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Analysis of the Consequences of Agricultural Policies on the Cropping Pattern of Agricultural Products and Employment in Afghanistan

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ABSTRACT

The discussion of employment and its complications in the world has attracted the attention of many politicians, government officials and experts. Creating sustainable employment and revenue is the most important way to create economic and social welfare in all human societies. Thus, in developing countries, management policies to support producers' revenue in the agricultural sector and increase employment in this area are considered as the main development goals for them. However, the current research used the positive mathematical programming (PMP) approach and then evaluated the economic consequences of changing the cropping pattern, especially evaluating the level of employment of the labor. Accordingly, the simulated scenarios include price variation of selected agricultural products (PMP1), Yield variation of selected agricultural products (PMP2), Change in the consumption of chemical fertilizers (PMP3), change in the consumption of pesticides (PMP4), change in the consumption of irrigation water (PMP5) and the combination of the mentioned scenarios (PMP6). The study Model was done by responding to 928 questionnaires from 16 districts in Nangarhar province, AFG. The investigators recorded and classified the data in Excel software and the analysis was done with the GAMS software. Finally, by applying the integrated model (PMP6), a suitable result is established between the policies and the amount of gross profit increases by 83 million Afghanis (1.06 percent) and the amount of employment decreases by only 391 thousand people (4.35 percent). Besides, in this model, the consumption of chemical fertilizers is 1.15%, the consumption of agricultural pesticides is 0.49%, and the consumption of irrigation water is 2.95% less than the current model of the province. According to the findings of this research, all the products under review have price elasticity lower than one.

Keywords: PMP, Optimal cropping pattern, Employment rate, GAMS Software, and Nangarhar province.

INTRODUCTION:

Afghanistan is currently facing problems with an unemployment and poor economic growth; the main reasons are the reduction of foreign aid, the continuation of war, insecurity and internal instability. Although many efforts have been made to improve and develop various sectors, especially mining and the industries, yet these successes will be viewed as the insufficient. However, the villagers have been able to see substantial outcomes as a consequence of investment in the agricultural sector, particularly in sub-sector of agriculture. It should be mentioned that Afghanistan has favorable climatic conditions for the production of products that are in high demand in the local and regional markets. About 70% of Afghans live in rural areas and most of them are busy in agricultural farms work. This sector has provided 50% of the employment opportunities, 61% of households get their income from sub-sector agriculture; Therefore, developing a suitable support policy in order to increase the price and yield of products, as well as applying other agricultural policies such as reducing the distribution and sale of inputs that disrupt sustainable agriculture can have a significant impact on the income and employment of Afghan farmers (Afghanistan Ministry of Agriculture, Irrigation and Livestock, 2020). Currently, mathematical programming models have become an important and widely used tool in the analysis of agricultural policies. An advantage of mathematical programming models in the analysis of agricultural policies is the ability of these models to examine the detailed effects of policies at the farm level (Paris and Howitt, 1998). So far, many researches have been carried out inside and outside of Country using the positive mathematical programming approach.

Hassanvand *et al*. (2014), Investigated the response of farmers to policy actions, the study revealed that 20 to 50 percent reductions in water consumption along with doubling the price. However, the result showed a decrease of up to 50% in the amount of water used, the cultivated area of wheat, barley, rapeseed and red beans will decrease by 49.5, 46.2, 69.6 and 3.8%, respectively, but the cultivated area of rainfed crops did changed due to the yield and lower market price of course, irrigation water consumption is also saved up to 56.53%. Nevertheless, Agh *et al*. (2015) reported that, in the fertilizer reduction policy, the cultivated area of all crops is reduced by 49%, and the largest reduction is related to the rainfed rapeseed crop. In the fertilizer reduction policy, the area under cultivation of all crops is reduced by 56%, the largest reduction being related to the dry wheat crop. In the policy of reducing the amount of water by 13%, the cultivated area of irrigated crops decreases and the cultivated area of the rainfed crops do not change. In the policy of reducing the amount of water 13.93, the cultivated area of irrigated crops is reduced and the cultivated area of rainfed crops remains unchanged. Joolaie *et al*. (2018) focused on the analysis of the effects of changing agricultural input consumption on crop pattern in Iran. The study reported that, If the scenarios are implemented (reduction 1% water consumption, the 7% chemical fertilizer consumption, 1% pesticide consumption and 0.64% increase in labor force employment in the agricultural sector) at the same time, a 5% and 0.2% reduction in the total level below Cultivation and gross margin are compared to the current pattern of the region; So that the maximum reduction of the cultivated area with 40 and 30% is related to rainfed barley and soybean products, respectively.

