Journal of Trends and Challenges in Artificial Intelligence

ASPUR PUBLISHING

Vol. 01, No. 02 (2024) 51-60, doi: 10.61552/JAI.2024.02.002 - http://jai.aspur.rs

MAXIMIZATION PROFIT OF AGRICULTURAL CROP PRODUCTION THROUGH DECISION MAKING APPLICATION

Moti Melkamu[1]
Tadesse Fisseha
Idossa Dugassa

Received 15.02.2024.
Revised 27.03.2024.
Accepted 15.05.2024.

Keywords:

Maximization, Profit, Agricultural, Crop Production, Decision Making.

Original research

A B S T R A C T

In Ethiopia different crops are produce (harvest), the major crops produced in the country are Teff, Sorghum, wheat, bean, barely, raise, pea, nueg and maize. Those crops produced state of nature (uncertain condition) like good condition or poor condition with deferent amount of generating profit in each crop. In this case depend up on the amount of crop produced, high amount of crop produced in good condition in 2017 year and low amount of crop produced in poor condition in 2016 year. In order to maximize the profit of each crop, it needs to minimize the amount of loss during each states of conditions (minimize the maximum regret of each crop). By using decision making criteria and POM software maximize the profit of each crop and evaluate through Maximax, Maximin, and Minimaxi regret criteria. According to assumption of this term paper, the price of the crop during good and poor condition are the same and during each criteria not take a single crop of product, because all of the crops are uses in the country. So it take priority according to their values decision criteria. At the end it select a crop which has low minmax regret and then order according their values of regret from lowest to highest values of the regret.

1. INTRODUCTION

In traditional agriculture, crop planning decisions were mainly guided by the farmer's judgment and experience (Jain et al., 2018). Agriculture is main economic pillars of the Ethiopian economy and the overall economic growth of the country is highly dependent on the success of the agriculture sector (Degu, 2019). The sector represents 42 % of the GDP of the country and about 85 % of the population gains their livelihood directly or indirectly from agricultural production. The government of Ethiopia have been devised and implementing different strategies and polices to boost the agricultural sector as the engine of the country overall growth (Lavers, 2012). Now we are in the era of growth and transformation plan (GTPs). Accurate, reliable and timely statistical information in the sector is crucial for designing, monitoring and evaluating these policies and strategies. Specifically estimates and forecasts of crop area and yield are of critical importance to policy makers for the planning of agricultural production and monitoring of food supply in the country (FDRE, 2018; Gizaw & Assegid, 2021).

Developing countries and their economic progress are likely to suffer tremendously from climate change, given their extremely nature-dependent agrarian economies. As a result, accurate quantification of the impact of climate change on the agricultural sector is of paramount importance in guiding appropriate adaptation measures (Gallup et al., 1999), Stage and ensuring genuine participation of developing countries in climate change agreements (FDRE, 2018). The sound performance of agriculture warrants the availability of food crops. This accomplishment in agriculture does not only signify the adequate acquisition of food crops to attain food security, but also heralds a positive aspect of the economy (Leakey, 2018). In regard to this, collective efforts are being geared

[1] Corresponding author: Moti Melkamu
Email: motimelka.auit@gmail.com

to securing agricultural outputs of the desired level so that self-reliance in food supply can be achieved and disaster caused food shortages be contained in the shortest possible time in Ethiopia. Most of the crops are Teff, wheat, maize, sorghum, Neug, Bea, Bean, Barley, Rice etc., this crops are wisely produced in the country. The amount of production of those crop is depend on the condition during cultivation. May be the condition is good condition like: good weather condition, properly uses DAP and UREA during cultivation, good conservation, humidity, fertile land etc. But if this requirement is not available the condition is poor condition, at that time amount of produced crop is reduce. The farmers not know what types of condition will happened, it is uncertain with state of nature and have not decide which crop produce in order to get more profit during good condition and which crop have high amount of loss during poor condition at optimal condition (Ashraf & Foolad, 2005). This paper is focused on analyzing and identifying optimum production at both good and poor condition by using decision making analysis. Also by using software we analysis the data and recommend depend on the result of the analyzed data.

2. LITERATURE REVIEW

2.1 Agriculture crop production and Components of Decision Making

Developing countries and their economic progress are likely to suffer tremendously from climate change, given their extremely nature-dependent agrarian economies (Mendelsohn & Dinar, 2009). As a result, accurate quantification of the impact of climate change on the agricultural sector is of paramount importance in guiding appropriate adaptation measures and ensuring genuine participation of developing countries in climate change agreements (Bezabih & Sarr, 2012; FDRE 2015).

The government of Ethiopia have been devised and implementing different strategies and polices to boost the agricultural sector as the main motor of the country overall growth (Shumuye, 2015). Now we are in the era of growth and transformation plan (GTPs). Accurate, reliable and timely statistical information in the sector is crucial for designing, monitoring and evaluating these policies and strategies. Specifically estimates and forecasts of crop area and yield are of critical importance to policy makers for the planning of agricultural production and monitoring of food supply in the country (Kalra et al., 2007).

Grain crops are highly important to enhance the food security of small holder framers in Ethiopia. Even though, intensity of cultivation & production of grain crops varies seasonally across regions and zones these crops are widely grown all parts of the country by small holder farmers in both seasons, dry season irrigation farms and by commercial farms (Kalra et al., 2007).

