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**Article**

## Strategic planning for the development of Ukrainian agriculture in the face of climate change

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## Strategic Planning For The Development Of Ukrainian Agriculture In The Face Of Climate Change

### Abstract

*The essence of the “strategic planning” is explored and the peculiarities of strategic planning in the agricultural sector are defined. Global climate change as a factor stimulating the formation of new approaches to strategic planning of agricultural development is considered, and the impact of climate change on the agricultural sector of Ukraine is evaluated. A predictive model of changes in the parameters of agricultural production under expected climate change conditions is constructed, and organizational, socio-economical and environmental components of the strategy of agricultural development are outlined and the conceptual bases for improvement of strategic planning for the development of the agricultural sector in the face of climate change are substantiated.*

**Keywords:** *strategic planning, agriculture, climate change, predictive model, Ukraine*

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## 1. Introduction

Modern agriculture implements a number of important macro- and microeconomic functions, such as ensuring national food security, providing related sectors of the economy with raw materials and rural people with working places etc. However, agricultural production in most countries of the world has been and is the type of economic activity that is subject to many risks, caused by a combination of various factors. Among these factors an outstanding role is played by natural and climatic conditions. The effect of these factors is particularly evident in the last decade, when emerging tendencies of climate change were outlined, arising due to strong human pressure on the environment. The global challenges associated with natural and climatic changes need to be incorporated into national development strategies concerning the agricultural sector as well as state strategic planning.

The aim of this article is to develop a conceptual basis for strategic planning as part of regulation of the economic, social, and ecological processes in order to mitigate the negative effects of climate change factors on the development of the agricultural sector. Achieving the research aim requires the formulation and resolution of tasks such as:

1. Deepening the understanding of strategic planning in a market economic system in order to create opportunities to ensure the effectiveness of strategic planning of agricultural development.
2. The characterisation of global climate change as factor underlying the formation of new conditions for the strategic planning of the economic, social, and ecological development of agriculture.
3. Evaluating the impact of climate change factors on resultant indices of agricultural management in order to substantiate the projected strategic decisions.
4. Estimating the expected parameters of Ukrainian agriculture in changing climate conditions.
5. Grounding the strategy of management of organizational, socioeconomic, and ecological development in the system of climate risks to agriculture.
6. Defining the algorithm of actions which should be taken to achieve the objectives of strategic planning for agriculture in climate change conditions.
7. Developing the components of the concept of improving the strategic planning of development of agriculture, which may prevent the expected negative effects of climate change.

## 2. Theory and methodology

The theoretical foundations of strategic planning are developed in both many foreign works as well as Ukrainian. Nevertheless, in Ukraine there is a lack of application of strategic planning in the agricultural sector. Strategic planning in most cases is considered only at the microeconomic level, with infrequent adaptation to agricultural enterprises, while the strategic planning of the agricultural sector at the macroeconomic level continues to be ignored. At the same time, the factor of climate change is not taken into account. However, strategic planning can be used to stabilize the agricultural sector of the economy, to minimize the effect of seasonal factors, to reduce the impact of factors of market volatility, and so on.

The problems surrounding climate change are currently investigated by many scholars and institutions worldwide (e.g. Adger 2006; Ford et al. 2010; IPCC 2007; Leiserowitz 2006; Nelson and Vucetich 2009; Pielke 2007; Tucker et al. 2015; Wilke and Morton 2015 etc.), but among Ukrainian scientists this subject isn't studied widely enough. Nevertheless, climate change is a global problem that influences social development, and we need to consider it in the strategic planning of the development of the agricultural sector, which demonstrates the relevance of research in this area.

The methodological basis of this research is based on special methods. To solve the tasks we used clustering and the summarizing of data – for processing and the using of statistical information; the table method – for visual representation of the results; correlation and regression analysis – for assessing the impacts of climate change on agriculture; SWOT-analysis – for characterization of processes of the ecologisation of Ukrainian agriculture; the method of economic-mathematical modelling based on neural networks (program 'Neural Tools' developed by Palisade Corporation) – for forecasting changes in yields of major crops under climate change conditions. For forecasting, we used data about major climatic factors and the yield of agricultural crops for 1990–2010. The numerical values of climatic factors were received from the Central Geophysical Observatory of Kyiv, and the values of yield – from the collections of the State Statistics Service of Ukraine 'Agriculture of Ukraine' for the relevant years.