Deylami *et al*. (2019), reported that, the Climatic parameters of temperature and precipitation have a significant effect on the yield of selected crops and also by applying climate variability prediction in the crop pattern model, blue potato has the highest increase in yield and cultivated area with 0.27 and 71.7% increase, respectively. The biggest decrease in yield with 0.17% decrease is related to high-quality long grain rice and the biggest decrease in cultivated area with 89.1% decrease is related to blue barley product. Also, the gross profit of farmers will increase in all three periods of the near future, the middle future and the distant future. Kohzad *et al*. (2020) reported that, farmers' reactions to the policy of reducing available water resources under the applied scenarios of 10%, 20%, 30% and 40% showed the existence of a significant difference between the economic value of irrigation water and the water price paid by farmers. It was also found that there is a significant economic difference between each cubic meter of irrigation water and the price of water paid by farmers, and only about 48% of the economic value of water is paid in terms of production and transportation costs.

Nevertheless, despite the decline in the economic benefits of the agricultural sector in the area, applying the demand of water management policy in the framework of various scenarios of reducing (40-100%) the area under rice cultivation improves the economic efficiency index of water resources and decreases the water demand by 26% (Bashiri *et al*., 2021). Besides that Parhizkari *et al.* (2021) reported that, A decrease in the area under cultivation of water-bearing crops such as watermelon, seed corn, sunflower and an increase in the area under cultivation of wheat and barley, as well as a decrease of 3.00 to 19.4 percent of the gross margin of farmers and an increase of 13.2 to 115.6 percent of the economic value of irrigation water is one of the results obtained under drought conditions. Besides that Saljooghi *et al*. (2021), worked on investigating water resources limitation based on model farming and resulted that, by applying a limit of 5% to 40% in the supply of irrigation water, the area under cultivation of all selected crops will decrease, except for water wheat, where water requirement is generally lower than other water crops. According to Yan *et al*. (2015) a 1% increase in urbanization might result in a 0.47 % drop in the percentage of water usage. Based on the model simulation, this decrease is observed more in the water areas and the increase of the rainfed area at the national and river basin levels, especially for water-rich crops (such as rice and wheat). Based on this, the average of the gross margin and the total production also decrease. Aayog *et al.* (2016) worked on investigating policies supporting prices on cultivation area of agricultural products and reported that 81% of farmers are aware of the Minimum Support Price (MSP) for various agricultural products such as rice, wheat, pulses, coarse grains and oil seeds announced by the government annually, while 67% of them sell their products to this are paying attention.