Despite the availability of overwhelming evidence in support of climate change, uncertainty prevails over the precise nature of these changes, especially at local level. Global predictions become less clear as to the magnitude and timing of the changes at national and local levels.

Global predictions become less clear as to the magnitude and timing of the changes at national and local levels. Even at the global scale, there will always be uncertainty in predicting future climates.

Decision situations can be categorized into two classes: situations in which probabilities cannot be assigned to future occurrences and situations in which probabilities can be assigned

Several decision-making techniques are available to aid the decision maker in dealing with this type of decision situation in which there is uncertainty. Decision situations can be categorized into two classes: situations in which probabilities *cannot* be assigned to future occurrences and situations in which probabilities *can* be assigned.

Decision situations in which there are two or more decision makers who are in competition with each other (Jain et al., 2018).

2.2 Components of Decision Making

A decision-making situation includes several components the decisions themselves *and* the actual events that may occur in the future, known as **states of nature**. At the time a decision is made, the decision maker is uncertain which states of nature will occur in the future and has no control over them. A state of nature is an actual event that may occur in the future (Taylor & Taylor, 2002; Oladejo et al. 2019).

2.2.1 Decision making criteria

Once the decision situation has been organized into a payoff table, several criteria are available for making the actual decision. Include maximax, maximin, minimax regret, Hurwicz, and equal likelihood.

2.2.2 Maximax Criterion

With the maximax criterion, the decision maker selects the decision that will result in the maximum of the maximum payoffs. (In fact, this is how this criterion derives its name a maximum of a maximum.) The maximax criterion is very optimistic. The decision maker assumes that the most favorable state of nature for each decision alternative will occur. Thus, for example, using this criterion, the investor would optimistically assume that good economic conditions will prevail in the future (Taylor & Taylor, 2002).

2.2.3 Maximin criterion

The maximin criterion results in the maximum of the minimum payoff. In contrast with the maximax criterion, which is very optimistic, the maximin criterion is pessimistic. With the maximin criterion, the decision maker selects the decision that will reflect the maximum of the minimum payoffs.

2.2.4 Minimax regret criterion

Regret is the difference between the payoff from the best decision and all other decision payoffs. The minimax regret criterion minimizes the maximum regret.

3. METHODOLOGY

Collected quantitative data for these paper work by face to face discussing with traders and farmers. Also get data from federal democratic republic of Ethiopia central statistical agency agricultural sample survey 2017/18. Based on those data it identified amount of each product per year in both conditions. Those products in 2016 and 2017 years are identified, the next process was to find amount in each decision criteria products produced per year and give priority for regret conditions. Then developed the model required for the decision making and solve the given model through POM version5 software.

4. DATA ANALYSIS AND DISCUSSION

As we have try to discuss on the previous parts of the paper, the output of the Ethiopian agricultural products depends on the seasonal condition of the air. If the weather condition is good farmers will expect good and much of production output and if not they will lose much yields of production. Even though Ethiopia has a lot of production areas in hectares, the outcome is not good as expected. The quality of grain crops and other products is poor as well.

The sound performance of agriculture warrants the availability of food crops. This accomplishment in agriculture does not only signify the adequate acquisition of food crops to attain food security, but also heralds a positive aspect of the economy. In regard to this, collective efforts are being geared to securing agricultural outputs of the desired level so that self-reliance in food supply can be achieved and disaster caused food shortages be contained in the shortest possible time in Ethiopia.

The basic question here under state of nature which determines the agricultural crop out puts is that what if the air condition is not good as expected? These mean that how we can minimize the risk of uncertainty by applying decision analysis concept to the agricultural products outputs.

Data analysis of this term paper was done on data collected from recent years 2017 and 2018. The procedure was conducted by taking data of the previous two years and forecasting for the future one year output and analyzing what should be done in order to give priority sequence of basic grain crop production in Ethiopia. The federal democratic republic of Ethiopia central statistical agency agricultural sample survey 2017/18, report on area and production of major crops states that the following terms should be define clearly in order to analyzing and clearly conducting a research on the agricultural production output in Ethiopia (Table 1).

Table 2. Federal democratic republic of Ethiopia central statistical agency agricultural sample survey 2017/18

crop	Area in hectares			Production in quintals			Yield in(quintals/hectares)		
	2016	2017	Change	2016	2017	Change	2016	2017	Change
Teff	3017914	3023283	0.18	50204400	52834011	5.24	16.64	17.48	5.05
Wheat	1696082	1696907	0.05	45378523	46429657	2.32	26.75	27.36	2.28
Maize	2135571	2128948	-0.31	78471746	8395872	6.99	36.75	39.44	7.32
Sorghum	1881970	1896389	0.77	47520956	51692525	8.78	25.5	27.26	7.96
Barley	959273	951993	-0.76	20249216	20529963	1.39	21.11	21.57	2.18
Neug	281206	290494	3.30	3024319	3233448	6.91	10.75	11.13	3.53
Rice	48418	53106	9.68	1360007	1510183	11.04	28.09	28.44	1.25
Bean	427696	437106	2.20	8780108	9217615	4.98	20.53	21.09	2.73
Pea	212530	220508	3.75	3481446	3685190	5.85	16.38	16.71	2.01

The federal democratic republic of Ethiopia central statistical agency agricultural sample survey 2017/18 report on area and production of major crops states.

