

Mathematical Game theory in green house economy and food security: an analysis of greenhouse facilities in India

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Abstract

Introduction: The aim of this article is to analyze the possibilities of using game theory in the field of greenhouse facilities in India. This goal will be achieved through the analysis of the main modern scientific works, the study of analytical data and statistical indicators of the industry. The greenhouse economy of India today is at a stage when significant changes are needed, the use of the most modern technologies both in the field of economic services for the industry, and fruitful interaction of individual parties. One of the most priority technologies for the development of individual areas of the greenhouse industry today is the so-called "game theory". Game theory is a prerequisite for the formation of separate and relevant directions for the development of the country's greenhouse economy; it establishes the rules for implementing the interaction of the parties-players in the process of creating strategies, functions of specific structures. A comprehensive review of low-cost greenhouse technologies is taken in the article. Also, the economic analysis of some of the greenhouse production operations from different parts of the worlds is summarized along with their environmental impacts.

Materials and methods: Research methods are analysis of scientific articles, research of analytical data. In this article, low-cost greenhouse technologies used for crop production are reviewed.

Results: Optimal strategies must be sustainable. This means that it should be unprofitable for each player to abandon their own strategy in this game

Conclusion: It was found that the best solution would be growing in the field of greenhouse farming of India, mainly tomatoes. Also, as in the problem considered, as the two players - may be a state and subjects of hothouse.

Keywords: Greenhouse technology, Game theory, Greenhouse economy, Optimal strategy, Government agencies, processing enterprises,

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1. INTRODUCTION

The greenhouse technology can be a key for sustainable crop production and to achieve food security in the regions facing the problems of food scarcity. It gives assured crop production and also increases the productivity. But, the high initial cost is one of the biggest concern in the adoption of the technology by the farmers. Over the period, many scientists and engineers helped to reduce the cost of the technology. In most of the cases, it is done by using alternate construction materials or by using innovative environmental control technology.

The application of game theory is considered an important aspect in the implementation of the tasks set at the state level.

India is considered one of the countries that have recently been trying to reach a significant stage of development, which has a fruitful effect on agriculture and greenhouse economy, their general improvement. Game theory has recently increased significantly in its role in various fields of science and areas of the country's life. It is applicable today in the economy of any country for the adoption of general economic tasks, the study of strategic problems, systems for stimulating the development of industries

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the development of organizational structures. In the form of examples of the use of the game theory toolkit today in the field of strategic government decisions in the greenhouse industry, we can name the following decisions firstly, entry into new sales markets for various products of the greenhouse industry Dyudyuk M V, Burda A G [6].

Secondly, implementation of a principled pricing policy within the country, as well as abroad and the formation of joint ventures, their cooperation within the greenhouse economy.

In general, the provisions of game theory should be applied to isolated types of decisions, when other actors in the form of players can influence their adoption. These players can be competitors of the greenhouse industry in the person of processing enterprises, leading customers, government agencies, etc.

2. MATERIALS AND METHODS

The main materials are data on the greenhouse industry in India, a strategy for the development of the industry and increasing its performance. Research methods are: analysis of scientific articles, research of analytical data. In this article, low-cost greenhouse technologies used for crop production are reviewed. The economic analysis of some of the greenhouse production operations from different parts of the world are summarized as well as the structures are reviewed for their environmental impacts. The major objective was to study low-cost greenhouse options along with their economic benefits and environmental impacts.

Low budget greenhouses

The capital cost of a greenhouse structure is mainly affected by frame material and environmental control system used while covering material affect the cost of a greenhouse to less extent as in many cases it is fixed (i.e. polyethylene), but covering material required will change a bit depending upon the design dimensions Bhatnagar, [27]. Therefore, one of the approaches to have cheap greenhouses is to use the locally available cheap material for greenhouse frames, strong enough to resist local wind forces. At the same time, such frame material(s) should also possess good corrosion or weather resistance to atmospheric and soil moisture and against creatures like rodents, termites, etc.

The glass greenhouses are good at retaining temperature, but glass installation difficulty and overall higher initial cost are the limiting factors in using glass houses for profitable commercial production. A playhouse (greenhouse with polyethylene as a covering material) is a good option to glass greenhouse. Reddy [28] reviewed the different low cost playhouse options for Indian conditions.

