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AN EFFECTIVE AND EFFICIENT METHOD TO ESTIMATE AVERAGE PADDY YIELD IN SRI LANKA OVERCOMING THE LIMITATIONS OF THE CURRENT METHOD

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ABSTRACT

The Department of Census and Statistics of Sri Lanka carries out an island-wide scheme of estimating paddy's average yield, called the Crop Cutting Survey. It was debated and argued about the accuracy of the data generated through a cumbersome approach which consumes a lot of labour and resources. The objective of this study was to develop an efficient method that would help overcome the limitations of the current method. This study was accomplished through a questionnaire survey and an experimental survey. The GIS technology has been applied to measure the cultivated area and yield measurements by weighting the harvested yield. The weight measurements were subjected to different scaling factors derived through the study. The sample survey of the new methodology was carried out in the Ampara district for 2 paddy varieties namely BG357 and AT362 for the 2017/2018 Maha season. A stratified Random sampling method was used for the selection of paddy parcels. Average paddy yield, scaling factors, and cost of production of these two paddy varieties were calculated separately. The district's estimated paddy yield through the proposed method is 4568.17 kg/ ha, which is not significantly different from the published average (4562 kg ha^{-1}) in paddy statistics of 2017/2018. This is obvious that the proposed method was more effective and efficient than the current method, which assists the government in planning and making policy decisions at the correct time.

Keywords: Crop cutting survey, Paddy, Scaling factor, Yield estimation

INTRODUCTION

Rice is known to be one of the topmost important staple food crops, mainly grown based on three irrigation regimes in Sri Lanka as major, minor, and rainfed irrigation schemes. Consequently, the estimation of paddy yield is one of the vital actions undertaken by government departments to screen the development of the sector and offer insurance on time to the sector. Therefore, reliable and timely estimates of rice crop areas and their production capacity are essential for providing information for decision-makers to formulate appropriate policies in the case of deficit or surplus. The accurate estimation of rice yield is important to assure food security and promote the country's sustainable development. It is needed to import in case of setback or to send out in case of surpluses, especially in locales characterized by climatic vulnerabilities; therefore, determining crop yield before harvest is prominent (Sawasawa, 2003). The Sri Lankan Census and Statistics Department carries out an island-wide investigation at the district level to estimate the average yield of paddy, called the Crop Cutting Survey. It was debated and questioned the quality of the data generated by a cumbersome approach that consumes a lot of labour and resources. Based on crop-cutting sample data from the districts, the average yield per acre/hectare of paddy is calculated in the Colombo headquarters, and paddy production is calculated on a seasonal basis using a complete list of paddy crop cutting survey results based on hundred percent enumeration of paddy growing parcels during the particular season and area. Crop yield estimates in many countries are based on traditional techniques of crop selection. The yield estimation was based on field-based visits and reports and is often arbitrary, expensive, time-consuming and vulnerable to greater error due to inaccurate observations of soil, leading to a low assessment of crop yield and estimate of the crop area (Reynolds *et al*., 2000). However, such a technique has three major drawbacks, such as being time-consuming, subjective and prone to significant inconsistencies due to insufficient ground observations, which result in the poor evaluation of crop output. (Prasad *et al.*, 2006).

Many studies using modern techniques have been done to estimate rice yields. Some of those techniques are remote sensing, microwave imagery and crop modelling (Chang *et al*., 2005). Remote sensing techniques can provide quantitative and instantaneous information on crops in wide areas (Chang *et al*.,

2005). Additionally, NASS of the USDA (2009), stated that remote sensing-based sampling methods were good solutions for large-area crop acreage monitoring systems. The benefit of using remote sensing methods to predict rice production is it allows government planners and decision-makers to devise effective policies to calculate either how much to import in the event of a shortage or else, if possible, to sell in the event of a surplus and to buy rice at a comparatively lower price at the appropriate moment without any delay (Noureldin *et al*., 2013).

According to the census of agriculture, a bi-annual crop cutting survey collects paddy statistics in three main aspects of paddy extent, average yield and production but in the existing methodology of crop cutting survey has some limitations like; there are nearly 20-30 experimental plots are needed for one divisional secretary division, high non-sampling errors; because only 1/3 of sampling is done by the department of census and statistics (Saddhananda., 2022).