4.1 Basic Assumptions of Decision making

(1) Conditions of state is uncertain
(2) Assuming the price of each crop are the same in both state of nature (good and poor condition).
(3) Assuming all crops produce are uses in the country, so we take as a priority in each case.

5. RESULTS AND DISCUSSION

Currently Hectares uses and produced crop in the country are: total hectares uses in 2016 and 2017 years, 10660660, 10698734 respectively with deference hectares of 18.86 and also total produced crops in 2016 year, 258470721 quintals and total produced crops in 2017 year 197528464 quintals with deference 53.5 quintals. But there is detail mount of each crop with their hectares in each year are locate in the table 2.

Table 3. Amount of crops with their hectares in each year

crop	Area in hectares			Production in quintals			Yield in(quintals/hectares)		
	2016	2017	Change	2016	2017	Change	2016	2017	Change
Teff	3017914	3023283	0.18	50204400	52834011	5.24	16.64	17.48	5.05
Wheat	1696082	1696907	0.05	45378523	46429657	2.32	26.75	27.36	2.28
Maize	2135571	2128948	-0.31	78471746	8395872	6.99	36.75	39.44	7.32
Sorghum	1881970	1896389	0.77	47520956	51692525	8.78	25.5	27.26	7.96
Barley	959273	951993	-0.76	20249216	20529963	1.39	21.11	21.57	2.18
Neug	281206	290494	3.30	3024319	3233448	6.91	10.75	11.13	3.53
Rice	48418	53106	9.68	1360007	1510183	11.04	28.09	28.44	1.25
Bean	427696	437106	2.20	8780108	9217615	4.98	20.53	21.09	2.73
Pea	212530	220508	3.75	3481446	3685190	5.85	16.38	16.71	2.01

Price of each crop per quintals and per annual in each year.

In this case it take assumptions as a price of each crops in good and poor conditions are the same (Table 3).

Table 4. Price of each crop per quintals and per annual in each year

Crops	**price/quintal in ETB**	**profit/quintal in ETB(poor condition and good condition)**	**profit/year in ETB(poor condition)**	**profit/year good condition**
Teff	2700	405	20332782000	21397774455
Wheat	1000	150	6806778450	6964448550
Maize	700	105	8239533330	881566560
Sorghum	1200	180	8553772080	9304654500
Barley	800	120	2429905920	2463595560
Neug	2300	345	1043390055	1115539560
Rice	7300	1095	1489207665	1653650385
Bean	2500	375	3292540500	3456605625
Pea	2300	345	1201098870	1271390550

By using decision criteria (maximax, maximin, minimax regret) it evaluate and identify which crop produce during each criteria depend up on profit gained per year by using POM software (Table 4).

Table 5. Insert data or profit per year of each crop in to POM software in each condition

Profits (maximize)
Costs (minimize)
0.00

DECISION ANALYSIS ON ETHIOPIAN AGRICULTURE

	poor air condition	good air condition
Probabilities	0	0
teff	20332780000	21397770000
wheat	6806778000	6964449000
maize	8239534000	881566600
sorghum	8553772000	9304655000
barley	2429906000	2463596000
neug	1043390000	1115540000
rise	1489208000	1653650000
bean	3292540000	3456606000
pea	1201099000	1271391000

5.1 Maximax criteria (good condition)

In this case, profit of crops produced in good conditions higher than that profit of poor condition, because much amount of quintals of crops is produce in that condition (Table 5). So using maximax criterion it select the maximum of the maximum among exist of the profit.

Table 6. Maximax criteria (good condition)

DECISION ANALYSIS ON ETHIOPIAN AGRICULTURE Solution				
	poor air condition	good air condition	Row Min	Row Max
Probabilities	0	0		
teff	2.03327...	2.13977...	20332780000	21397770000
wheat	6.80677...	6.96444...	6806778000	6964449000
maize	8.23953...	8.81566...	881566600	8239534000
sorghum	8.55377...	9.30465...	8553772000	9304655000
barley	2.42990...	2.46359...	2429906000	2463596000
neug	1.04339...	1.11554...	1043390000	1115540000
rise	1.48920...	1.65365...	1489208000	1653650000
bean	3.29254...	3.45660...	3292540000	3456606000
pea	1.20109...	1.27139...	1201099000	1271391000
		maximum	20332780000	21397770000
			maximin	maximax

According to above maximax result Teff has maximum profit during good condition (21397770000ETB) (Table 6). This indicate if produce teff in good condition it get high amount of profit rather than others crop. But in this case, not only selecting teff crops and omit the others because in the country it uses those the rest crops so it considering all the crops according to their maximax priority (orders).

Table 7. Based on maximax criteria and taking priority

Crop	**teff**	**wheat**	**maize**	**sorghum**	**barley**	**neug**	**rise**	**bean**	**pea**
maximax	21397770000	6964449000	8239534000	9304655000	2463596000	1115540000	1653650000	3456606000	1271391000
Priority	1	4	3	2	6	9	7	5	8

Then cording to maximax criteria, it ordered the crops generating profit 1st: Teff , 2nd : Sorghum, 3rd : Maize, 4th: Wheat, 5th: Bean, 6th :Barley, 7th : Rise 8th: Pea 9th: Neug (Figure 1).

