tr>
<td>总体总值估计值（m²）</td>
<td>1196107178</td>
<td>598069619</td>
<td>393651628</td>
<td>1486401968</td>
<td>900946045</td>
</tr>
<tr>
<td>CV(%)</td>
<td>2.35</td>
<td>4.32</td>
<td>4.95</td>
<td>4.81</td>
<td>4.92</td>
</tr>
</tbody>
</table>
Developing of sampling frame

- **Cultivated land updating**
  By visual interpretation or change detection with current satellite imagery, the cultivated land polygons from the 2nd land use census data were updated for more accurate, complete cover and no missing.

- **Identification of major crops**
  Using remote sensing images to identifying major crops to acquire more ancillary information. Depending the situation of data acquirement, change detection and unsupervised classification method are used for identification of target crops.

- **Sampling units construction**
  **Division with administrative area**: The cultivated land polygons are divided with administrative boundaries and the identification results was summed up by crops for each administrative area.
  
  **Division with grid delineation**: Land polygons were split into grid blocks of same size, and the identification results was summed up by crops for each block.
Two stage PPS sampling

- **First stage:** Primary sampling units, which are villages or grid blocks, were sampled.
- **Second stage:** Land segments were selected with SRS within sampled villages or grid blocks.
Field work package

- Field maps suites: Hardcopy image of sampling villages, vector maps, maps of sampling segments.
- GPS task package: GPS devices are needed for area measurement of the screening survey. All the task base data and forms are packed into task package and loaded into GPS.
Field survey methods

- **Screen survey**
  - Sampling segment screen questionnaire: Collect data at the beginning of each survey round. Location, crop used area, non crop used area, field splitting, and users data are collected.
  - Sampling village questionnaire: Collect data at the end of each year.

- **Seasonal survey**
  - Cropping intention survey: Farmers’ planting intention and plan are carried at sampling segment before winter planting and summer planting. 10 farmers will be selected for survey at each sampling village.
  - Crop area survey: Carried at winter planting, spring planting and early rice planting, summer planting period. Crop area are collected from sampling segments directly.
  - Crop yield and production survey: Carried at summer harvest, early rice harvest and autumn harvest.
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Integrated service platform for agricultural rapid survey.
Overall framework

- **农林统计快速调查**
- **自主遥感卫星**
- **北斗导航卫星**
- **省级数据资源**
  - **省级节点**
- **国家级数据资源**
  - **国家级节点**
- **县级数据资源**
  - **县级节点**
- **区域级数据资源**
  - **区域节点**
  - **中心数据资源**
  - **中心节点**
- **国家统计遥感信息共享服务平台**
- **初级产品标准处理云平台**
- **信息产品服务平台**
- **移动通讯卫星**
- **国家统计遥感信息共享服务平台**
- **移动通讯卫星**
Data source system

- Developing the agricultural statistical remote sensing data source assurance system to provide required satellite imagery.
- Producing and providing data products for operational agricultural remote sensing surveys.
- Exploring the data partnership with line ministries & business firms.
- Developing standard and norm of satellite imagery data product for agricultural remote sensing surveys.
- Carrying out provincial demonstration application.
Agricultural remote sensing survey infrastructure

- **Data source assurance system**
  - *Satellite imagery*: High Resolution Satellite series, Resource Satellite series, Environmental Satellite series ...
  - *Partnership*
    - Line ministries: ministry of land resource, National Bureau of Mapping and Geo-information, National Geo-information Center...
    - Business firms: Oriental Roadnear, PeaceMap, China Science Geo-do...

- **Geo-spatial base data framework construction**
  - *Completely covered satellite imagery*: Multi-phase medium and high resolution satellite imagery, completely covered the major provinces of grain production.
  - *Level by level base geography data*: Based on 2nd land use census data, build up provincial, county-level, village-level, and plot-level base geography dataset.
  - *Other data types*: Geo-referenced statistics, meteorology data, phenology data, hydrology data...
Statistical remote sensing data sharing and service system

It will realize the transformation of agricultural statistics to plane or three-dimensional distribution form at spatial and regional level, which will improve the display methods and means of agricultural statistics, promote the standardization of statistical information, and enhance the ability of analysis, exploration and forecasting to agricultural statistics.
Crop production survey vehicle

产品组成

载车
作用：监测、导航、指挥
特点：
- 能载量大
- 强抗风能力
- 全车集成定制

视频采集系统
作用：实时监测
特点：
- 全方位360度视角
- 高清晰度
- 满足各种监测

固定翼无人机
作用：大范围空间信息采集
特点：
- 体积小
- 操作简单
- 续航久
- 低成本
- 稳定性好
- 封闭设计
- 机翼长度5-8m

手持智能终端
作用：补充调查
特点：
- 调查表单及访问
- 支持多任务信息采集
- 支持多种设备

线路规划
导航
数据处理
样本解析

应用场景
Unmanned Aircraft (drones)