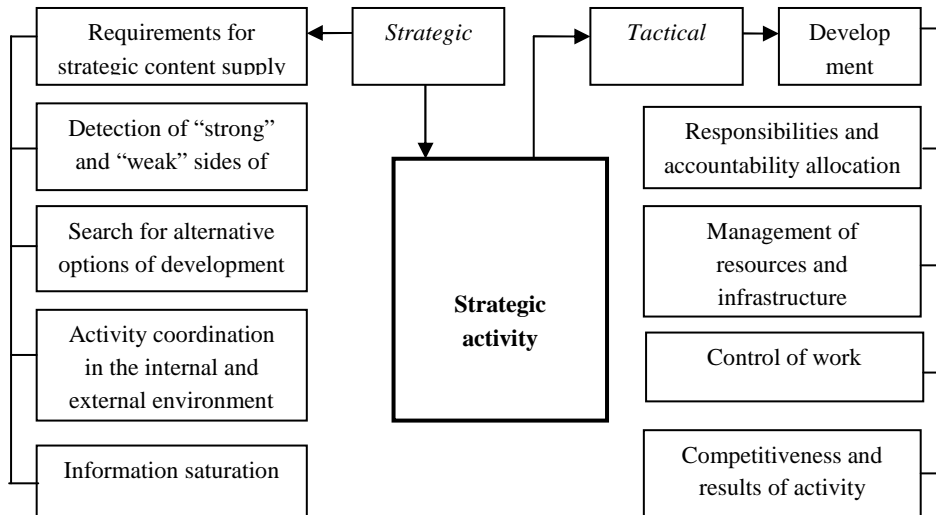
The database for other studies includes legislative and regulatory acts, statistics of the State Statistics Service of Ukraine, some results and predictive models of climate change of international organizations, research papers of Ukrainian and foreign scholars and organizations, and scientific and analytical information from the Internet.

### 3. Results and discussion

Strategic planning at the macro level can be defined as the development of long-term public policy for regulation of the national economy or of a particular sector; the definition of priority goals, and ways and means to achieve them. Strategic planning involves modelling the way to achieve some desired state of an enterprise, region, sector, or the economy as a whole (Lopatynska 2011).

Strategic planning has many benefits for both organizations and the economy. Among them we can emphasize the identification of existing and arising problems, the preparation for sudden changes in the external environment, the improvement of coordination, the ability to better allocate resources, the enhancing of the capabilities to provide the necessary information, the improvement of control, etc. (Fig. 1).

**Figure 1. Strategic approach to development**



Source: Authors own elaboration.

The main objective of macroeconomic strategic planning for the agricultural sector of the economy can be defined as improvement of living standards in rural areas, provision of employment (i.e. of a workforce), laying the foundations for food security based on clear delineation and implementation of priority directions for agricultural development.

The leading elements of strategic planning should ensure the implementation of the following strategic objectives:

1. ensuring the profitability and sustainability of agricultural production;

2. creation of conditions to meet the needs of agricultural enterprises and individual farmers with respect to deferred expenses;
3. providing industry and processing companies with raw materials;
4. support the competitiveness of agricultural products;
5. ensuring a balanced level of export of surplus of agricultural products;
6. increasing the state food reserve;
7. reproduction of rural communities, providing employment for peasants as well as a certain level of their income and social security and access to consumer goods and services, etc.

The definitions and summaries of the methodological foundations of sectoral strategic planning mechanisms allowed us to specify the components of this mechanism for the development of agriculture through the implementation of economic instruments: the regulation of prices and volumes of supply, tax and credit instruments, subsidy and environmental payments, commodity and financial intervention, regulation of trade, personnel policy, and others.

However, the strategic planning of agricultural development should take into account the totality of risks that may affect agricultural production, including natural and climatic factors. This explains why such a global problem, as is climate change, is urgent. Climate change can be defined as a significant change in the mean values of meteorological elements (such as temperature or rainfall) over a period of time, where the averages are taken for periods of about ten years or longer. It takes into account any differences between long-term statistics of meteorological elements calculated for different periods, but belonging to the same region (Cryosphere 2013; Glossary 2013; UNFCCC 2012).

The main causes of climate change are the increasing use of fossil fuels and changes in land use patterns and conditions, which in turn leads to the increasing of greenhouse gases and the amount of solar heat in the atmosphere. The main consequences of climate change are increasing of the average temperature and changes in rainfall patterns.

For estimating the relationship between climatic factors such as annual average air temperature, relative humidity, the temperature of soil and amount of precipitation we used correlation and regression analysis (Table 1). The relationship (scale according to Cohen 2002) between air temperature and humidity is high ( $0.7 < r < 0.9$ ), between air temperature and rainfall is mean ( $0.5 < r < 0.7$ ), and between air temperature and soil is very strong ( $0.9 < r < 1$ ).