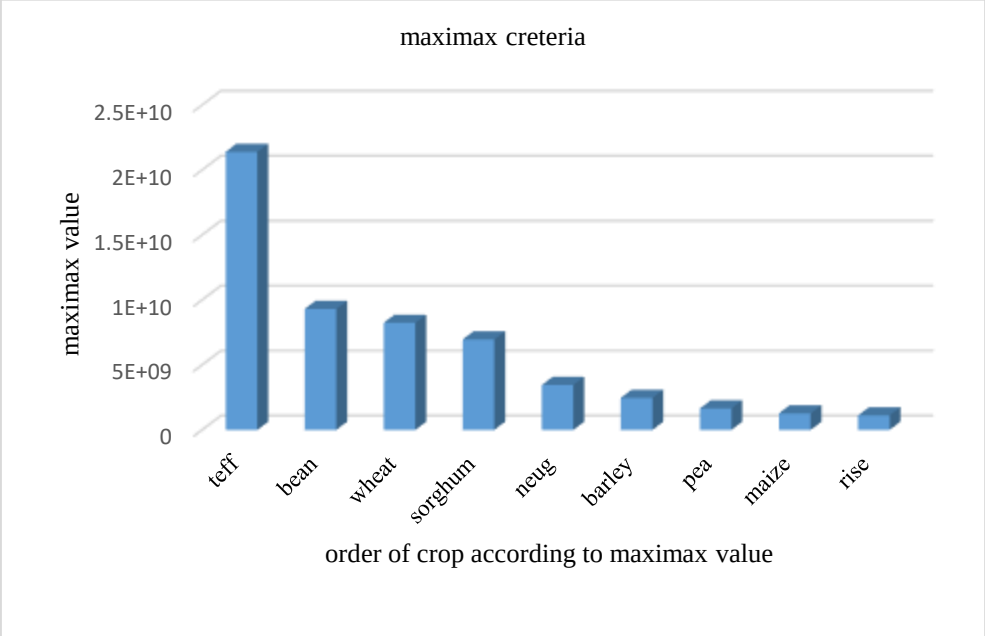

Figure 1. Order of crop according to maximax value

5.2 Maximin criteria or optimistic air condition

In maximin, it maximize the minimum profit, in this case maximize profit generated during poor condition, because it is low profit than good condition (Table 7).

Then according to maximin criterion Teff has high profit (20332780000ETB) rather than the other in poor condition.

Table 8. Maximin criteria or optimistic

	poor air condition	good air condition	Row Min
Probabilities	0	0	
teff	2.03327...	2.13977...	20332780000
wheat	6.80677...	6.96444...	6806778000
maize	8.23953...	8.81566...	881566600
sorghum	8.55377...	9.30465...	8553772000
barley	2.42990...	2.46359...	2429906000
neug	1.04339...	1.11554...	1043390000
rise	1.48920...	1.65365...	1489208000
bean	3.29254...	3.45660...	3292540000
pea	1.20109...	1.27139...	1201099000
		maximum	20332780000
			maximin

Also in this case, depend on maximin criterion in poor condition not producing only Teff crops and not leave the rest crops. Because all crops are uses in the country, so it taking priority for producing the crops in poor condition in order to generate high amount of profit (Table 8).

Then according to above maximin tables it order crops produce in poor conditions (Figure 2).

Table 9. Based on maximin taking of priority for each crop 1st: Teff, 2nd: sorghum, 3rd: wheat, 4th: Pea, 5th: barley, 6th: Rise, 7th: bean, 8th: neug, 9th: Maize

Crop	teff	wheat	maize	sorghum	barley	neug	rise	bean	pea
maximin	2.03E+10	6.81E+09	8.82E+08	8.55E+09	2.43E+09	1.04E+09	1.49E+09	3.29E+09	1.2E+09
Priority	1	3	9	2	5	8	6	7	4

