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Full Length Research Article

Application of Optimization Technique for Increasing the Agricultural Production of Wheat with a Special Reference to Sustainable Development Goals

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Abstract

There are 17 Sustainable Development Goals (SDGs) in the framework for sustainable development. Goals, targets, and indicators for reducing poverty, attaining food security, sustainable agriculture, protecting the environment, promoting human prosperity, fostering peace, and other topics are included in the SDGs. The 2030 Agenda's central theme is sustainable agriculture, which is also the first critical step towards achieving zero hunger. The Indian economy's most significant industry is agriculture, where about 70% of the population makes their living from farming. Additionally, there aren't many work opportunities in other industries. Therefore, the agriculture sector needs to be examined from the perspective of sustainable development and some suggestions need to be made for its improvement. Wheat is considered as an important source of energy. So, it is really important to study the parameters of the production of wheat. Operation Research is utilized to make better decisions and to make the most use of the resources that are available. For the linked objective's optimization and the best use of the available resources, optimization techniques are widely employed in various fields.so, in the present study Linear programming problem provides the guideline about how much area of the farm should be used for each crop in order to maximize the production of any crop. Production of any crop can be increased by increasing the area under that crop or by increasing productivity.

***Key words*:** Sustainable development, Target, Agriculture, Optimization, Resources

The agriculture sector plays a key role in India's growing economy. So, it is necessary that this sector must be studied from a Sustainable development goal point of view. The agricultural planning problems are important from both social and economic points of view. They involve complex interactions between nature and economics. Agricultural planning is important in recent times due to the increased demand for agricultural commodities because of the population increase [9]. Seven of the 17 SDGs have a direct connection to agriculture. For instance, agriculture's performance is crucial to the achievement of the goals of "no poverty and zero hunger" [10].

The Millennium Development Goals (MDGs) of the 2000 Millennium Declaration, the first comprehensive global governance framework for achieving sustainable development, served as a precursor to the 2030 Agenda [2]. Between 2016 and 2030, the UN's major goal is to accomplish these goals in every industry. India has 17% of the world's population and 6.4% of the world's land area. However, just approximately 25% of Indians have regular access to power. It has an extremely low per capita gross domestic product (GDP) of around USD (United States Dollar) 1408 annually. Sustainable Development (SD) is a concern for everyone because almost 30% of Indians live in poverty, 1.77 million people are homeless, and 4.9% of persons aged 15 and over are unemployed [4]. The demand of India for wheat is continually growing and it is projected that production increase from present level of about 110 MT to 140 MTs by 2050 is needed to full the consumption demand [11]. Agriculture is a relatively unprofitable sector in India. One can apply operations research to determine which crop can be cultivated most effectively in which state as well as which crop is the most profitable in that state [3]. There are 17 goals in the SDG framework, including "End Hunger," "End Poverty," and "Achieve Gender Equality." The performance of agriculture is essential for achieving the aim of "no poverty and zero hunger." In order to check whether these goals are achieved or not different targets are set and corresponding to these targets number of indicators are there. The important goals, targets, and indicators related to agriculture sector are identified in the study.

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MATERIALS AND METHODS

The NIF Baseline Report [5] is studied in detail and the goals and targets related to the agriculture sector are identified and listed below:

Goal 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture".

Target 2.3: "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment".

Indicator 2.3.1: "Agriculture productivity of wheat and rice, (in kg per hectare)".

One of the earliest domesticated food crops in India is wheat. It is the fundamental staple food of Maharashtra's primary civilization. It is the most significant source of grain for human use. Wheat is regarded as a significant energy source. Therefore, it is crucial to research the factors that affect wheat production.

Primary analysis is done with the help of data available in the Economic Survey of Maharashtra for the year 2016 to 2022 as follows [6].

Table 1 Area under wheat in Maharashtra

Year	Area ('000Ha)
2016	911
2017	1272
2018	1138
2019	834
2020	1057
2021	1126
2022	1132

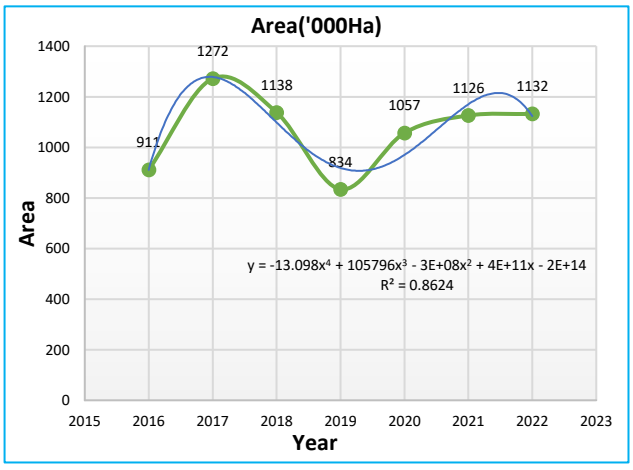

Fig 1 Area under wheat

Table 2 Analysis of area under wheat

Mean	1067.1429
Standard Error	56.378157
Median	1126
Mode	#N/A
Standard Deviation	149.16258
Sample Variance	22249.476
Kurtosis	0.3424508
Skewness	0.4957278
Range	438
Minimum	834
Maximum	1272
Sum	7470
Count	7