According to Tavakkoli *et al.* (2019), policies to the increase the price and yield of wheat demonstrated that the effect of increasing the yield on the area under poppy cultivation is much more effective than the policy to increase the price of wheat and applying combined policies. Products like hybrid corn were also found to partially compensate for the decrease in income (nearly 45%). The increase in the price and yield of wheat has a greater effect on the reduction of poppy cultivation. Also, saffron, in the current situation, is a serious alternative to poppy, especially for representative farms. But if the price of the poppy farm becomes higher than 80 thousand Afghanis per sere (about 4 kg), saffron cannot be an alternative product, so it is not possible to eliminate poppy cultivation with the policies of the product supply side only, and management & monitoring policies must be implemented. The demand is also more attention. Besides, the use of PMP models in multidisciplinary agricultural research can help policy analysis. For example, a hypothetical improvement in yield for rainfed soybean types was included in the model and a positive effect on the watershed results and producer profit was observed (Ashwell *et al.*, 2021). Nevertheless, according to the vastness of Afghanistan's border region and the diversity of different climatic regions, the statistical research is present; all the farmers are in Nangarhar province. According to the last census, there are 1400 farmers in the agricultural sector of this province, 74512 people are reported. Nangarhar is one of the 34 provinces of Afghanistan, with Jalalabad as its center in the east of the country (Afghanistan Ministry of Agriculture, Irrigation and Livestock, 2020).

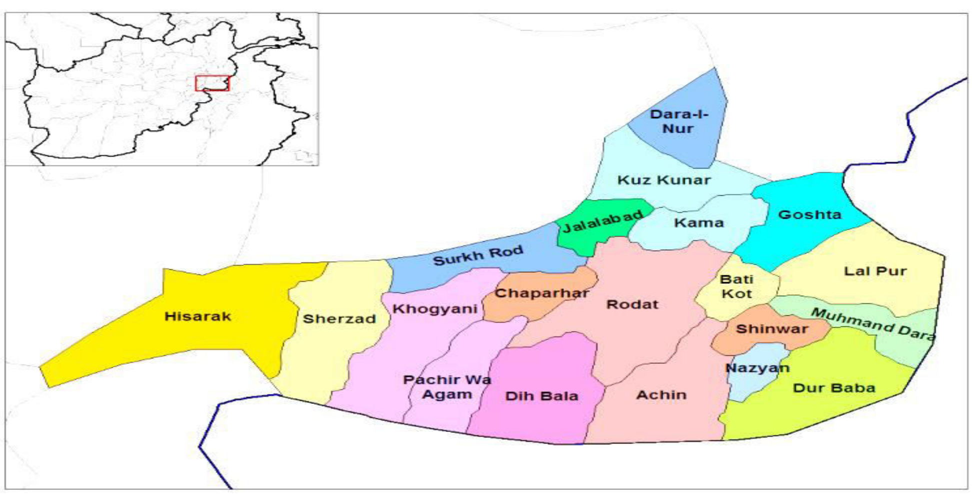

Fig. 1: Geographical location of Nangarhar province.

In the present study, using random sampling and with 92% confidence, the sample size is 928; next using the Positive Mathematical Programming (PMP) approach, the reaction of the farmers of Nangarhar province to the important policies in the agricultural sector is investigated.

MATERIALS AND METHODS:

Positive Mathematical Programming has been widely used in the studies regarding sustainable farm management/ also, in recent years several variants of the Positive Mathematical Programming have been developed and used in bio economic analysis. Positive Mathematical Programming is widely used in the analysis of the economic, social and environmental problems, in the context of the Common Agricultural Policy try to present a PMP model, suitable for estimating the variable cost of agricultural production linked to the different agricultural activities (Mougianni, 2022). Since one of the goals of policy-makers, especially programmers in the agricultural sector, is to be aware of the results of the implementation of different policies and the response of farmers to them; Therefore, they are looking for models who can achieve this goal with the high confidence. Also, the programmers believe that simulating the possible reaction of farmers to the implementation of different policies can help in making more correct decisions. The usual method for the simulating producers' decisions is to pattern a model that reflects the constraints, opportunities and objecttives of the existing conditions, and then solve the assumptions arising from the implementation of the policy in the question. This method is also called affirmative programming (Howitt, 1995). It is an empirical analysis method that uses all available information to build model calibration. In a situation where the time series data is small, it is especially important in regional and sectoral policy analysis (Arfini *et al.*, 2003; Rohm, 2003). In the original PMP model, it was assumed that the non-diagonal elements of the matrix related to the parameters of the quadratic cost function were zero, and then this problem was solved (Arfini & Paris, 1995; Heckelei, 2002; Hazell & Norton, 1986). With this assumption, effects such as periodic effects that different products have on each other were ignored. To solve this problem, the maximum entropy method was suggested (Paris & Howitt, 1998). Using this method, the PMP negative degree of freedom problem is solved and all the elements of the non-linear cost function related to the objective function can be estimated without the need to consider any assumptions (Mohsani and Zabet, 2019). Since the PMP model reconstructs the current data, it is called the positive (true) method. The main purpose of these types of models is to express the reactions of producers to external changes. The main argument for building PMP models is to increase confidence by avoiding the difference between the current baseline situation and the simulated baseline situation (Britz *et al.*, 2003). The general idea in PMP is to use the information available in the binary variables of the calibration constraints, which limits the solution of the linear programming problem to the level of the existing activities. These dual values are used to express the non-linear objective function that reconstructs the observed activity level through the optimal solution of a new programming problem that does not have calibration constraints (Meyer *et al.*, 1993). PMP models include three stages. The first step is to explain a linear programming model; the second step is to estimate the coefficients of the non-linear objective function and the last step is to explain the recalibrated model and analyze the policy. The mathematical structure of positive mathematical programming is as follows (Howitt, 2005).

Max $Z = r'x - c'x$

Subject to

$$\begin{aligned} Ax &\le b \quad [\lambda_1] \\ x &\le (x^0 + \varepsilon) \quad [\rho] \\ x &\ge 0 \end{aligned} \tag{1}$$

In this relationship,

Z = Objective function value,

$r = (N \times 1)$ vector of gross margins of productions activities,

$x = (N \times 1)$ Vector of production activities levels,

$c = (N \times 1)$ vector of variable cost per unit of activity

$A = (M \times N)$ matrix of coefficient in resource constraints,

$b = (M \times 1)$ vector of available resource quantities,

$\lambda_1 = (M \times 1)$ vector of dual variable associated with the resource constraints,

$x^0 = (N \times 1)$ vector of observed activity levels,

$\varepsilon = (N \times 1)$ vector of a small positive numbers,

$\rho = (N \times 1)$ Dual variables associated with the calibration constraints (Heckelei, 2005).

Usually, the quadratic cost function is expressed as follows:

$$C^v(x) = a'x + \frac{1}{2}x'Q_x \tag{2}$$

In the above relationship, $a = (N \times 1)$ vector of the parameters associated with the linear term and $Q = N \times N$ is a symmetric, positive (semi-) definite matrix of parameters associated with the quadratic term. The quadratic formulation implies that the Marginal costs are relatively increases to the level of the product. The parameters a, and Q are determined in such a way that the solution of the non-linear programming is equal to the linear programming of equation (1). In other words, the parameters are then specified such that the linear marginal variable cost (MC^v) functions fulfil

$$MC^v = \frac{\partial C^v(x^0)}{\partial x} = a + Qx^0 = c + \rho \tag{3}$$

PMP method, the nonlinear cost function estimated in the previous step is examined in the objective function of the problem and is used in a nonlinear programming problem similar to the initial problem with the exception of the calibration constraint but with other system constraints:

$$\text{Max} \quad Z = r'x - d'x - \frac{1}{2}x'Qx$$

Subject to:

$$\begin{aligned} &Ax \le b, \\ &x \le x^0 + \varepsilon \\ &x \ge 0 \end{aligned} \tag{4}$$

Now the above calibrated nonlinear model correctly reproduces the observed activity levels in the base state and Dual values of open resource constraints and is ready to simulate changes in the desired parameters (Paris, 2001). In the present study, the agricultural sector model of Nangarhar province is calibrated and the effect of policies (1) price change (PMP1), (2) yield change (PMP2), (3) chemical fertilizer use change (PMP3), (4) agricultural pesticide use change (PMP4),(5) change of irrigation water consumption (PMP5) and (6) integration of the mentioned policies (PMP6) are studied. **Table 2** shows a list of the current research information.