无人机可实现高分辨率影像的采集，弥补了卫星遥感和普通航空摄影经常因云层遮挡获取不到影像的缺陷，同时解决了传统卫星遥感重访周期过长、应急不及时等问题。

无人机的应用领域包括：灾情监测、火情侦查、森林火情监控、自然灾害区域评估等各方面的应急机构提供最及时、可靠的高分辨率影像，为制定相应的应急预案、指挥决策提供强有力的数据支持。

优势特点

- **安全性**：对许多交通偏僻、危险或人员到达不到的地方，无人机可以降低不必要的人员风险，保障工作人员的生命安全，同时完成任务。
- **成本低廉、操作便捷**：无人机虽然是一款高端产品，但它仍远低于采购卫星及有人飞机的设备成本，它具有在小面积航测中极具成本优势；无人机从起飞到降落全程无人操作，整个飞行过程无需人工干预。
- **机动性高，性能灵活**：无人机体积小，便于携带，只要事先做好飞行准备，便可以自由起飞。
- **设计多样化**：针对不同的任务及需求，可以选择各种不同的数字相机及摄像机。
- **解析度高**：无人机的飞行高度较低，可获取高分辨率的影像。影像的分辨率可达到0.06m，甚至更高。
- **环境限制低**：无人机可以在大风、小雨、阴天等环境下执行任务，完全不受环境的影响。

无人机组成

<table>
<thead>
<tr>
<th>型号</th>
<th>飞机照片</th>
<th>载荷</th>
<th>作业时间</th>
<th>作业面积</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatewing X100</td>
<td>理光 N5 1200 万像素</td>
<td>40min</td>
<td>3 平方公里 (分辨率 15CM)</td>
<td></td>
</tr>
<tr>
<td>Swallow (飞燕)</td>
<td>Samsung NX200 2030 万像素</td>
<td>40min</td>
<td>4~5 平方公里 (分辨率 8CM)</td>
<td></td>
</tr>
<tr>
<td>Avian (飞鹰)</td>
<td>Sony NEX-7 2430 万像素</td>
<td>50min</td>
<td>4~5 平方公里 (分辨率 8CM)</td>
<td></td>
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<tr>
<td>T10 (大黄蜂)</td>
<td>佳能 5D 2100 万像素</td>
<td>40min</td>
<td>4~5 平方公里 (分辨率 5CM)</td>
<td></td>
</tr>
</tbody>
</table>
Mobile data collection devices

- GPS (Windows Mobile)
- Smartphone (Explorer)
- PAD (Android)
Challenges

- **Challenges from the complexity of farming in China**
  - **Complexity of farming structure in China**: Lots of crop types, region difference, Non-scale farming, multiple crop rotation, intercropping and interplanting.
  - **Fragmented landscape in most regions**: Except the northeast, the size of crop plots are very small.
  - **Complex terrain**: There are cropping in all kinds of landscape type, plain, hill, or mountainous area.
  - **Largely impacted by market, the farming structure change rapidly**
  - **Following impact of the social and economical development, arable land changes very rapidly**.

- **Challenges from remote sensing technologies**
  - **Time phase requirement**: Because the crop planting is strongly seasonal, suitable satellite imagery must be acquired at specific period.
  - **Cloud and rain weather**: Because of the constraint of cloud/rain weather and satellite passing period, the data availability is very limited for large scale crop area remote sensing.
  - **Identification accuracy**: At complex situation, the accuracy of remote sensing identification must be researched to improve substantially.

- **Challenges from operational implementation**
  - **Cost**: It includes the infrastructure, purchase and process of imagery, geo-spatial framework, purchase of survey tools. If it were applied at national wide, bulks of fund are required.
  - **Workload**: For the timeliness, huge volume satellite imagery must be processed in short time, and field work finished rapidly. The workload is huge. More manpower and resource are needed.
Future development

Improvement of technical ability, efficiency, data quality and services

Operational application

Evaluation ➔ New system ➔ Available Data

Survey means

Self-contained methodology

Integrated survey technologies to capture from space, air, fields

Estimation

Spatial sampling ➔ Small area estimation ➔ Model estimation

Data basis

Agricultural statistical OneMap

Data source assurance system

Remote sensing data ➔ Base geographic data ➔ Statistical data ➔ Social and economic data ➔ Climate data

Survey means

Survey means

Survey means

Survey means

Survey means
Thanks for your attention!