The initiation of paddy crop cutting experiments took place in 1952, overseen by the Department of Census and Statistics in Sri Lanka, which holds responsibility for this (Saddhananda., 2022). Subsequently, paddy production witnessed a notable increase due to the Mahaweli Accelerated Development Multipurpose Programme and the successful completion of various related agricultural projects (Saddhananda., 2022).

In agrarian services, approximately two-thirds of the paddy data collection work is completed. The over estimation of cultivated land is common as, a result of inaccurate information provided by farmers in hopes of receiving fertilizer subsidies. Additionally, there is no effective system in place to cross-check or monitor this data. Moreover, small-scale farmers often do not measure their yields due to the bulkiness of measuring tools, and field officers are hesitant to carry these tools to the fields because it is time-consuming and labor-intensive. Furthermore, practical difficulties, such as delayed estimations, fields that have already been harvested, and inaccessible fields, contribute to the unreliable nature of the data, as officers may not report accurate information in a timely manner.

This study revealed a new approach for crop-cutting surveys utilizing GIS technology, with the objective of developing an efficient and effective method for paddy yield estimation that will assist in overcoming the existing system's shortcomings. Additionally, to determine the scaling factors for the AT362 and BG357 rice varieties, as well as to quantify the cost of paddy production in the 2017/2018 Maha season in the Ampara district, and to compare those values to various statistical references.

METHODOLOGY

The selected study area was the Ampara district consisting of 19 divisional secretariats divisions. They are Damana, Mahaoya, Pothuwil, Lahugala, Alayadiwembu, Akkarapaththu, Eragama, Sammanthurei, Uhana, Dehiaththakandiya, Padiyathalawa, Kalmunai, Karthivu, Navinthanveli, Ninthavur, Ampara, Thirukkovil, Sainthamarathu, Addalachchenai (Figure 01). The selected study area belongs to DL_2 agro-ecological region which belongs to the Eastern province.

Fig. 1. 19 DS divisions of the Ampara district

The sample size was 76 paddy parcels, and a stratified and Random sampling technique was used to select paddy parcels**.** Paddy parcels are the rough sketch of the selected paddy field which the sample is ***drawn. The*** proposed protocol was tested with the varieties BG357 and AT362**.** Here, divisional secretariats divisions were used as a stratum and paddy variety was used as a substratum and from each substratum, two paddy parcels were selected randomly. GIS technology was applied to estimate the area under cultivation of selected paddy parcels. The harvested rice plants of the crop cutting experiment have to be collected to the gunny bag and wrapped gunny bag with rice plants should be brought to the threshing floor.

Paddy statistics and extent of cultivation data was collected through a questioner led in 19 DS divisions concerning the BG357 and AT362 paddy varieties.

The area of each paddy parcel was measured by using GIS technology and GPS coordinates of each paddy parcel were taken by using the Google Maps mobile phone app. At that point area of each paddy parcel, was measured by using the Google earth pro application. Then the yield of each paddy parcel was measured and the average weight of a filled yield bag and partially filled bags were weighted separately. Afterwards, total numbers of fully filed paddy yield bags and partially filled bags were counted. Total paddy yield for each

paddy parcel just after harvesting was calculated and then total dried stage paddy yield for each paddy parcel was calculated with the assistance of separate dried stage scaling factors according to the paddy varieties and the average paddy yield of each paddy parcel was calculated separately. At last, calculate the average paddy yield for two related varieties separately in the Ampara district. 20 number of 5kg paddy samples were taken (10 by each variety) at the time of just after harvesting. Paddy yield samples were dried for an optimum temperature level separately and weighed after drying. Then dried samples were milled and weighed. In the end, average scaling factors were calculated separately for two varieties at the drying and milling stages. The cost of production is composed of the cost of seed paddy, the cost of bed maintenance, the cost of land preparation, the cost of bund preparation and sawing, fertilizer application, other applications, and harvesting.

