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Yield and Income Estimation of Maize Farmers per Harvesting Using K-Means Clustering Algorithm

Ms.M.Jaishanthi[1], Mr.C.Rajkumar[2], Mr.P.Vengatesh[3]

Student, BCA, Kaamadhenu Arts and Science College,Sathyamangalam[1]

Assistant Professor, Dept. Of. CA &IT, Kaamadhenu Arts and Science College,Sathyamangalam[2]

Student, BCA, Kaamadhenu Arts and Science College,Sathyamangalam[3]

Abstract: Standardization of crop yield estimating methodologies at various levels of farming aids in the development of accurate agricultural statistics and the evaluation of agricultural practises' acceptability under diverse production situations. The current research examines various strategies for estimating maize yields.It examines the yield difference between maize and other crops, taking into consideration available yield factors.produce potential and attainability The simplest and most reliable approaches for estimating yield are based on yield parameters gathered on the job Farmer estimating approaches, on the other hand, are less expensive and speedier in comparison to any other way of estimating yields from farmers' fields. This document also goes into detail about the significance of using more advanced yield estimation approaches, such as remote sensingas well as crop modellingThese complicated approaches are more time-consuming.

INTRODUCTION

Maize (Zeamays L.) is one of the world's most significant annual cereal crops, providing a staple food and an economic source for many people in underdeveloped nations.The manner maize is processed and consumed varies widely from country to country, with maize flour being one of the most common products.The most popular goods are cereal and meal [1,2]. It is a significant carbohydrate source for humans.In poor countries' diets and in developed countries' livestock feed [3].Evans and Fisher [4] defined yield as the mass of product harvested at a specified dry matter content at the end of the process. Crop yield is defined as the quantity of harvested product in a given area (quantity of harvested products/crop area) [5].Maize grain yield is influenced by the genotype's genetic potential, soil characteristics, field management practises, and agro-climatic conditions [6,7]. The maximum yield that a crop can achieve in a particular climate is referred to as potential yield [4].Solar radiation, soil type, temperature, plant density, genetic potential of a given genotype, and biotic and abiotic restrictions are all important elements that influence potential yield [8–10]. Poor agricultural methods, on the other hand, have a greater impact on a farmer's realised yield, also known as attainable yield [9].Maize yields can be calculated for a variety of objectives, including marketing, storage requirements calculation, harvest equipment organisation, pest and disease management, and crop improvement.Estimates of maize yields are also used to forecast production, which helps to evaluate food security status at the local, provincial, and national levels.

Depending on the reason for which the crop was grown, different methods for assessing maize yields might be utilised. Kernel weight at harvest, plot area harvested, plant density, and grain moisture content at harvest can all be used to estimate production. To get the most out of maize yield potential, for example, the plants must be at their optimal density. Because to poor germination, pest and disease damage, animal grazing, floods, a shortage of harvesting manpower, and inadequate markets for the product, the maize planted area may be larger than the plot area harvested in some cases [11].Crop cuts (on-station, on-farm trials), statistical techniques, farmer estimates, full plot harvest procedures, harvest unit sampling, expert assessments, and yield prediction through simulation models (such as crop modelling and remote sensing) are all used to estimate crop yields [11].

This research examines a variety of maize yield estimation strategies, including statistical methodologies, farmer estimation, crop modelling, and remote sensing. It explains the benefits and drawbacks of each of the approaches listed. It also looks at the yield gap between potential maize production and actual yield.

COMPONENTS OF MAIZE YIELD ESTIMATES

The yields of maize plants are controlled by numerous factors associated to the agronomic practisesutilised in each agro-climatic setting. The quantity of cobs and kernels collected in a particular area is determined by plant population density,

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shelling percentage, and the amount of water in the harvested grains. The size of yield components is a result of a crop's physiological response to its growing environment, which is crucial for maize physiologists, modellers, and breeders.
Maize Harvest and Shelling Percentage
Shelling percentage = (seed weight/cob weight) × 100%
Several factors influence the shelling percentage, including the technique of measurement, years, locations, genotypes, agro-climatic conditions, cultural methods, and kernel moisture content [49].

Harvest Area

The use of global positioning system (GPS) technology in large-scale agriculture gives an economical and more reliable alternative way for measuring plot area harvested.
Harvest area = row length × intra − row distance × number of rows (2)
where harvest area is in m2, row length is in m, and intra–row distance is in m.

Grain Yield Estimates

Crop yield is the sum of a plant population's efficiency in utilising available environmental resources for growth [52]. It's the amount of harvest product produced per acre of cropland. The yield of a crop is measured in kilogrammes (kg) or metric tonnes (t) per hectare (ha) [53]. One of the most important indices of agricultural progress is crop productivity per unit area. Crop yield estimation entails estimating crop area and harvested product quantities [11]. It has been demonstrated in maize production that yield increases consistently with density up to 90,000 plants ha1 and decreases at higher densities [13]. In today's maize breeding, genotypes with high potential yield under high plant density are developed.Grain yield determination is fraught with mistakes and biases in many cases, and the measurements are time-consuming.

Maize production takes into account a variety of yields (Figure 1).

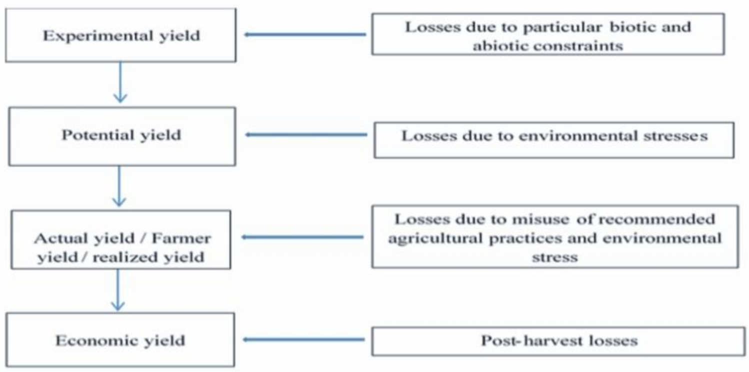

Figure 1. Different types of yields from maize production.