**Table 1. The correlation coefficients for natural and climatic factors**

Indicators	$t_n$ °C	$\varrho$	$t_p$ °C	$Q_{on}$
Air average temperature, °C ( $t_n$ °C)	1	-0.70	0.98	-0.57

Air relative humidity, % ( $\varrho$ )	-0.70	1	-0.69	0.55
Soil surface average temperature, °C ( $t_p$ °C)	0.98	-0.69	1	-0.69
Precipitation amount, mm ( $Q_{on}$ )	-0.57	0.55	-0.69	1

Source: Author's own compilation.

We determined the impact of these factors on the basic indicators of functioning of Ukrainian agriculture, in particular on the yield of major crops (Table 2). The comparison of the correlation coefficient ( $r$ ) with the scale of correlation ratio shows that the yield of barley, sugar beet, sunflower, rape and potatoes is closely dependence on climatic factors; the yield of cereal crops and vegetables has a high dependence; and the yield of grapes, fruits and berries has a weak dependence. Based on the numerical values of the coefficient of determination ( $R^2$ ) we can assert that the change of productivity, for example of potatoes, in 69% of cases depends on changes in climatic factors. Thus, the analysis of the relationship between changes in temperature parameters and the yields of crops has a high level of dependence.

**Table 2. The dependence of yield on a combination of climatic factors**

Crop	The coefficient of correlation	The coefficient of determination
Cereal crops	-0.60	0.36
Barley	-0.76	0.58
Sugar beet (factory)	-0.79	0.62
Sunflower	-0.73	0.53
Rape	-0.69	0.48
Potatoes	-0.83	0.69
Vegetables	-0.52	0.27
Fruits and berries	0.24	0.06
Grapes	-0.36	0.13

Source: Author's own compilation.

Using the method of economic-mathematical modelling based on neural networks (NeuralTools 2009) we evaluated the expected changes in yield of crops in Ukraine with respect to increases of the average temperature and related changes in other climatic factors (Table 3). We have found that yields of some crops would grow under moderate temperature increases (up to 1 degree Celsius), but the total yield of major crops would decrease with further increases in the average air temperature.

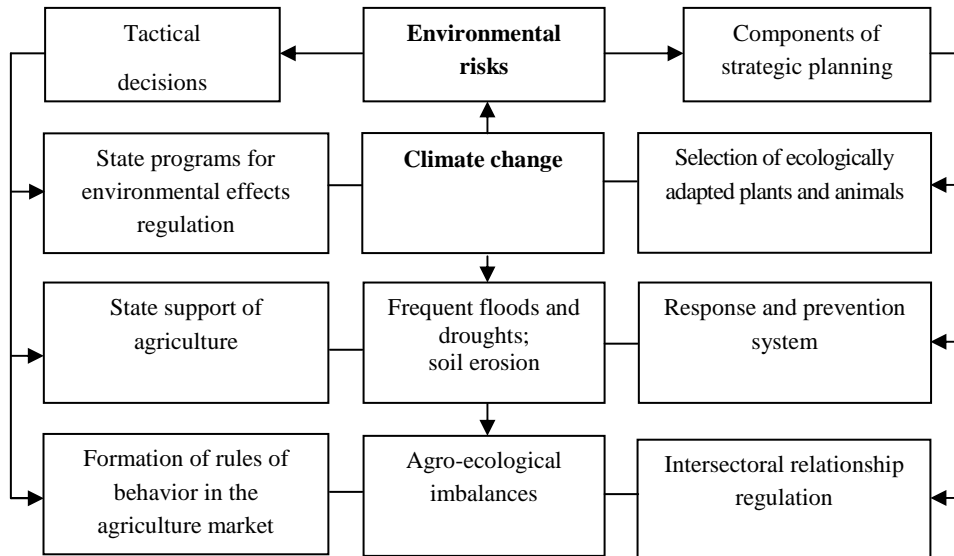
**Table 3. Predicted changes in climatic factors and crop yield by incremental increases in the air temperature in Ukraine**

Indicators	Current values	+0,5°C	+1,0°C	+1,5°C	+2,0°C
The average annual temperature, °C	9.4	9.9	10.4	10.9	11.4
The relative humidity, %	74.8	74.2	73.4	73.4	72.8
Average annual temperature of the soil surface, °C	11.0	11.6	12.4	13.1	13.1
Amount of precipitation, mm	579.1	563.1	547.5	519.7	495.4
Cereal crops, centner/hectare	27.8	27.2	27.5	25.7	26.1
Barley, centner/hectare	24.0	24.0	22.5	21.4	21.2
Sugar beets (fabric), centner/hectare	227.7	229.0	187.6	179.4	118.5
Sunflower, centner/hectare	13.6	13.9	12.6	11.7	11.8
Rape, centner/hectare	14.1	13.1	12.8	13.1	13.5
Potatoes, centner/hectare	120.6	99.9	98.1	96.8	96.0
Vegetables, centner/hectare	154.9	144.6	149.1	141.7	151.1
Fruits and berries, centner/hectare	53.5	56.1	52.5	57.2	59.6
Grapes, centner/hectare	112.8	114.0	119.8	100.2	99.8

Source: Author's own compilation.