When estimating of average paddy yield, the assumed area of each paddy parcel was measured by using google earth pro application (A), total numbers of fully filed paddy yield bags were counted as (N), and an average weight of a filled yield bag was measured as (M) and therefore total weight of filled bags (M_1):

$$M_1 = M \times N \quad \text{---------- Equation [1]}$$

The height of a filled paddy yield bag (H) and the height of a partially filled bag (h), then the weight of a partially filled bag (m);

$$M = \frac{h}{H} \times M \quad \text{--------- Equation [2]}$$

The total paddy yield for each paddy parcel at the stage of just after harvesting(M_2) ;

$$M_2 = M_1 + m \quad \text{---------- Equation [3]}$$

The total dried stage paddy yield (Y) for each paddy parcel using dried stage scaling factors (x) according to the paddy varieties and average paddy yield (Q) of each paddy parcel was calculated separately using the equations;

$$Y = m^2 \times x \quad \text{---------- Equation [4]}$$

$$\frac{Y}{A} = Q \quad \text{---------- Equation [5]}$$

When calculating the average paddy yield for two relevant varieties (Q1 – Values for average paddy yield of variety 1, Q2- Values for average paddy yield of variety 2, n – Number of paddy parcel), the equations (Σ Q1 / Σn →for paddy variety 1) and (Σ Q2 / Σn →for paddy variety 2) were used.

Additionally for the calculation of the scaling factors;

$$SF_{After\ drying} = \frac{M_{Dried}}{M_{Harvesting}} \quad \text{---------- Equation [6]}$$

$$SF_{After\ milled} = \frac{M_{Milled}}{M_{Harvesting}}$$

In these two equations, the weight of 10 samples just after harvesting ($M_{Harvesting}$), the weight of dried samples (M_{Dried}) and the weight after milled (M_{Milled}) and scaling factors (SF). For calculating average Scaling factors:

$$ASF_{After\ drying} = \frac{SF_{After\ drying}}{n} \quad \text{--- Equation [7]}$$

$$ASF_{After\ milled} = \frac{SF_{After\ milled}}{n}$$

RESULTS AND DISCUSSION

The graph showed that the average paddy yield of AT362 (Figure 02) was 4490.50± 578 kg/ ha (1881kg/ac) whereas the average paddy yield of BG 357 was 4645.85± 432 kg/ ha (1818 kg/ ac) (Figure 03). There is no significant difference between the average paddy yield of AT362 and BG357 paddy varieties (P<.01). According to the rice varietal distribution in Sri Lanka (2017), Bg 94-1, AT362 and BG357 are the main three varieties spread in the Ampara district (Figure 04).

The average yield of these two varieties was 4,568.17 kg/ha which was estimated using this study formulated methodology. According to Paddy statistics (2017/2018), district average yields were 4,562 kg/ha which was estimated by using the existing crop-cutting survey method. STD error of district average was 105 kg/ha according to paddy statistics, whereas according to the study calculation, it was 81 kg/ha. The lower confidence level of the district average was reported as 4,357 Kg/ha, whereas the upper confidence level was 4,767 kg/ha in paddy statistics while it was 4,409 Kg/ha and 4,728 kg/ha respectively, which was calculated by the formulated methodology.

According to the paddy statistics (2017/2018), the average yield of paddy estimated for the 2017/2018 Maha season was 4,302 kg/ha. The highest average yield of 6,355 kg / ha was reported during this season from Udawalawe special area. The second-highest average yield of 5,773 kg/ha was reported from the Hambantota district. The estimated paddy production for the (2017/2018) Maha season was 2,396,926 MT. This is about a 63% increase compared with the previous Maha season.

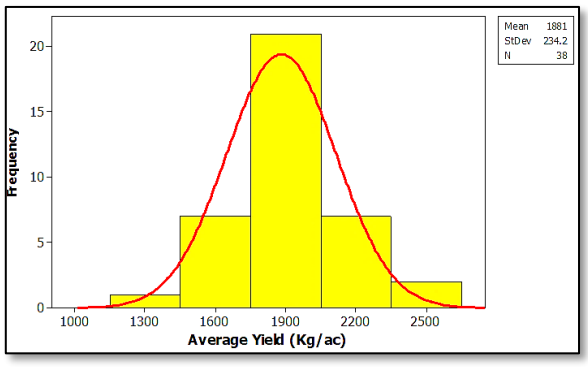

Fig. 2. Shows the average yield of AT362 (kg/ac)