3. REVIEW OF LITERATURE

Game theory can help in building effective strategies in management Durmanov *et al.* [20], applied marketing, management accounting, making it possible to choose the best options, taking into account the ideas about many other participants, their resource capabilities, as well as its potential, in addition to probable actions, taking into account the existing risks Varaksa and Fedorenko [2]. A strategy is a set of rules that characterize the choice of his action in any personal process in connection with the formed situation. As a rule, in the course of the game, for any personal move, the participant in the game makes a choice in connection with a certain situation Volkov and Yezhova [3]. It is game theory that is presented in the form of a section in which possible models for making appropriate decisions in conflict situations are studied Ganicheva

and Ganichev [4]. Game theory, assesses the relationship between agricultural actors in India, who adhere to mismatched motives. Formation of an effective concept of economic relations in the field of agriculture, which is partly based on market mechanisms aimed at ensuring food security of the state, pricing in agriculture, as well as the liberalization of resource allocation, and the introduction of effective land use mechanisms. At the moment when new technologies begin to come to the greenhouse industry of India Durmanov *et al.* [21] the whole world is "in full swing" moving from open field farming "under the roof". Despite the fact that there are countries with the most favorable climates for agriculture, the area of protected ground is ten times larger than in the Republic of Uzbekistan. A single global trend in the formation of the greenhouse industry is a dynamic growth in production volumes Makarevich and Uskova [13]. This became possible due to the fact that all countries began to switch to active technologies and methods of growing plants in greenhouses, the use of the latest designs, materials, as well as energy-saving technologies Matyushina [14]. In addition, in the context of global urbanization, an increase in urban conglomerates, there is a growing shortage of land suitable for agriculture Nurimbetov *et al.* [23] in such circumstances, a decrease in the production of fruits and vegetables in the open field is compensated for by an increase in the indicator for growing in greenhouses. The direction of the country's transition to a balanced and healthy diet leads to an increase in the use of environmentally friendly greenhouse products Gurova and Konev [5]. To improve the management system and introduce effective elements of state support in the agricultural sector and the greenhouse industry, as well as to significantly expand the production of high-quality Durmanov *et al.* [18], export-oriented and competitive products based on modern technologies and, including the features of game theory, are traced:

1. It is worth fully agreeing with the proposals of the Ministry of Agriculture, the Ministry of Finance of the India, the Ministry of Economy and Industry, on the formation of: - companies for the development of horticulture, as well as greenhouse facilities under the Ministry of Agriculture of the India (hereinafter referred to as the Agency) with a maximum number of administrative personnel including 29 units; - Departments of horticulture and greenhouse facilities in the structures of the Ministry of Agriculture of the India, as well as agricultural departments of the regions with a maximum number of administrative personnel in the number of 58 units; - areas of horticulture and greenhouse farming in the structures of agricultural departments of districts with a maximum number of management personnel in the amount of 185 units.

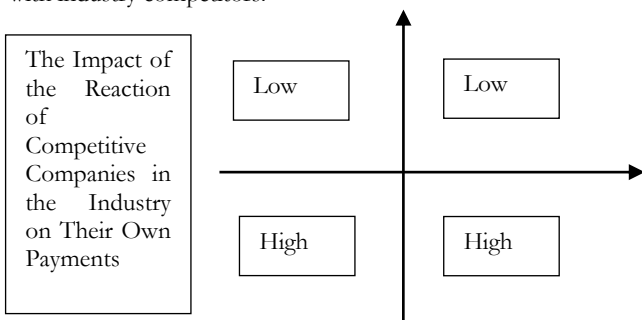
2. The main tasks of the Agency: Creation and implementation of comprehensive targeted programs aimed at ensuring the stable development of horticulture and greenhouse facilities taking all necessary measures to increase the areas of intensive gardens and greenhouses using modern resource-saving technologies, as well as rain and drip irrigation, in addition to a significant expansion of the entire range of fruit products, taking into account the analysis of market conditions, organization, taking into account the soil and climatic conditions of the regions, of the wide use of scientific achievements, modern scientific developments, as well as active agricultural technologies in horticulture and greenhouse farming; - assistance to a horticultural company and greenhouses in the implementation of international certification standards Durmanov *et al.* [24]. Implementation of measures for the formation of a system and organization of a cluster form, which contains the entire chain from production,

then procurement, sorting, calibration, packaging and ending with the sale of fruit products indication of assistance in attracting investments, this also applies to direct ones from abroad, for the production of competitive products, the organization of their sales, increasing the export potential by carrying out in-depth marketing research of market conditions development of appropriate recommendations for the placement and cultivation of more popular varieties of fruit products in foreign markets; - joint work with Russian and foreign educational institutions, research institutes, specialized foreign companies and manufacturers on the problems of training, professional development of specialists, development and implementation of innovations in the field of horticulture and greenhouse economy.