We determined the organizational, socioeconomic and ecological imperatives of strategic development with respect to climate change conditions that reflect the processes of developing modern adaptation mechanisms (Fig. 2). The basis of our vision for improving the Ukrainian agricultural development is "the concept of balances", which can combine and balance the ecological, economic, social and cultural processes within a single system of agricultural management. The concept of balances is, in the author's interpretation, an expression of equilibration of anthropogenic and natural cumulative processes in a single complex of agricultural interactions. Anthropogenic processes are the basic foundations for managing of agricultural development; they find their expression in the form of organizational, technical, technological, social, and other support systems. At the same time, today's ecological processes in Ukrainian agriculture are unbalanced and thus they give rise to a large number of problems, such as landscape change, soil depletion, low quality of agricultural products, and so on.



**Figure 2. Ecological management strategies in the agriculture system**

Source: Author's own elaboration.

We believe that small farms are ecologically safe in climate change conditions. It is advisable to diversify the use of small land plots; in particular we should offer ecologically substantiated changes in the structure of land toward natural components, for example due to a significant increase in the area of natural boundaries, hedges, small ponds, shelterbelts, etc. This could also include the extension of natural land with recreational purposes, rural (“green”) tourism, and with economic purposes – the development of biological farming in order to obtain organic agricultural products in Ukraine. These ecologically and socially adapted measures will, on the one hand, progressively develop rural areas; on the other hand they will balance anthropogenic and natural processes in the system of functioning of agricultural farms in climate change conditions.

It is urgent for Ukraine to improve ecological processes at the level of individual farms using a single complex of recovery processes. This is related to quantitative and qualitative indicators of the interaction and interdependence of agricultural systems management (internal environment) and environmental systems (taken as the external environment), which should then be summarized in the form of a SWOT-analysis (Table 4).

**Table 4. SWOT-analysis of ecological and social processes in the climate adaptation of Ukrainian agriculture**

Internal Environment	Strengths	Weaknesses
	<ul style="list-style-type: none"> <li>▪ favourable climatic conditions of certain areas;</li> <li>▪ production of crop and animal products</li> <li>▪ creation of a raw materials' base;</li> <li>▪ providing the population with food;</li> <li>▪ national food security;</li> <li>▪ powerful human capital</li> </ul>	<ul style="list-style-type: none"> <li>▪ Excessive soil tillage;</li> <li>▪ Reduction in crop yield;</li> <li>▪ Reduction of the wildlife population;</li> <li>▪ Decrease in agricultural production;</li> <li>▪ Small capacity of products' primary processing at the level of individual farms</li> </ul>
External environment	Opportunities	Threats
	<ul style="list-style-type: none"> <li>▪ recreational areas (renewal of environmental sustainability);</li> <li>▪ growing of ecologically pure products;</li> <li>▪ perspective of environmental priorities;</li> <li>▪ ability to occupy an important place in the international food market</li> </ul>	<ul style="list-style-type: none"> <li>▪ large number of environmentally damaged areas;</li> <li>▪ land degradation;</li> <li>▪ contaminated raw materials;</li> <li>▪ low ecological quality of finished products;</li> <li>▪ imbalances in agricultural production and ecological reproduction;</li> <li>▪ deterioration of the social perception of the adequacy of state regulation measures</li> </ul>

Source: Author's own elaboration.

We defined a conceptual basis for improving strategic planning for the agriculture in the face of climate change conditions, which covers the following components:

1. Defining the problem to be solved by strategic planning;
2. Analysis of the causes of the problem and discussion over its resolution by strategic planning;
3. Definition of the purpose of strategic planning and determination of strategic priorities;
4. Ways and means of solving problems, implementation of strategic planning;
5. Expected results from the strategic planning, identifying its efficiency;
6. Estimation of the financial resources needed for strategic planning.