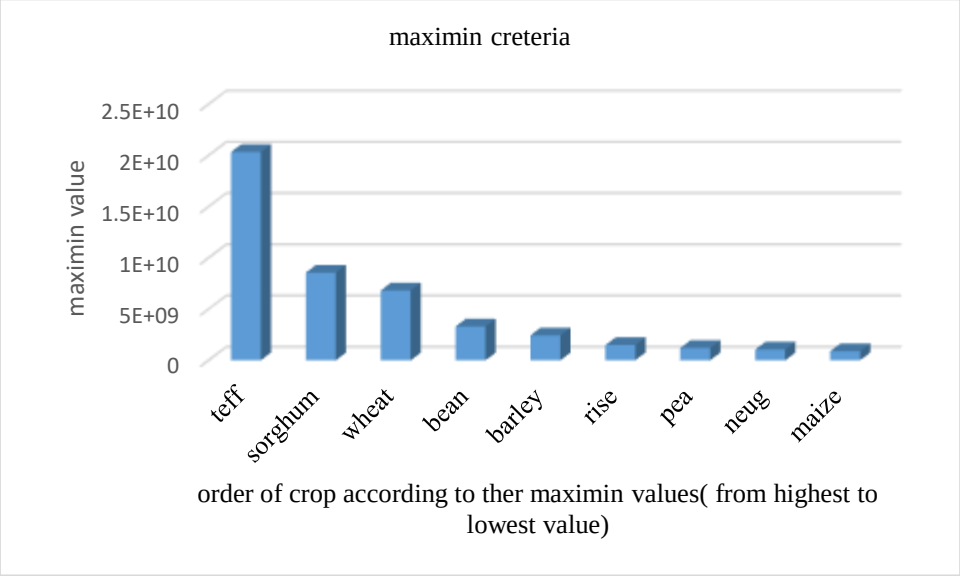

Figure 2. Order of crop according to their maximin values

5.3 Minimax regret

In minimax regret is in order to identify the amount of regret in both good and poor condition by losing amount of profit in each crops produced in each year (Table 9). Then in order to maximize the profit it should be minimize the regret amount of each crops. In this case take priority regret of each crops from lowest regret to highest regret because lowest regret indicate existence of high profit and high regret it shows existence of lose.

According to minimax regret Teff crop has selected with 0 regret. But give the regret priority for crops, because all crops are uses in the country (Table 10, Figure 3).

Table 10. Minimax regret criteria

Profits (maximize)
Costs (minimize)
0.00

DECISION ANALYSIS ON ETHIOPIAN AGRICULTURE Solution

	poor air condition Regret	good air condition Regret	Maximum Regret	Expected Regret
Probabilities	0	0		
teff	0	0	0	0
wheat	13526000000	14433320000	14433320000	0
maize	12093250000	20516200000	20516200000	0
sorghum	11779010000	12093120000	12093120000	0
barley	17902870000	18934170000	18934170000	0
neug	19289390000	20282230000	20282230000	0
rise	18843570000	19744120000	19744120000	0
bean	17040240000	17941160000	17941160000	0
pea	19131680000	20126380000	20126380000	0
Minimax regret			0	

Table 11. Based on minimax regret taking of priority for each crop Then: 1st: teff, 2nd: sorghum, 3rd: wheat, 4th: bean, 5th Barley, 6th: rise. 7th: pea, 8th: neug, 9th: maize

Crop	teff	wheat	maize	sorghum	Barley	neug	rise	bean	pea
Minimax regret value	0	14433320000	205162000000	12093120000	18934170000	20282230000	19744120000	17941160000	20126380000
Priority	1	3	9	2	5	8	6	4	7

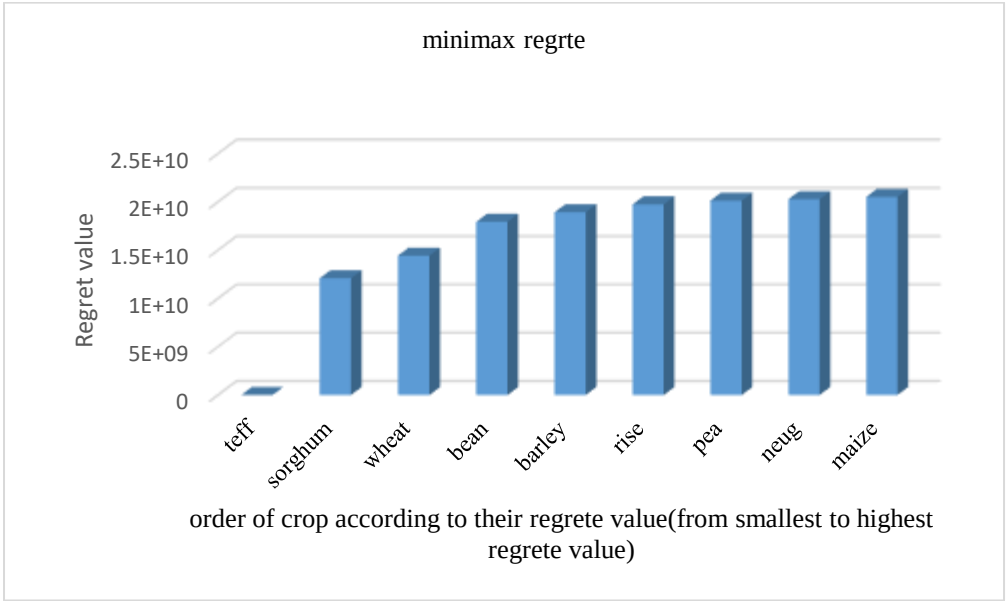

Figure 3. Order of crop according to their regret value (from smallest to highest regret value)

5.4 Hurzwiz criteria

In this by taking some probability (0 to 1) for good and poor conditions for profit of each crops, then evaluate the profit of each crops.

Generally, in order to maximize profit of each crop it should be minimize loss of each crops by producing according to bellow orders in both condition.