The main directions of development of the greenhouse economy in the India, according to the theory of games (consideration of positive results not only for the field of greenhouse economy, but also for consumers). The formation of modern greenhouse complexes using alternative energy sources, energy saving and energy efficient technologies location of greenhouse complexes, taking into account the characteristics of the region, its location, soil and climatic conditions, the level of provision of territories with energy resources, logistics and adjacent infrastructure, all types of crops grown and many other factors that affect the efficiency of the greenhouse economy. Introduction of a cluster form for the production of fruit and vegetable products, this concerns the conditions of public-private cooperation, which includes the entire chain, starting from production, then procurement, sorting, grading, packaging and further directions for export of fruit and vegetable products. Implementation of projects in the field of the agro-industrial complex and food security in 2020 is planned to attract about \$ 500 million through the credit lines of the International Fund for Agricultural Development, the World Bank and the Asian Development Bank, as well as other international financial institutions and foreign state financial companies Valiev[1].

4. RESULTS:

Today, state bodies of the India are actively using the game theory toolkit in order to find "dependencies" in the direction of making Hilormeet.a[16] various kinds of payments in the greenhouse industry. The figure shows all kinds of situations with industry competitors.



The 1st and 2nd quadrants define a situation in which the reaction of competitive greenhouse companies cannot have a significant impact on the payments of a stand-alone firm Khaustovaet.a[22]. This happens when competitors have no motivation (1st quadrant), or the ability (2nd quadrant) to strike back. Thus, the importance of the implementation of a detailed analysis of the strategy of motivated actions of competitors is lacking Umarovet.a[17]. The investigated conclusion is also formed relative to the 3rd quadrant. In this case, the reaction of

competitors can pretty much affect the company, but its forces cannot significantly affect the payments of the competing company, the reaction should not be feared. Only the situation that is reflected in the 4th quadrant can require the application of game theory Ziborov and Kosyrev [7]. But here only the most necessary, insufficient conditions are reflected that justify the use of game theory tools for making decisions regarding the situation of struggle with competitors Kashapova and Sagadeeva [8]. Situations often arise in which one state strategy dominates others, regardless of what kind of actions the competitor will take Lazareva [9]. The greenhouse economy is reflected in one of the important sectors of the economy of the India. The state of this industry is influenced by many factors, it is important to take them into account when manufacturing products. The volume and quality of production of greenhouse products depends, in particular, on the basic conditions of growth. At the same time, with the expansion and development of the industry, it is important to identify the most profitable crops for sowing using conditions. Consider the solution to this problem using game theory Linnik [10]. In this case, the mathematical model of the given theory Lobastova and Sagadeeva [11]. To get the maximum benefit, it is important to choose one of the presented options for growing greenhouse crops:

- A 1 - Salads and greens
- A 2 - Tomatoes
- A 3 - Cucumbers
- A 4 - Pepper

At the same time, the implementation of the plans of companies for the production of greenhouse products depends on different conditions:

- B 1 - Substantial amount of sunlight
- B 2 - Moderate amount of sunlight
- B 3 - Excess sunlight
- B 4 - The need for constant artificial lighting

In the table, we write down the possible options and conditions for making a profit when taking into account the costs of increasing the level of collection of products, we will perform an analysis based on the Laplace criterion. The basis of the criterion is the assumption that any option will be equally probable, because nothing is known about the state of nature and options for the future development of events.

Table 1.Payment matrix of profit per cent.

A/B	B1	B2	B3	B4
A1	-5	40	45	45
A2	40	30	40	10
A3	45	15	40	10
A4	-25	20	5	10

Here you can calculate the utility function of the selected alternatives:

$$F_i = \frac{1}{4} * \sum_{i=1}^4 B_i = 30, \text{ where } i = 1, 2, 3, 4$$

$$F_1 = 30$$

Similarly $F_2 = 31.25, F_3 = 16.25, F_4 = 31.25.$

It turns out that the best option - 31.25 - growing tomatoes in greenhouse conditions. In this case, 2 players are observed - conditionally, 1 player - the subject of the greenhouse economy, 2 players - weather conditions (sunny weather). Player 1 will win only if player 2 provides the appropriate conditions; otherwise, player 1 will need to form such conditions at his own expense. The game is a mathematical model of a conflict situation. The parties to the conflict are called players, and the result of the

