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Article

Problems of Ensuring Economic Sustainability in The Agricultural Sector Based on Yield Risk Management

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Abstract: The article analyzes the theoretical and practical aspects of yield risk management in agriculture, as well as its role in ensuring the economic sustainability of agrarian production. Using the example of Namangan region, the dynamics of cotton yield for the period were examined through variation indicators, the coefficient of variation (CV), quantile analysis (Q10), and probabilistic assessment methods (Pr(Y<30)). A district-level risk passport was developed, and the average yield losses and their economic equivalents were calculated. The study revealed that rising temperatures and the increasing frequency of drought years have led to a higher probability of yield declines below 30 centners per hectare, resulting in annual economic losses of 20–25 million USD across the region. The article substantiates organizational and economic measures aimed at reducing yield risks.

Keywords: crop yield risk, economic sustainability, agriculture, cotton growing, climate change

1. Introduction

The sector constitutes intrinsically a non stable one. It is very susceptible to climate, water supply and markets, pests and diseases etc which makes the agrarian system vulnerable to natural as well as economic vagaries Hence the trade-off between risk and stability is one of the central themes in agricultural economics.

Theoretical perspective Risk in theoretical terms, risk is the possibility of less than expected performance; in agriculture, it indicates getting yields lesser and better with comparison to anticipation[1]. Economically speaking, risk influences farmer's income level, costs and profitability. [1]

Risk identification and appraisal are fundamental in making the best decision in crop production. They assist farmers in selecting the insurance policies and assigning additional resources, agrotechnical activities and provide recommendations. In general, balancing risk and stability is an important tool for quantitative evaluation of the variation in yield and management of economic risks associated with agriculture.

In the world practice, the elucidation and appraisal of risks in agriculture have grown to be important tools for decisionmaking, agrarian policy, insurance systems building, and financial strategy planning in many countries. [2]

For example, the United States' Risk Management Agency (USDA RMA) operates a crop insurance and risk sharing product for farmers. In Turkey, other aid and insurance mechanisms have also been installed to alleviate the consequences of drought and water shortage. In India, by contrast, a comprehensive index-based insurance and subsidy scheme is used to ensure crop yields for farmers.

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Literature Review

Agricultural risk management is considered as one of the key instruments of economic security of the agricultural production sector. There are several things that cause risks to appear in agriculture including Uncertainties, natural changes and market volatilities, lack of financial capital and government policy change.

Proper risk management reduces the magnitude of economic losses, and this is vital to the country's food security. These considerations suggest that the management of risk in agriculture will continue to be a timely and topical issue for both scientific and policy discourse into the future. [3]

The mere academic and methodological soundness of risk assessment has been intense studied among different schools and economists. In particular J.M. Keynes, in works, paid close attention to the problem solving of the economy and credit risk as well as inflations under uncertainty. F. Knight Subject Area: Economics Abstract: F. Knight conducted systematic analysis of conditions under which risk and uncertainty would be positively related to profits, focusing on both perfect and imperfect competition. T he Austrian economist J. Schumpeter, for instance, examined the processes of ceaseless change and innovation occurring in the economic system with an emphasis on their relationship with risk. [4]

N. Siropolis described entrepreneurial risk with the term likelihood of financial losses and distinguished among three types: 1) pure, as well as 2) speculative and (inevitable) 3 fundamental risks.

Several scientific studies on quantitative and qualitative evaluation of agricultural risks were conducted by B. Hardaker et al, which implied a variety of agricultural risks: 1) production risks, 2) market risks, 3) financial risk., 4) institutional risk., and 5) personal risk.

Furthermore, R. Anderson at al. made an important contribution to the applicational use of mathematical methods for decision making under risk in agriculture. They suggested Bayesian theory as a useful means of assessing the distributions of random variables. [5]

2. Materials and Methods

The analysis of long series of yields according to the mean value, standard deviation and coefficient of variation (CV) is one of the basic procedures for risk evaluation in agriculture. One example in risk assessment techniques is to estimate the mean level of yields during bad years (Q5, Q10) or how many times yield drops below a specified threshold over a period. In the US, for example, the Risk Management Agency (RMA) of the USDA assumes that average yields in catastrophic years are based on different scenarios. These scenario or model-based estimates incorporate projected changes in climate, water availability and agrotechnical practices to generate forecasts of yield risk. Such considerations provide a more precise insight into the risk implications in agriculture.