Table 11. Maximax criteria (good condition)

DECISION ANALYSIS ON ETHIOPIAN AGRICULTURE Solution

Hurwicz Value	teff	wheat	maize	sorghum	barley	neug	rise	bean	pea
00	20332780	6806778000	881566600	8553772000	2429906000	1043390000	1489208000	3292540000	1201099000
01	20343430	6808355000	955146200	8561281000	2430243000	1044111000	1490852000	3294181000	1201802000
02	20354080	6809931000	1028726000	8568790000	2430580000	1044833000	1492497000	3295821000	1202505000
03	20364730	6811508000	1102306000	8576298000	2430917000	1045554000	1494141000	3297462000	1203208000
04	20375380	6813085000	1175885000	8583807000	2431254000	1046276000	1495786000	3299102000	1203911000
05	20386030	6814662000	1249465000	8591316000	2431590000	1046998000	1497430000	3300743000	1204614000
06	20396680	6816238000	1323045000	8598825000	2431927000	1047719000	1499075000	3302384000	1205316000
07	20407330	6817815000	1396624000	8606334000	2432264000	1048441000	1500719000	3304025000	1206019000
08	20417980	6819391000	1470204000	8613843000	2432601000	1049162000	1502363000	3305665000	1206722000
09	20428630	6820968000	1543784000	8621352000	2432938000	1049884000	1504008000	3307306000	1207425000
10	20439280	6822545000	1617363000	8628860000	2433275000	1050605000	1505652000	3308946000	1208128000
11	20449930	6824122000	1690943000	8636369000	2433612000	1051327000	1507297000	3310587000	1208831000
12	20460580	6825698000	1764523000	8643878000	2433949000	1052048000	1508941000	3312228000	1209534000
13	20471230	6827275000	1838102000	8651387000	2434286000	1052770000	1510585000	3313869000	1210237000
14	20481880	6828852000	1911682000	8658896000	2434622000	1053491000	1512230000	3315509000	1210940000
15	20492530	6830429000	1985262000	8668405000	2434959000	1054212000	1513874000	3317150000	1211643000
16	20503180	6832005000	2058841000	8673913000	2435296000	1054934000	1515519000	3318790000	1212346000
17	20513830	6833582000	2132421000	8681422000	2435633000	1055655000	1517163000	3320431000	1213049000
18	20524480	6835159000	2206001000	8688931000	2435970000	1056377000	1518808000	3322072000	1213752000
19	20536130	6836735000	2279580000	8696440000	2436307000	1057098000	1520452000	3323713000	1214455000
20	20545780	6838312000	2353160000	8703949000	2436644000	1057820000	1522097000	3325353000	1215157000
21	20556430	6839889000	2426740000	8711458000	2436981000	1058542000	1523741000	3326994000	1215860000
22	20567080	6841465000	2500319000	8718966000	2437318000	1059263000	1525385000	3328634000	1216563000
23	20577730	6843042000	2573899000	8726475000	2437655000	1059985000	1527030000	3330275000	1217266000
24	20588380	6844619000	2647479000	8733984000	2437991000	1060706000	1528674000	3331916000	1217969000
25	20599030	6846196000	2721059000	8741493000	2438328000	1061428000	1530319000	3333556000	1218672000
26	20609680	6847772000	2794638000	8749002000	2438665000	1062149000	1531963000	3335197000	1219375000
27	20620330	6849349000	2868218000	8756511000	2439002000	1062871000	1533607000	3336838000	1220078000
28	20630980	6850926000	2941797000	8764020000	2439339000	1063592000	1535252000	3338478000	1220781000
29	20641630	6852503000	3015377000	8771528000	2439676000	1064313000	1536896000	3340119000	1221484000
30	20652280	6854079000	3088957000	8779037000	2440013000	1065035000	1538541000	3341760000	1222187000
31	20662930	6855656000	3162536000	8786546000	2440350000	1065756000	1540185000	3343400000	1222889000
32	20673580	6857232000	3236116000	8794055000	2440687000	1066478000	1541830000	3345041000	1223592000
33	20684230	6858809000	3309696000	8801564000	2441024000	1067199000	1543474000	3346682000	1224295000
34	20694880	6860386000	3383276000	8809073000	2441361000	1067921000	1545118000	3348322000	1224998000
35	20705530	6861963000	3456855000	8816581000	2441698000	1068642000	1546763000	3349963000	1225701000
36	20716180	6863539000	3530435000	8824090000	2442034000	1069364000	1548407000	3351604000	1226404000
37	20726830	6865116000	3604015000	8831599000	2442371000	1070086000	1550052000	3353244000	1227107000
38	20737480	6866693000	3677594000	8839108000	2442708000	1070807000	1551696000	3354885000	1227810000
39	20748130	6868270000	3751174000	8846617000	2443045000	1071529000	1553340000	3356526000	1228513000
40	20758780	6869846000	3824754000	8854126000	2443382000	1072250000	1554985000	3358166000	1229216000
41	20769430	6871423000	3898333000	8861634000	2443719000	1072972000	1556629000	3359807000	1229919000
42	20780080	6872999000	3971913000	8869143000	2444056000	1073693000	1558274000	3361448000	1230622000
43	20790720	6874576000	4045493000	8876652000	2444393000	1074414000	1559918000	3363088000	1231325000
44	20801380	6876153000	4119072000	8884161000	2444730000	1075136000	1561562000	3364729000	1232028000
45	20812030	6877730000	4192652000	8891670000	2445066000	1075858000	1563207000	3366370000	1232730000
46	20822680	6879306000	4266232000	8899178000	2445403000	1076579000	1564851000	3368010000	1233433000
47	20833330	6880883000	4339811000	8906686000	2445740000	1077300000	1566496000	3369651000	1234136000
48	20843970	6882460000	4413391000	8914195000	2446077000	1078022000	1568140000	3371292000	1234839000
49	20854620	6884037000	4486971000	8921704000	2446414000	1078744000	1569785000	3372932000	1235542000