Table 3 Production of wheat in Maharashtra

Year	Production ('000MT)
2016	981
2017	2214
2018	1885
2019	1249
2020	1793
2021	2071
2022	2144

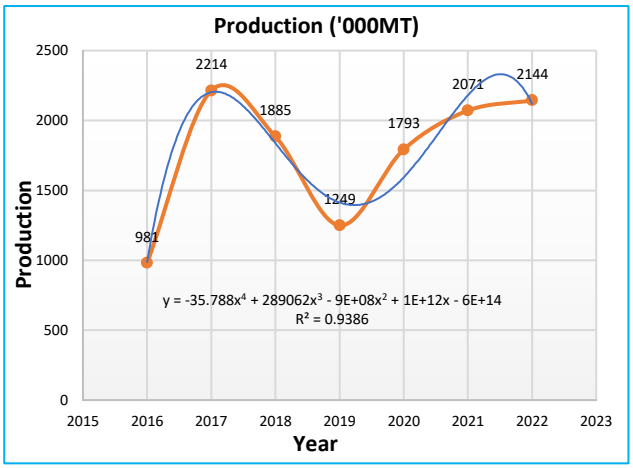

Fig 2 Production of wheat in Maharashtra

Table 4 Analysis of production of wheat

Mean	1762.428571
Standard Error	178.2806585
Median	1885
Mode	#N/A
Standard Deviation	471.686286
Sample Variance	222487.9524
Kurtosis	-0.550217566
Skewness	-0.964107034
Range	1233
Minimum	981
Maximum	2214
Sum	12337
Count	7

The primary analysis of wheat indicates the need for a detailed analysis of key factors involved in the process of wheat production. The study can be useful for the production of other crops too.

The major objective of target 2.3 is to double wheat productivity and the income of small-scale food farmers. The production must be maximized to meet these goals, and various statistical and optimization techniques can help with this.

Model I

At a given point of time productivity is given by:

$$Y = \frac{P}{A}$$

Where;
P→ Production
A→ Area
Y→ Productivity

After a specific period of time, we have

$$Y + \delta Y = \frac{P + \delta P}{A + \delta A}$$

In the 2030 agenda, the goal is to double productivity by 2030. So, by 2030 we have

$$Y + Y = \frac{P + \delta P}{A + \delta A}$$

i.e.,

$P + \delta P = (A + \delta A)(Y + Y)$
$P + \delta P = 2Y(A + \delta A)$
$P + \delta P = 2AY + 2\delta AY$
$P + \delta P = AY + AY + 2\delta AY$
$\delta P = AY + 2\delta AY$

The above expression clearly indicates that for doubling productivity, there should be a change in production. The change(increase) in the production depends on change(increase) in the area i.e., δA and productivity.

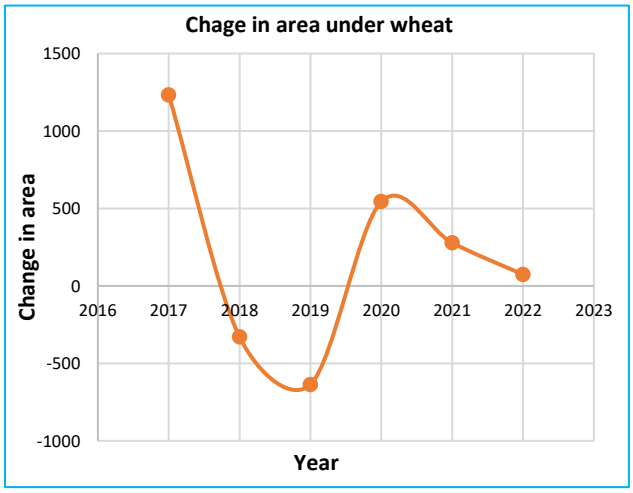

Fig 3 Change in area under wheat in Maharashtra

The above graph indicates that the increase in the area under wheat is not steady. At some point of time, there is decrease in the area under wheat also.

Model II

Since the announcement of the SDGs Agenda 2030 during the adoption by the UN general assembly in 2015, the optimization models have been extensively employed by different writers in various countries [8]. More than 58 percent of the households in the rural sector are dependent on agriculture as their primary means of livelihood [3]. So, use of optimization techniques will definitely play an important role in the agriculture sector. Wheat is major staple food and a chief source of energy [1]. So, the tasks associated with the crop production process of wheat are identified.