The coefficient of variation measures the magnitude of yield variability, and quantiles are the "lowest yield levels" reached even in the worst years. Through a probabilistic approach the likelihood and severeness of yield decreases towards a certain threshold is evaluated, which represents an important scientific and practical instrument for strategic decision-making of farmers, investors and government organisations.

3. Results

Uzbekistan along with the entire Central Asia is regarded as one of the areas most at risk from climate change. In the last 50 years the mean annual temperature has increased by 1.5–2.0°C The number of hot days in summer has also increased significantly, with temperatures above 40°C being more frequent in July and August than earlierRCTs or NoRCTs were those where there were increasing ichosoc invesibio pienio fungi crapansil vio XT length is available ite, arox diliognog are availablene nuxt droxxamPont: how much does NCDV guarantee you will be able to earnSLSub.. [6]

The Amu Darya and Syr Darya basins are the sources of most of its water. Yet, the accelerated melting of glaciers and the shifts in precipitation patterns have further exacerbated water shortage. 5 Widening gap between water offers and demand In general, by 2030 the water offer will be reduced in the area after checking the different international studies (by 15–20%).

Cotton is high water-consuming crop, in Central Asia it consumes about 40–50% of the total water, mainly used for watering the fields from where the OEMI cotton originates. In the traditional irrigation networks water losses can account for 30–40% of delivered water, mainly due to evaporation and seepage. This wastage leads to high risk in yield under changing climate. [7]

Cotton yields can also decrease 25 to 35 percent during drought, reflecting its high susceptibility to water deficit and the critical need for more efficient irrigation management and climate adaptation strategies in order to maintain agricultural production.

Cotton cultivation is one of the strategic sectors of agriculture in Uzbekistan. A series of agrarian reforms have been acted in recent years with the aim to develop agricultural sector more efficiently and sustainably. They consist of actions to regulate land and water use relations, secure the effective use of arable lands, attract investments and technologies of an innovative nature, cut unprofitable cotton and grain fields while liberalizing procurement and purchase of staple farm produce for state needs within certain limits. [8]

In the process of these reforms, a series of laws and regulations have been enacted or promulgated and put into practice to strengthen the financial base for farm operations as well as the market-based transformation of agriculture. The news has led to a dramatic improvement in cotton harvest, both countrywide and especially in Namangan province.

The cotton is the leading crop in the agricultural development of the Namangan region. Farmers are important in this industry and 93.4 per cent of total raw cotton material produced in the region is from Farmers. Area sown with cotton amounted to 61.7 thous ha, the gross yield was equal to 153.3 thous t at an average yield of 25.8 centners/ha in 2024.[9]

Given the significant share of cotton cultivation in the regional agricultural structure, a comprehensive risk passport for cotton yield was developed and analyzed based on the yield data from 1990 to 2024, see Table 1.

Table 1. Comprehensive Risk Passport of Cotton Yield in Namangan Region for the Period 1990–2024

№	Districts	Average yield (c/ha)	Standard deviation (c/ha)	Coefficient of variation (%)	Degree of fluctuation	Yield decline in worst years (c/ha)	Average of the worst 10% years (c/ha)	Probability of yield falling below 30 c/ha (%)	Degree of probability of yield falling below 30 c/ha
1	Mingbuloq	22.6	5.9	26.1	High	11.3	16.2	91.4	Very high
2	Kosonsoy	22.8	3.8	16.5	Moderate	7.9	18.1	97.1	Very high
3	Namangan	34.2	3.1	9.0	Low	10.8	31.2	2.9	Low
4	Norin	31.6	4.2	13.3	Moderate	13.9	27.4	25.7	Moderate
5	Pop	23.0	4.8	20.9	High	9.8	17.2	91.4	Very high
6	To'rago'rg'on	32.7	3.4	10.5	Moderate	6.9	28.4	28.6	Moderate
7	Uychi	32.2	4.4	13.8	Moderate	11.3	28.3	31.4	Moderate
8	Uchqo'rg'on	31.8	3.5	10.9	Moderate	10.2	26.8	22.9	Moderate
9	Chortoq	30.5	4.5	14.7	Moderate	7.9	24.2	42.9	Moderate
10	Chust	23.8	5.4	22.8	High	7.7	18.1	85.7	Very high