Yield Simulation

Crop simulation models [77–81] are mathematical representations of complicated real-world systems that can simulate crop growth and estimate crop yield based on weather (precipitation, temperature, and solar radiation), soil, and crop management conditions. Many simulation models for a variety of crops have been developed throughout the years and are valuable in understanding cropping systems [80–83].Early crop output projections give farmers a heads-up as they plan for the coming season. Farmers might presumably adapt the planting date, cultivar type, and management and monitoring activities such as fertiliser application rates and irrigation cycles in line with the expected conditions if the season is forecasted to be bad [84]. Yield simulation can help farmers mitigate the risks associated with seasonal volatility, allowing them to make informed decisions and capitalise on good seasons.
5. Remote Sensing

Remote sensing is a technique for observing the earth's surface and atmosphere from space (through satellites) or from the air (via aeroplanes) (airborne). It relates to the acts of recording, observing, and perceiving (sensing) items or occurrences from afar (remote) locations [91]. Remote sensing is a yield estimating approach that uses dynamic monitoring to predict crop yields on a large scale and deliver meaningful results in a variety of crops. Because of the synoptic view and online information provided in a short period of time, it is an important tool for generating agricultural statistics [11,51]. It can be used to predict yield before harvesting.Remote sensing is used to estimate spatial variability parameters using a large area frame sample design. It allows for efficient and low-cost stratification based on crop proportions generated from remote sensing data visual interpretation or digital categorization. Remote sensing allows for

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near-real-time monitoring of crops, relatively easy derivation of vegetation (even mountainous terrain), and a reduction in the amount of field data to be acquired [11,99].Remote sensing techniques have been used successfully in a number of investigations.Jovanovi'c et al. [99] used a moderate resolution imaging spectroradiometer (MODIS), the normalised difference vegetation index (NDVI), as an indicator of specific crop condition, and land surface temperature (LST) as an indicator of crop moisture to estimate crop yields in Serbia's Vojvodina province two months before harvest.Using the MODIS sensor, Doraiswamy et al. [100] discovered that their maize and soybean forecast findings were within 20% standard deviation of official estimations.Using Spot-5 satellite pictures and empirical models, Fernandez–Ordoez and Soria–Ruiz [95] evaluated maize yields at flowering stage and overall volume of production in Mexico. For the models Y = f (LAI) and Y = f (NDVI), they found a prediction value of 5.96 t/ha and 5.04 t/ha, respectively.

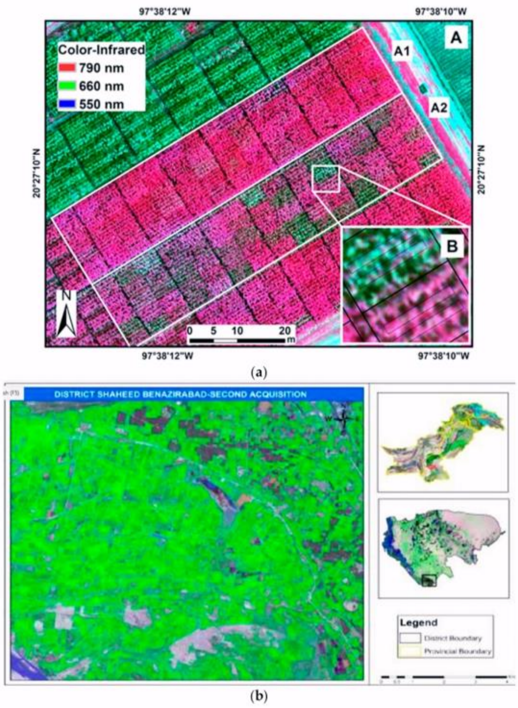

Figure 2. *Cont.*

Yield Gap Between Potential and Actual Yields

Maize crop yields (real or attainable yield) are typically lower than planned yields in farmers' fields (potential yield). Poor agricultural policies that limit cost and access to production inputs are among the factors that contribute to lower yields.

Table 3. Attainable and potential yield of maize in some countries.

Country	Current Yield (t/ha)	Potential Yield (t/ha)	Yield Gap (t/ha)	Equation Used	Source
Argentina	6.8	11.6	4.8	(3)	[54]
Cameroon	1.8	6.5	4.1	(4) (3)	[108,109]
Bangladesh	12	13	1	Hybrid-Maize model	[89]
Serbia	4.9	13.3	8.4	(4)	[19]
Western U.S. Corn Belt	13.2	15.4	2.2	Hybrid-Maize model	[110,111]
Mozambique	0.9	5.7	4.8	Growing degree-day accumulation model	[112]
South Africa	3.0	6.4	3.4	CERES-Maize model	[113,114]

CONCLUSIONS

In any crop production system, yield estimation is crucial. Production area, plant density, kernel moisture content, and sometimes shelling % are all factors in determining possible yields.Because of continual planting and the use of mixed intercropping systems on smallholder farms, yield estimation is difficult. Nonetheless, under such conditions,

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maize yield production can be roughly calculated.Crop yield simulation models and remote sensing allow government agencies, commercial sector, and researchers to estimate yield prior to harvest, which can assist farmers in being well prepared for the coming growing season. For small plot sizes, these yield estimation methods are expensive and inaccurate. In comparison to any other method of yield estimation at the farmer level, farmer estimation approaches remain the cheapest and fastest.

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