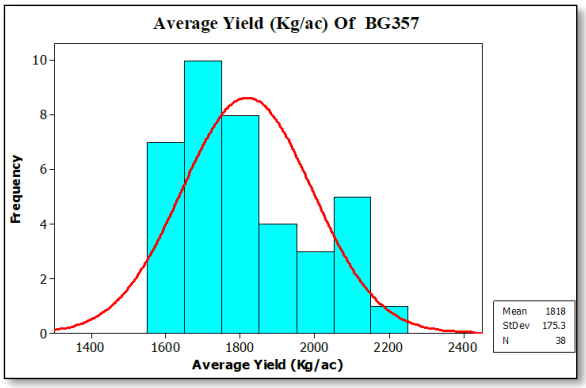

Fig. 3. Shows the average yield of BG357 (kg/Ac)

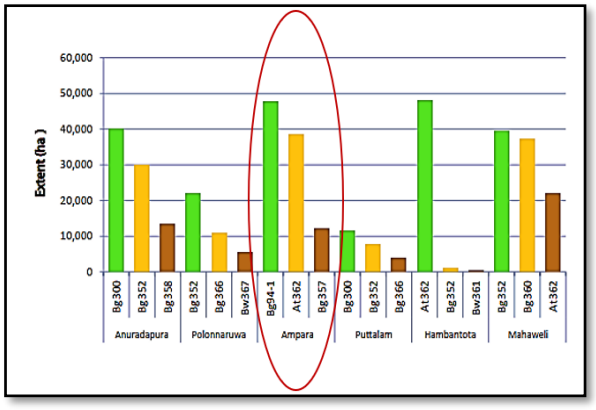

Fig. 4. Shows the spread of three major rice varieties in Ampara district

The highest production of 332,767 MT of paddy was valued from the Ampara district and it was responsible for about 14% of paddy production of the country. Only 61,028 ha was sown in Ampara district (2017/2018) Maha season (major schemes) whereas 60,974 ha was harvested and the average yield of Ampara district (major scheme) was 4,803 kg/ha.

The scaling factor after the drying stage of AT362 is 0.93516 ± 0.007 and for the BG 357 is 0.91260 ± 0.01. There is no significant difference between AT362 and BG 357 (P<.01). The scaling factor after the milling stage of AT 362 is 0.671 ± 0.01 and for the BG 357 is 0.6445 ± 0.02. There is no significant difference in Scaling factors after the drying stage and milling stage between AT362 and BG 357(P<.01).

The cost of production of AT362 is 32.67 ± 5.7 Rs/kg, whereas BG357 is 34.44 ± 4.85 Rs/kg for milled rice. Hence the study discloses that the cost of production of BG357 was a little higher than the AT362. Therefore, it is profitable to cultivate AT362 than the BG357. However, the Central Bank report (2017), reported that the cost of production in the 2015/2016 Maha season was 18.82 Rs kg^{-1} in the Ampara district. Obviously, the calculated figures from this study are closer to the figures reported by different statistics reports. Therefore, this study suggested a suitable alternative application that overcomes the difficulties of the current crop-cutting survey, and this method is effective and more efficient.

CONCLUSIONS

The average yield of AT 362 and BG 357 varieties were 4,568.17 Kg/ha which was estimated using this study formulated methodology. According to Paddy statistics (2017/2018), district average yields were 4,562 Kg/ha which was estimated by using the existing crop cutting survey method. Hence it was obvious that calculated average paddy yield through the existing methodology and proposed methodology was quite similar and there was an assurance for the accuracy of the proposed methodology. According to the results, BG362 has a higher scaling factor than BG357. Hence, the technical efficiency of the paddy variety is higher in AT362. when considering the scaling factor, it was profitable cultivating the AT362 variety than BG357. Thus, the study discloses that the cost of production of BG357 is much higher than the AT362. When considering only the cost of production it is profitable of cultivating AT362 than the BG357.

The methodology introduced through this study was a suitable application to overcome the limitations of the conventional crop-cutting survey method. This effective and efficient method enables the government to make timely policy decisions and planning. Ultimately, it greatly contributes to regional development and the national economy.

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