50	20865270	6885614000	4560550000	8929213000	2446751000	1079465000	1571429000	3374573000	1236245000
51	20875930	6887190000	4634130000	8936722000	2447088000	1080186000	1573074000	3376214000	1236948000
52	20886580	6888767000	4707709000	8944231000	2447425000	1080908000	1574718000	3377854000	1237651000
53	20897220	6890343000	4781289000	8951740000	2447762000	1081629000	1576362000	3379495000	1238354000
54	20907870	6891920000	4854869000	8959248000	2448099000	1082351000	1578007000	3381136000	1239057000
55	20918520	6893497000	4928449000	8966757000	2448435000	1083073000	1579651000	3382776000	1239760000
56	20929170	6895074000	5002028000	8974266000	2448772000	1083794000	1581296000	3384417000	1240463000
57	20939830	6896650000	5075608000	8981775000	2449109000	1084515000	1582940000	3386057000	1241166000
58	20950470	6898227000	5149188000	8989284000	2449446000	1085237000	1584584000	3387698000	1241868000
59	20961120	6899804000	5222768000	8996793000	2449783000	1085959000	1586229000	3389338000	1242571000
60	20971770	6901381000	5296347000	9004301000	2450120000	1086680000	1587873000	3390980000	1243274000
61	20982420	6902957000	5369927000	9011810000	2450457000	1087401000	1589518000	3392620000	1243977000
62	20993070	6904534000	5443507000	9019319000	2450794000	1088123000	1591162000	3394261000	1244680000
63	21003720	6906110000	5517086000	9026828000	2451131000	1088844000	1592807000	3395901000	1245383000
64	21014370	6907687000	5590666000	9034337000	2451468000	1089566000	1594451000	3397542000	1246086000
65	21025020	6909263000	5664245000	9041846000	2451804000	1090287000	1596095000	3399183000	1246789000
66	21035670	6910841000	5737825000	9049354000	2452141000	1091009000	1597740000	3400824000	1247492000
67	21046320	6912417000	5811405000	9056863000	2452478000	1091730000	1599384000	3402464000	1248195000
68	21056970	6913994000	5884984000	9064372000	2452815000	1092452000	1601029000	3404105000	1248898000
69	21067620	6915571000	5958564000	9071881000	2453152000	1093174000	1602673000	3405745000	1249601000
70	21076270	6917148000	6032144000	9079390000	2453489000	1093895000	1604317000	3407386000	1250303000
71	21088920	6918724000	6105723000	9086899000	2453826000	1094616000	1605962000	3409027000	1251006000
72	21099570	6920301000	6179303000	9094407000	2454163000	1095338000	1607606000	3410668000	1251709000
73	21110220	6921878000	6252883000	9101916000	2454500000	1096060000	1609251000	3412308000	1252412000
74	21120870	6923454000	6326462000	9109425000	2454836000	1096781000	1610895000	3413949000	1253115000
75	21131520	6925031000	6400042000	9116934000	2455174000	1097502000	1612540000	3415589000	1253818000
76	21142170	6926608000	6473622000	9124443000	2455511000	1098224000	1614184000	3417230000	1254521000
77	21152820	6928184000	6547202000	9131952000	2455847000	1098946000	1615828000	3418871000	1255224000
78	21163470	6929761000	6620781000	9139461000	2456184000	1099667000	1617473000	3420511000	1255927000
79	21174120	6931338000	6694361000	9146969000	2456521000	1100388000	1619117000	3422152000	1256630000
80	21184770	6932915000	6767941000	9154478000	2456858000	1101110000	1620762000	3423793000	1257333000
81	21195420	6934491000	6841520000	9161987000	2457195000	1101831000	1622406000	3425433000	1258035000
82	21206070	6936068000	6915100000	9169496000	2457532000	1102553000	1624050000	3427074000	1258738000
83	21216720	6937645000	6988680000	9177005000	2457869000	1103274000	1625695000	3428715000	1259441000
84	21227370	6939222000	7062259000	9184514000	2458206000	1103996000	1627339000	3430355000	1260144000
85	21238020	6940798000	7135839000	9192022000	2458543000	1104717000	1628984000	3431996000	1260847000
86	21248670	6942375000	7209419000	9199531000	2458879000	1105439000	1630628000	3433637000	1261550000
87	21259320	6943951000	7282999000	9207040000	2459216000	1106161000	1632273000	3435277000	1262253000
88	21269970	6945528000	7356578000	9214549000	2459553000	1106882000	1633917000	3436918000	1262956000
89	21280620	6947105000	7430158000	9222058000	2459890000	1107603000	1635561000	3438559000	1263659000
90	21291270	6948682000	7503737000	9229567000	2460227000	1108325000	1637206000	3440199000	1264362000
91	21301920	6950258000	7577317000	9237075000	2460564000	1109047000	1638850000	3441840000	1265065000
92	21312570	6951835000	7650897000	9244584000	2460901000	1109768000	1640495000	3443481000	1265768000
93	21323220	6953412000	7724476000	9252093000	2461238000	1110489000	1642139000	3445121000	1266471000
94	21333870	6954988000	7798056000	9259602000	2461575000	1111211000	1643784000	3446762000	1267174000
95	21344520	6956565000	7871635000	9267111000	2461912000	1111932000	1645428000	3448403000	1267876000
96	21355170	6958142000	7945215000	9274620000	2462248000	1112654000	1647072000	3450043000	1268579000
97	21365820	6959718000	8018795000	9282128000	2462585000	1113375000	1648717000	3451684000	1269282000
98	21376470	6961295000	8092375000	9289637000	2462922000	1114097000	1650361000	3453325000	1269985000
99	21387120	6962872000	8165955000	9297146000	2463259000	1114818000	1652006000	3454965000	1270688000
1.00	21397770	6964449000	8239534000	9304655000	2463596000	1115540000	1653650000	3456606000	1271391000

