USE OF REMOTELY SENSED DATA FOR YIELD ESTIMATION SURVEYS

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1. INTRODUCTION

The increased potentialities of the remote sensing techniques and the growing experience in a variety of civil applications during the last decade demonstrated new ways to the solutions of many problems of natural sciences and opened a broader view on the relations between various large scale natural phenomena. But the potential utilisation of the remote sensing technology in the field of agriculture may be expected to bring even more important achievements.

The availability of satellite gathered spectral and meterological data provide an immense potential to obtain comprehensive and timely information on the Earth's resources. The LACIE and AgRISTARS Programmes highlighted the usefulness of the spectral data to obtain crop acreage estimates and to evaluate crop conditions on a global basis. Some of the application areas for which immediate gain may be expected in the field of agriculture relating to land and vegetation are

I) Land Use (inventory and planning)

II) Soil classification and conservation (agricultural production, irrigation).

III) Control of plant diseases (crop and forest protection).

IV) Disaster assessment and prediction (floods and droughts).

V) Crop yield forecasting.

However more effective and useful results from remote sensing technology may accrue by combining the remotely sensed spectral data with the ground based data and further the remote sensing technology can be used in planning agricultural surveys more efficiently.

For estimating the yield for various major crops, yield estimation surveys based on crop cutting experiments are conducted in most of the countries where reliable crop yield and crop production statistics exist. In India the sampling design for these surveys is a two stage stratified sampling design where Blocks (within a state) form the strata, the villages within blocks form the primary sampling units and fields of crops within a village form the second stage unit. From each block a random sample of villages is selected and from each selected village again a random sample of fields is selected. From each selected field a plot of given size is selected randomly for actual harvesting (for measurement of the yield) of the crop in the plot. A stratified estimator of crop yield is obtained based on this sample design.

However, there may be several factors during the growth of the crop which may result in varying crop growth conditions resulting in high variability in yield within the same stratum (block). As such this stratification may not prove very effective for yield estimation.

2. Stratification for yield estimation surveys based on vegetation vigour as seen on the satellite immage

Stratification is adopted in planning of surveys for obtaining more precise estimates for the character under study. With the advent of remote sensing technology the availability of satellite gathered spectral data provides an immense potential to monitor any changes in crop conditions taking place over time. The vegetation vegour as seen on a satellite imagiry derived from such spectral data can be effectively used for delineating areas of homogeneous nature according to cover types, crops, soils or crop conditions. In case of yield estimation surveys, based on crop cutting experiments, the efficiency of the estimators can be improved by stratification based on the satellite imagery of most recent year at the time of grain filling period (which is highly correlated with yield) of the crop area into areas of homogeneous crop conditions say very good crop, average crop, poor crop and/or very poor crop and then using improved estimation procedures.

Consider a finite population constituting of N primary sampling units divided into L strata based on interpreting the satellite image of previous years crop vigour. Let N_h and n_h be the no of psu,s(the villages) in the h^{th} stratum in the population and in the sample respectively. Also let M_{hj} and m_{hj} denote the number of second stage units (crop fields) in the j^{th} psu of the h^{th} stratum belonging to population and the sample respectively. One plot is selected from each selected field for actual crop harvest and yield measurements.

Let $W_h = \frac{h}{N}$ denote the proportion of primary sampling units in the h^{th} stratum and let y_{hjl} be the yield for the l^{th} field of the j^{th} village in h^{th} stratum .

An unbiased estimator of the Average yield may be given by

$$\bar{y}_{st} = \Sigma W_h \bar{y}_h$$

and $V(\bar{y}_{st}) = \Sigma W_h^2 V(\bar{y}_h)$

where $\bar{y}_h = \frac{1}{n_h} \Sigma \frac{M_{hj}}{\bar{M}_h} \frac{1}{m_{hj}} \overset{m_{hj}}{\Sigma} y_{hj}$, $\bar{M}_h = \frac{1}{N_h} \overset{N_h}{\Sigma} M_{hj}$

and $V(\bar{y}_h) = (\frac{1}{n_h} - \frac{1}{N_h}) S_{hb}^2$

$$+ \frac{1}{n_h N_h} \Sigma (\frac{1}{m_{hj}} - \frac{1}{M_{hj}}) S_{hj}^2 ,$$

where

$$S_{hb}^2 = \frac{1}{N_h - 1} \Sigma (\frac{M_{hj}}{\bar{M}_h} \bar{Y}_{hj} - \bar{Y}_h)^2 \quad \text{and}$$

$$S_{hj}^2 = \frac{1}{M_{hj} - 1} \Sigma (y_{hjl} - \bar{Y}_{hj})^2$$

3. Post-stratification based on the current year's satellite imagery

The stratification based on a previous years satellite imagiry may often fail to correspond to the current crop conditions which may be influenced by several factors during the crop growth period. In such a situation it may be more desirable to adhere to the stratification based on the administrative units say Blocks or talukas and for obtaining more efficient estimators, post - stratification of the region may be implemented by using the satellite imagery of the current crop conditions for delineating areas of homogeneous crop growth conditions.

These homogeneous strata, obtained on the basis of crop condition may not correspond to the original strata and instead parts of several strata may constitute a single stratum of homogeneous crop conditions.

Let k_h be the number of sub-strata in the h^{th} original stratum and let Σk_h (=L' say) be the total number of sub strata. Let W'_k (k=1...L') denote the weight (proportion of area) for the k-th sub-strata. W'_k can be obtained by using the satellite imagery and the Topographical maps on the scale 1:50,000. Further let n'_k denote the k-th sub strata. sample size

An unbiased estimator of Average yield in this case may be given by

$$\bar{y}_{pst} = \sum^{L'} W'_k \, \bar{y}'_k \quad ,$$

Where again

$$\bar{y}'_k = \frac{1}{n'_k} \Sigma \frac{M_k}{\bar{M}_k} \frac{1}{m_{kj}} \Sigma y_{hjk} \quad \text{and}$$

$$V(\bar{y}_{pst}) = \Sigma \; W'^2_k \quad E \, V \quad (\bar{y}'_k)$$

$$= \Sigma \, W'_k \left[\frac{S'^2_{kb}}{n} + \frac{1}{nN} \Sigma \left(\frac{1}{m_{kj}} - \frac{1}{M_{kj}} \right) S'^2_{kj} \right]$$

$$+ \frac{1}{n^2} \Sigma \, (1- W'_k) \left[S'^2_{kb} + \frac{1}{N} \Sigma \left(\frac{1}{m_{kj}} - \frac{1}{M_{kj}} \right) S'^2_{kj} \right]$$

Where S'^2_{kb} and S'^2_{kj} have their usual meaning and are defined like S^2_{kb} and S^2_{kj}.

As crop condition is highly correlated and directly determines the final crop yield, therefore, the stratification based on crop condition is expected to result in much efficient stratification and hence the efficiency of the estimator $\bar{y}_{pst}$ is expected to be much higher as compared to the estimator $\bar{y}_{st}$.

REFERENCES

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