According to the analysis, the highest yield variability in the region was observed in Mingbuloq district (26.1%), which can be attributed to the natural and climatic conditions, irrigation constraints, and agro-technical disparities in cotton cultivation. A similar situation was also noted in Chust (22.8%) and Pop (20.9%) districts, where environmental and technological factors contributed to higher yield fluctuations.[10]

During the analyzed period, the most stable yield performance was recorded in Namangan district (9.0%), followed by To‘raqo‘rg‘on (10.5%) and Uchqo‘rg‘on (10.9%), where cotton yields remained relatively stable across years. Meanwhile, Kosonsoy (16.5%), Chortoq (14.7%), Uychi (13.8%), and Norin (13.3%) districts exhibited moderate levels of yield variability, reflecting a balanced influence of climatic and management factors.

Thus, in Namangan, To‘raqo‘rg‘on, Uchqo‘rg‘on, Norin, and Uychi districts, where yield levels have remained relatively stable, the impact of production (yield) risk is considered low, allowing for more efficient planning of agro-technical measures. In contrast, in districts with moderate risk levels such as Kosonsoy and Chortoq, and high-risk areas such as Mingbuloq, Chust, and Pop, the influence of natural-climatic conditions and agro-technical factors is significantly stronger. These areas therefore require the development of strategic measures aimed at improving water resource management and reducing yield risks.[11]

The probability of yield falling below 30 c/ha was found to be highest in the most vulnerable districts — Kosonsoy (97.1%), with an average decline of 7.9 c/ha in the worst year; Mingbuloq (91.4%), with a decline of 11.3 c/ha; Pop (91.4%), with a decline of 9.8 c/ha; and Chust (85.7%), with a decline of 7.7 c/ha.

In Kosonsoy district, despite the moderate level of fluctuation (16.5%), the average yield has remained around 22.8 c/ha. As a result, the risk of yield falling below 30 c/ha has been observed almost annually. In Mingbuloq district, although the average yield is approximately 22.6 c/ha, the high yield variability (standard deviation of 5.9 c/ha) has contributed to an elevated level of production risk.[12]

The high probability of yield decline below the 30 c/ha threshold in these districts underscores the need to stabilize water supply, improve agricultural technologies, reassess crop variety selection, and promote the development of agricultural insurance mechanisms to mitigate the adverse effects of yield variability.

In the moderate-risk zone, which includes the Chortoq, Uychi, To‘raqo‘rg‘on, Norin, and Uchqo‘rg‘on districts, the probability of yield falling below 30 c/ha ranged between 25.7% and 42.9%. Effective management of this risk zone, based on climate-adapted agro-technical practices and resource optimization, can yield substantial improvements in productivity stability and overall agricultural resilience.

The Namangan district, characterized as the lowest-risk area, demonstrates a stable production profile, with the probability of yield falling below 30 c/ha being almost negligible. The main task for this district is therefore to maintain and further enhance the existing agricultural management system to preserve stability and productivity.[13]

According to the analysis, based on the weighted average of cotton cultivation areas in Namangan region for 2024, the average yield loss in the lowest-yielding years amounted to 4.77 c/ha, resulting in an estimated total regional production loss of 29,467 tons, see Table 2.