6. CONCLUSION

Depend on decision criterion, we give priority for production of crops in order to maximize profit (Table 11): during maximax criteria 1st: Teff , 2nd : Sorghum, 3rd: Maize, 4th: Wheat, 5th: Bean, 6th :Barley, 7th : Rise 8th: Pea 9th: Neug Maximin criteria: 1st: Teff, 2nd: sorghum, 3rd: wheat, 4th: Pea, 5th: barley, 6th: Rise, 7th: bean, 8th: neug, 9th: Maize and Minimax regret: 1st: teff, 2nd: sorghum, 3rd: wheat, 4th: bean, 5th Barley, 6th: rise. 7th: pea, 8th: neug, 9th: maize 1st: teff, 2nd: sorghum, 3rd: wheat, 4th: bean, 5th Barley, 6th: rise. 7th: pea, 8th: neug, 9th: maize this indicate produce the much amount of Teff greater than the other and then produce according to their sequence by reducing amount of their production.

Generally, in order to maximize profit of each crop it should be minimize loss of each crops (minimum regret) order by producing according to bellow orders in both condition.

References:

Ashraf, M., & Foolad, M. R. (2005). Pre-sowing seed treatment—A shotgun approach to improve germination, plant growth, and crop yield under saline and non-saline conditions. *Advances in agronomy*, 88, 223-271.

Bezabih, M., & Sarr, M. (2012). Risk preferences and environmental uncertainty: Implications for crop diversification decisions in Ethiopia. *Environmental and Resource Economics*, 53, 483-505.

Degu, A. A. (2019). The causal linkage between agriculture, industry and service sectors in Ethiopian economy. American *Journal of Theoretical and Applied Business*, 5(3), 59-76.

FDRE. (2015). Ethiopia: central statistical agency.

FDRE. (2018). Area And Production of Major Crops. Addis Ababa: Statistical Bulletin.

Gallup, J. L., Sachs, J. D., & Mellinger, A. D. (1999). Geography and economic development. *International regional science review*, 22(2), 179-232.

Gizaw, W., & Assegid, D. (2021). Trend of cereal crops production area and productivity, in Ethiopia. *Journal of Cereals and Oilseeds*, 12(1), 9-17.

Jain, R., Malangmeih, L., Raju, S. S., Srivastava, S. K., Immaneulraj, K., & Kaur, A. P. (2018). Optimization techniques for crop planning: A review. *The Indian Journal of Agricultural Sciences*, 88(12), 1826-1835.

Kalra, N., Chander, S., Pathak, H., Aggarwal, P. K., Gupta, N. C., Sehgal, M., & Chakraborty, D. (2007). Impacts of climate change on agriculture. *Outlook on Agriculture*, 36(2), 109-118.

Lavers, T. (2012). 'Land grab'as development strategy? The political economy of agricultural investment in Ethiopia. *Journal of Peasant Studies*, 39(1), 105-132.

Leakey, R. R. (2018). Converting 'trade-offs' to 'trade-ons' for greatly enhanced food security in Africa: multiple environmental, economic and social benefits from 'socially modified crops'. *Food Security*, 10(3), 505-524.

Mendelsohn, R. & Dinar, A. (2009). Climate change and agriculture.An economic analysis of global impact, adaptation and distributional effects, Elgar, Cheltenham.

Oladejo, N. K., Abolarinwa, A., Salawu, S. O., & Lukman, A. F. (2019). Optimization principle and its'application in optimizinglandmark university bakery production using linear programming. *International journal of civil engineering and technology (IJCIET)*, 10(2), 183-190.

Shumuye, M. Y. (2015). The role of developmental state in development: The case of Ethiopia. *International Journal of African and Asian Studies*, 14, 96-110.

Taylor, B. W., & Taylor, B. W. (2002). Introduction to management science (pp. 26-27). Prentice Hall.

Moti Melkamu
Ambo University,
Institute of Technology,
Ambo, Ethiopia.
motimelka.auit@gmail.com
ORCID: 0000-0002-9968-1293

Tadesse Fisseha
Hawassa University,
Institute of Technology,
Hawassa, Ethiopia
fissehatadesse9@gmail.com

Edossa Dugassa
Ambo University,
Institute of technology,
Ambo, Ethiopia
edo2best@gmail.com