The most important is point of the concept is Point 4. In order to mitigate the potential negative impacts and to adapt to expected climate change, the government, professional and public associations, agricultural enterprises and

representatives of farms must join efforts (Borodina et al. 2013). Measures to be implemented can be divided into the following classifications:

- enhancing control and reducing carbon dioxide ( $CO_2$ ) emissions into the atmosphere;
- management of water resources;
- improvements in crop production;
- management of agricultural land;
- improvement of organizational and ecological conditions in livestock management;
- improvement of state regulation in the area of environmental policy;
- activating of professional associations of agriculture producers in line with the strategic planning;
- organizing and activating social movements.

All of the above should be taken into consideration in the implementation of strategic planning. A general action plan to be carried out on various levels of government for the development of strategic planning in the agricultural sector of Ukraine in a climate change conditions should be introduced:

Stage 1 – improving the regulatory framework for strategic planning (which belongs to the state level of government);

Stage 2 – the creation of a public authority of strategic planning (within the department of agriculture) at the state level and the creation of regional advisory bodies for strategic planning at the regional level;

Stage 3 – the involvement of the public and outside consultants (state level), local farmers (regional level), and employees of enterprises (level of agricultural enterprises) in the formulation of strategic documents at each level;

Stage 4 – development of a system of strategic plans and programs (at all levels of government);

Stage 5 – consulting with regional advisory bodies and services in developing strategic plans (enterprise level);

Stage 6 – formation of a mechanism for presenting the formulated plan to all employees (enterprise level);

Stage 7 – development of a mechanism for implementing the plan (all levels of government);

Stage 8 – control over the implementation and adequacy of the plan and making any necessary corrections or adaptations (all levels of government).

#### 4. Conclusions

On the basis of our research results we can offer three scenarios for the future state of Ukrainian agriculture, with respect to the expected impact of climate change – pessimistic; realistic (the base); and optimistic.

1. The pessimistic scenario is based on the assumption that few or no significant measures will be taken with respect to strategic planning aimed at preventing and minimizing the negative impacts of climate change. As a result, the changing of natural and climatic factors for the worse with respect to agriculture will be “unexpected.” The quality and fertility of soil will be reduced, as will crop yields, livestock production, export of agriculture products and so on. Additional negative factors will be declining investment (both domestic and foreign) and reduced funding from the state. Among the consequences will be higher prices for agricultural products, growth of unemployment in the industry, and a lower standard of welfare of the entire population.
2. Realistic – partial measures will be taken, mainly tactical. As a result, the productivity of some crops will be maintained at the current level, with a slight decrease in the yield of others, and with variation and changes in the structure of livestock production. A relatively constant level of government support and investment will be maintained.
3. The optimistic scenario is associated with the active introduction of principles of strategic planning in the development of the concept (doctrine and program) of preventing and minimizing the impacts of climate change on the Ukrainian agriculture. As a result there will be appropriate adaptation to climate change we will witness: the optimal allocation of cultivation in climatic zones in order to increase yields; the nurturing of crop varieties adapted to future natural and climatic conditions; the introduction of an effective mechanism for managing crops to achieve higher yields; improvement of the quality of products and an increasing their export; increasing government support and investment; a growth of revenue for agricultural producers; and sustainable development of the sector, ensuring food security of the population. This scenario will provide production, social, and environmental positive effects, higher efficiency, and profitability of the sector, and therefore should be viewed as the optimum solution.

Changes in the course of events will be based on many factors, both natural and man-made. However, the joint efforts of experts, government, international organizations, research centres and foundations can prevent the negative impacts of climate change and mitigate the risks in the agricultural sector.

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**Streszczenie****ZNACZENIE PLANOWANIA STRATEGICZNEGO  
DLA ROZWOJU UKRAIŃSKIEGO ROLNICTWA  
W OBLCZU ZMIAN KLIMATYCZNYCH**

*W artykule przedstawiono istotę "planowania strategicznego" i zdefiniowano specyfikę planowania strategicznego w sektorze rolniczym. Przeanalizowano rolę globalnych zmian klimatu jako czynnika stymulującego tworzenie nowego podejścia do strategicznego planowania rozwoju oraz poddano ocenie wpływ zmian klimatu na sektor rolniczy na Ukrainie. Skonstruowano model prognostyczny zmian parametrów produkcji rolnej w zależności od przewidywanych zmian klimatu. Opisano organizacyjne, społeczno-ekonomiczne i środowiskowe elementy strategii rozwoju rolnictwa a także zweryfikowano teoretyczne podstawy dla poprawy planowania strategicznego służącego rozwojowi sektora rolniczego w obliczu zmian klimatycznych.*

**Słowa kluczowe:** *planowanie strategiczne, rolnictwo, zmiany klimatyczne, Ukraina, model prognostyczny*