Table 2. Estimated Volume of Cotton Yield Losses (tons) in Namangan Region for 2024, Weighted by Cultivated Area

Districts	Cotton cultivation area in 2024 (ha)	Average yield loss in low-yield years (c/ha)	Total loss by district (tons)	Share of district in total loss (%)
Mingbuloq	16,646	7.84	13,050	44.3
Pop	13,799	7.13	9,839	33.4
Kosonsoy	3,535	7.19	2,542	8.6
Chust	3,472	6.81	2,364	8.0
Uchqo‘rg‘on	7,204	0.80	576	2.0
Norin	4,768	0.91	434	1.5
Uychi	4,370	0.71	310	1.1
Chortoq	868	1.58	137	0.5
To‘raqo‘rg‘on	2,846	0.47	134	0.5
Namangan	4,232	0.19	80	0.3

This is a heavy loss in economic terms. At an average of 700–800 US$ per ton raw cotton, the annual expected loss is around 20 to 24 million US$. This proportion is a substantial part of farmers' earnings in the area. Yield losses could be further reduced, and additional economic benefit of 15–20 million USD per year may be achieved based on bettermanagement and adaptation activities. [14]

Total annual losses are concentrated in Mingbuloq and Pop districts, which account for about 77% of the areas. These sites are characterized by variability of yields and strong determining role of natural risks (droughts, irregularities in water supply). Thus, the construction of agricultural facilities and modern irrigation facilities together with crop insurance services in these districts is an economic necessity for cotton stability and resilience.

On the basis of the elaboration of casualty passport, taking into account the dynamics of cotton yield in Namangan region for 1990–2024, some conclusions and recommendations on organizational and economic provision when managing yields are suggested. [15]

Average cotton yield in the region varied from 22.6 to 34.2 c/ha, and optimum (maximum) was obtained in Namangan district (34.2 c/ha). The coefficient of variation (yield fluctuation) was between 9.0% and 26.1%, and the districts of Mingbuloq, Pop, and Chust showed even more than >20% yield variability, indicating these areas were high-risk zones [16].

Substantial contrasts in the risk of falling below 30 c/ha yield were found among districts (e.g., district Namangan: only 2.9% expecting it; between: 25.7 and 42.9% as moderate-risk districts such as Chortoq, Uychi, Toʻraqoʻrgʻon, Norin and Uchqoʻrgʻon; above >85% Mingbuloq, Kosonsoy, Pop and Chust).

4. Conclusion

The results uncover a marked spatial non-uniformity and instability of yield levels at district level in Namangan oblast, and indicate the demand for district-specific risk management and adaptation measures in the most vulnerable areas.

On the high-risk territories where average yields are low and variability is high – in Mingbuloq, Kosonsoy, Pop and Chust rayons – followed by an extremely high probability (85.7 to 97.1 %) that farmers will achieve yields below 30 c/ha and the respective average losses per ha at of 6 to c/ha. In those regions, the primary difficulties in agro-technical operations are caused by irrigation systems' malfunction and high variability of soil moisture content as well as crop yield that depend on weather conditions.

Therefore, in high risk territories, it is necessary to take measures to rehabilitate the agricultural infrastructure -on a priority basis-building and modernization of water retention facilities, expansion of drip irrigation and drainage systems and selection and cultivation by using climate- adapted varieties on drought resistant water within antipuppy policy and variety. Equally important in the financial and insurance context is the introduction of agricultural insurance policies that cover yield risk and of targeted subsidies. Encouraging the production of high-value agricultural crops namely vegetables and horticulture instead of raw cotton will help in diversifying the economy as well increasing its resistance to shocks within the agrarian sector.

In the districts of moderate risk with highest mean yields (Norin, Toʻraqoʻrgʻon, Uychi Uichqoʻrgʻon and Chortoq), the average return (c/ha) is more than 30 c/ha and losses are relatively low (0.7–1 c/ha). Nonetheless, issues remain with climate variability and water service interruptions. It is necessary, therefore, to optimize the agro-technique and ensure an ongoing monitoring and swift decision-making in districts if yield stability is to be maintained.

The crop-yield risk passport for Namangan region reveals spatial disparity of level of risks among the districts with large geographical differences. Consequently, improving agro-technical management and water resource governance, agricultural insurance and production diversification should be regarded as strategic directions for managing in high-risk regions. Only with specific risk management in the agrarian sector, can yield stability be guaranteed and additional income opportunities for farm-related enterprises whorl regional economy may become open.

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