Linear programming problem is the problem of constraint optimization. The decision variables for the combination of crops are defined as follows:

x_1 --------- Area under crop I (Wheat) (in acre)
x_2 ---------- Area under crop II (in acre)
x_3 ---------- Area under crop III (in acre)

The objective of a farmer is to maximize the production. So, the objective function is as follows:

Max $Z = c_1x_1 + c_2x_2 + c_3x_3$
S.t
$b_{11}x_1 + b_{12}x_2 + b_{13}x_3 \leq b_1$
$b_{21}x_1 + b_{22}x_2 + b_{23}x_3 \leq b_2$
$b_{31}x_1 + b_{32}x_2 + b_{33}x_3 \leq b_3$
$b_{41}x_1 + b_{42}x_2 + b_{43}x_3 \leq b_4$
$b_{51}x_1 + b_{52}x_2 + b_{53}x_3 \leq b_5$
$b_{61}x_1 + b_{62}x_2 + b_{63}x_3 \leq b_6$
$x_1, x_2, x_3 \geq 0$

Table 5 Interpretation

Term	Interpretation
Z	Total Production
b_1	Labor budget
b_2	Irrigation budget
b_3	Fertilizer budget
b_4	Seeds budget
b_5	Transportation budget
b_6	Total area of the farm
b_{11}	Labor cost per acre incurred for crop I
b_{12}	Labor cost per acre incurred for crop II
b_{13}	Labor cost per acre incurred for crop III
b_{21}	Irrigation cost per acre incurred for crop I
b_{22}	Irrigation cost per acre incurred for crop II
b_{23}	Irrigation cost per acre incurred for crop III
b_{31}	Fertilizer cost per acre incurred for crop I
b_{32}	Fertilizer cost per acre incurred for crop II
b_{33}	Fertilizer cost per acre incurred for crop III
b_{41}	Seed cost per acre incurred for crop I
b_{42}	Seed cost per acre incurred for crop II
b_{43}	Seed cost per acre incurred for crop III
b_{51}	Transportation cost per acre incurred for crop I
b_{52}	Transportation cost per acre incurred for crop II
b_{53}	Transportation cost per acre incurred for crop III
c_1	Production of crop I
c2	Production of crop II
c3	Production of crop III

The above LPP can be solved by simplex method and the values of decision variables can be obtained as a solution.

RESULTS AND DISCUSSION

A farm of size 10 acres from Chandur bazar is considered for a case study. Production of wheat per acre is 15 quintals and production of chana per acre is 12 quintals.

In this farm irrigation cost for wheat and chana is 3000 Rs and 2000 Rs per acre respectively. The labor cost for wheat and chana is 3000 Rs and 2000 Rs per acre respectively. The fertilizer cost for wheat and chana is 2000 Rs and 1200 Rs per acre respectively. The seed cost for wheat and chana is 1200 Rs and 1600 Rs per acre respectively and the transportation cost for wheat and chana is 1500 Rs and 1200 Rs per acre respectively. A linear programming problem is formulated with the help of above information. The linear programming problem is solved by using Excel Solver and the solution is displayed as follows:

Objective cell (Max)

Cell	Name	Original value	Final value	
$D$2	solution z	134.9999988	135	
Cell	Name	Original Value	Final value	Integer
$B$2	solution x1	6.999999598	9	Contin
$C$2	solution x2	2.500000402	0	Contin

Constraints

Cell	Name	Cell value	Formula	Status	Slack
$D$10	Con 6z LHS	9	$D$10<=$F$10	Not Binding	1
$D$5	Con 1 LHS	27000	$D$5<=$F$5	Not Binding	3000
$D$6	Con 2 LHS	27000	$D$6<=$F$6	Not Binding	8000
$D$7	Con 3 LHS	18000	$D$7<=$F$7	Not Binding	2000
$D$8	Con 4 LHS	10800	$D$8<=$F$8	Not Binding	2200
$D$9	Con 5 LHS	13500	$D$9<=$F$9	Binding	0

The optimum solution of the LPP is

$x_1 = 6.99$ and $x_2 = 2.50$.

It means that for getting the maximum production of 135 quintals from 10-acre farm, the area under wheat should be 6.99 acres, and area under chana should be 2.50 acres and the maximum production is 135 Quintals.

CONCLUSION

United Nations adopted 17 sustainable goals in 2015. They set the target that the goals must be attained by 2030. In the sustainable development goal framework, it can be easily observed that maximum goals rely on the agriculture sector. If all identified targets related to the agriculture sector are analyzed carefully then it can be easily seen that problems and parameters related to the agriculture sector need to be identified and after identification of the objective some optimization technique should be used for planning the various process in the agriculture sector. One of the useful techniques is the linear programming problem. Also, the solution to the Linear programming problem will provide how much area of the farm should be used for each crop in order to maximize the production of any crop. Production of any crop can be increased by increasing the area under that crop or by increasing productivity. Thus, optimization techniques can play a very important role in decision-making about various agriculture processes. Thus, it can play an important role in achieving the targets in sustainable development goals.

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