Table 2: Research model information.

Description	Number	Type
Sampled areas	16 Districts	Khewa, Kama, Surkh Rod, Bihsud, Goshta, Bati Kot, Momand Dara, Achin,, Spinghar, Rodat, Darai Noor, Ghanikhel, Lalpura, Pachir Agam, Kot and Khogyani
Model decision variables	13 crops	Wheat, Corn, Rice, Potato, Cauliflower, Melon, Watermelon, Onion, Spinach, Cotton, Okra, Tomato and Cabbage
Constraints of the model	45 production inputs	Phosphate fertilizer(1) , Urea fertilizer(1) , Nitrogen fertilizer(1), Herbicide(1), Insecticide(1), Fungicide(1) , Seed(1), Monthly Labor(12), Monthly irrigation

		water(12) , Monthly mechanization(12), Capital(1) and Land(1)
Agricultural policies	3scenarios	Change in the price of selected crops to the maximum price of the last five years, Change in the yield of selected crops to the maximum price of the last five years, 10% reduction in chemical fertilizer consumption, 10% reduction in agricultural pesticide consumption, 10% reduction in irrigation water consumption, and Simultaneous application of scenarios.

Monthly: for 12 months of the year (April to March)

RESULTS AND DISCUSSION:

The GAMS.25.1.2 software package is used to estimate the present research model, and the findings are displayed in **Table 3**.

Table 3: The cultivated area of crops in Nangarhar province based on the results of the current and proof model.

Product Name	Cropping pattern (hectares)						
	Current region	PMP1	PMP2	PMP3	PMP4	PMP5	PMP6
Wheat	69262	69827	67160	65683	63028	60258	64100
Corn	23990	23533	23941	23990	23990	23990	23455
Paddy	14216	14001	14893	14216	14216	12999	14008
Potato	2416	2443	2505	2126	2314	2416	2442
Cauliflower	2292	2294	4396	1146	2292	2292	2506
Melon	2250	2294	902	1710	1733	2250	2293
Watermelon	1840	1895	2360	1141	1251	1840	1894
Onion	1770	1808	1830	974	920	1643	1808
Spinach	1342	1310	1400	1342	1342	1342	1310
Cotton	1294	1259	1230	1294	1294	1294	1258
Okra	1566	1567	1602	470	1394	1535	1567
Tomato	1008	1013	1025	827	837	1008	3016
Cabbage	1048	1050	1050	105	1048	1006	1050
Total cultivated area (hectares)	124294	124294	124294	115023	115658	113873	120706
Gross Margin(million afghanis)	7853	7889	8087	6596	7133	7244	7936
Employment rate, Labor (thousands of people)	8983	8999	8981	8171	8271	8204	8592

Source: research findings

Table 4: The rate of changes in Nangarhar province based on the results of the current and proof model.

Product Name	Rate of change (percentage)					
	PMP1	PMP2	PMP3	PMP4	PMP5	PMP6
Wheat	+0.82	-3.03	-5.17	-9	-13	-7.45
Corn	-1.90	-0.20	0	0	0	-2.23
Paddy	-1.51	+4.76	0	0	-8.56	-1.47
Potato	+1.10	+3.68	-12	-4.24	0	+1.06
Cauliflower	+0.07	+91.80	-50	0	0	+9.34
Melon	+1.95	-59.91	-24	-23	0	+1.91
Watermelon	+2.98	+28.26	-38	-32	0	+2.91
Onion	+2.14	+3.39	-45	-48	-7.18	+2.13
Spinach	-2.35	+4.32	0	0	0	-2.41
Cotton	-2.72	-4.95	0	0	0	-2.76
Okra	+0.06	+2.30	-70	-11	-2	+0.05

Tomato	+0.48	+1.69	-18	-17	0	+199.21
Cabbage	+0.23	+0.19	-90	0	-4	+0.22
Total cultivated area (hectares)	0	0	-7.46	-6.95	-8.38	-2.89
Gross Margin(million afghanistan)	0.46	+2.98	-16.01	-9.17	-7.75	+1.06
Employment rate, Labor (thousands of people)	+0.18	-0.02	-9.04	-7.93	-8.67	-4.35

Source: research findings

Table 3 shows that the current cropping pattern of Nangarhar province, wheat and corn occupy the largest cultivated area with 55.72% and 19.30%, respectively. Also, the total cultivated area of 13 crops under investigation in this province in 2021 is about 124 thousand hectares, the gross profit of the agricultural sector is equal to 7853 million Afghanis (equivalent to 98.79 million dollars) and the employment rate of the labor force in the agriculture sector is 8983 person-days. In the model (PMP1), the policy of increasing the price of Agricultural products is considered. The pricing policy of agricultural products is considered one of the important tools to support agriculture in Afghanistan. This type of policy, as a lever of government intervention, has an effect on the allocation of production factors, combination of cropping patterns and investment incentives in the agricultural sector. Considering that the pricing policy has the dual goal of increasing the income of farmers and increasing the welfare of consumers; its success depends on the price level that should be supported. The results of table (3) indicated that the implementation of this policy, the area under wheat cultivation as the most important strategic product of this province will increase by 565 hectares. Also, the gross profit will increase to 7,889 million Afghanis (equivalent to 99.243 million dollars) and the employment rate will increase to 8,999 person-days. In the model (PMP2), the policy of increasing crop yields is considered. Various factors such as crop rotation, optimal use of chemical inputs, conservation tillage, seed modification, timely agricultural operations, time and method of irrigation, etc. are effective in improving crop yield. The results of **Table 3** shows that with the implementation of the policy to increase yield, the cultivated area of wheat, corn, melon and cotton is 3.03%, 0.20%, 59.91% and 4.95% less respectively and the cultivated area of paddy, potato, cauliflower, watermelon, onion, spinach, okra, tomato, and cabbage are 4.76, 3.68, 91.80, 28.26, 3.39, 4.32, 2.30, respectively. However, 1.69 and 0.19% are more compared to the current model. Also, the gross margin will increase to 8087 million Afghani (equivalent to 101.734 million dollars), but the employment rate will also decrease to 8,981 person-days.

In the model (PMP3), the policy of reducing the consumption of phosphate, nitrogen and urea fertilizers by 10% in order to reduce the environmental damage caused by the use of chemicals for the production of crops is considered. By implementing this scenario, the cultivated area of crops such as corn, rice, spinach and cotton will not change. Cabbage has the largest decrease in cultivated area with 90% and wheat has the lowest decrease with 5.17%. It should be noted that this policy can have adverse effects such as a 16.01 percent decrease in gross profit and a 9.04 percent decrease in employment. In the (PMP4) model, the policy of reducing the consumption of herbicides, insecticides and fungicides by 10% is considered for the sustainable development of agriculture. By implementing this scenario, the cultivated area of 6 crops including corn, rice, cauliflower, spinach, cotton and cabbage will not change. The largest and the smallest decrease in cultivated area with 48% and 4.24% respectively is reserved for onion and potato. It should be noted that this policy also causes a decrease of 9.17% in gross profit and 7.93% in labor force employment, but the negative effects of the model (PMP3) are much less. In the (PMP5) model, the policy of reducing irrigation water consumption by 10% in order to preserve the water resources of Nangarhar province and also adapt to the drought stress and climate changes that we have witnessed in the recent years; considered. By implementing this scenario, the area under cultivation of water-bearing crops such as wheat, rice, onion, cabbage, and okra will decrease by 13, 8.56, 7.18, 4, and 2 percent, respectively. The implementation of this scenario causes the gross profit to be 7.75% less than the current model of the province, but this profit is more than the models (PMP3) and (PMP4). Also, the employment rate is higher than the model (PMP3) but lower than the current models and the model (PMP4). By simultaneously executing the above five scenarios, a combination of results is obtained; So that according to the model (PMP6), the amount of gross profit increases by 1.06 percent and the amount of employment decreases by 4.35 percent. Besides, in this model, the consumption of chemical fertilizers is 1.15%, the consumption of agricultural pesticides is 0.49%, and the consumption of irrigation water is 2.95% less than the current model of the province.

Table 5: Price and Yield elasticity of selected crops (Source: research findings).

Product Name	Price elasticity	Yield elasticity
Wheat	+0.12	-1.56
Corn	-0.30	-0.11
Paddy	-0.26	+2.40
Potato	+0.21	+2.43
Cauliflower	+0.01	+31.77
Melon	+0.25	-53.89
Watermelon	+0.40	+15.60
Onion	+0.31	+3.05
Spinach	-0.47	+4.17
Cotton	-0.54	-3.93
Okra	+0.01	+1.91
Tomato	+0.09	+1.12
Cabbage	+0.04	+1.10

Table 4 findings indicate that all of the tested items have price elasticity that is less than unity and are thus regarded as having low elasticity. The absolute lowest amount of the price elasticity with 0.01 belongs to cauliflower and okra, and the absolute highest amount with 0.54 belongs to cotton. Also, the lowest absolute value of functional elasticity with 0.11 belongs to corn and the highest absolute value with 53.89 belongs to melon.

CONCLUSION AND RECOMMENDATIONS:

Increasing farmers' income and improving their living conditions is always one of the priorities of planners and policy makers in the agricultural sector. In this study, using the positive mathematical programming approach, the effects of agricultural policies in the agricultural sector of the Nangarhar province of Afghanistan were analyzed in three scenarios. The results of the study show that the positive mathematical programming model is completely successful in reproducing the values of the base year and can also show the changes in the cultivated area if any of the policies are applied. In addition to, the results indicate that the farmers show different behavior patterns in response to the adoption of the mentioned policies, considering the effect of the policy on the relative income of the products. Following is a broad summary of the results that should be taken into consideration:

1) According to the study, it is advised that policy and decision makers in the agricultural sector evaluate various scenarios using the positive mathematical planning method for forecasting and future planning. By looking at the magnitude of various risks, they should be able to make predictions that are more accurate in terms of management. Put this significant economic sector in front of more effectively and successfully.
2) Undoubtedly, the obtained results are highly related to the data used and the products in question. This means that by changing the data or adding or subtracting products, the results will change. But for the farmers of the Nangarhar province who consider such plants in their cropping pattern, the results of this study are beneficial. They can predict what crops to plant

with different fluctuations in price and yield compared to previous periods.

3) Taking into consideration that the amount of land that is farmed is significantly impacted by price volatility. Thus, it is recommended that the findings of this study be taken into consideration when establishing the policies for this industry, such as market regulation, product pricing, and long-term production planning.
4) During the implementation of the yield increase policy, the area of wheat cultivation decreases, the improvement of production technology and the application of research and education can be an incentive for the cultivation of these crops.
5) The results of the present study showed that price and yield fluctuations can cause fluctuations in planned yield and cultivated area of Nangarhar crops. This increase the risk-taking of farmers that can be a suitable solution to increase their income. To do this, assistance programs must be put in place, financial institutions like insurance must absorb some of the risk, and farmers' understanding must be raised via education.
6) The results of this study indicate that the implementation of the policy of reducing the consumption of chemical fertilizers alone causes the greatest damage to the income of farmers and the employment of the labor force and causes a decrease in agricultural activity; Therefore, it is suggested to consider other support policies such as the guaranteed price of products along with this policy.

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CONFLICTS OF INTEREST:

There is no conflict of interest from the authors' end.

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