conflict is called a win. Here the players can be, for example, the state and the subjects of the greenhouse economy. The stages of the game are the periods during which the players take their turns (in this case, the seasonal growing time for greenhouse crops). Selected moves at each stage at the end determine the win or loss (payments) of each of the players. They are calculated in money or material values. The player's strategy is defined as a set of rules that reflect the choice of his action depending on the current situation at each personal move. In order to find a solution to the game, each player must choose the strategy that will satisfy the optimality condition. Namely, one player should have the maximum payoff if the other adheres to his own strategy Lubenets [12]. In addition, the second player should have a minimal loss when the first player sticks to his strategy. These strategies are called optimal. Optimal strategies must be sustainable. This means that it should be unprofitable for each player to abandon their own strategy in this game.

Game theory aims to determine the optimal strategy that will satisfy all players Shaulska *et.al* [25]. Many sciences (including economics) received their development precisely thanks to mathematical methods. Game theory is constantly evolving and modifying, thereby remaining relevant both in economics and in other sciences. The application of this theory can have a positive impact on the economy of the India Pavlova and Lovyannikova [15].

5. DISCUSSION

Thus, it can be noted that game theory has an essential role in the assumption, for example, about which greenhouse crops should be grown in the India. For the country's economy, this theory is of great importance, because it can increase the potential of the entire greenhouse industry, in general, increase its efficiency. In the problem we have considered, it is clear that each solution has various obstacles and opportunities for the development of events. Players must provide appropriate conditions to achieve the stated goal of the game.

6. CONCLUSION

We examined the main aspects of the application of game theory in the greenhouse economy of India, identified the basic dynamic characteristics of the country's greenhouse economy. It was found that the best solution would be growing in the field of greenhouse farming of India, mainly tomatoes. Also, as in the problem considered, as the two players - may be a state and subjects of hothouse. With the help of this theory, the country can maintain its food security, which consists in the appropriate provision of citizens with greenhouse crops, reimbursement of the costs of planting certain types of crops. Acknowledgment We express our gratitude and deep gratitude to the scientific staff of the Ministry for Development of Information Technologies and Communications of India, the scientific staff of the State Committee of India on statistics for the information, in addition, we especially thank the scientific department of the Irrigation and Agricultural Mechanization Engineers for valuable advice and comments on the article

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Linnik P L 2020 Game theory in economics Fundamental scientific research 2 92-96
- Lazareva U A Game Theory and its Application in Economics Synergy of Sciences 23 486-495
- Kashapova M M, Sagadeeva E F 2018 Game Theory in Agriculture Youth, Education, Economics. Collection of scientific articles 211-213
- Dyudyuk M V, Burda A G 2020 Game theory in solving economic problems Digitalization of the economy: directions, methods, tools. The collection of materials of the All-Russian student scientific-practical conference 352-355
- Ganicheva A V, Ganichev A V 2019 Models of game theory in economics and business Epoch of science 20 587-590
- Gurova T I, Konev I L 2019 Some aspects of the application of game theory in economics Bulletin of the RMAE 1 38-43
- Valiev R N 2018 The use of game theory in economics Youth, education, economics 5 126-128
- Varaksa A M, Fedorenko M S 2018 Features of the use of game theory in the economic sphere Actual problems of the development of economic entities 4 57-60
- Volkov V S, Yezhova V D 2019 Game theory Innovative technologies in science and education 2 155-158
- Ziborov V I, Kosyrev A A 2018 The solution of economic problems by means of game theory Youth Scientific Bulletin 5 251-256
- Lobastova D D, Sagadeeva E F 2018 Game Theory in Economics Youth, Education Economics Collection of scientific articles 237-239
- Lubenets Yu V 2018 Game Theory Mathematical Economics 1 80
- Makarevich D E, Uskova A A 2020. Application of game theory in economics Collection of
- Matyushina E D 2018 Game theory: definition and types Modern Economics: current issues, achievements and innovations. Collection of articles of the international scientific and practical conference 21-23
- Pavlova E V, Lovyannikova V V 2018 Application of game theory in economics Bulletin of modern studies 11 280-281
- Hilorme T, Tkach K, Dorenskiy O, Katerna O & Durmanov A 2019 Decision making model of introducing energy-saving technologies based on the analytic hierarchy process Journal of Management Information and Decision Sciences 22(4) 489-494
- Umarov S R, Durmanov A S, Kilicheva F B, Murodov S M and Sattorov O B 2019 Greenhouse Vegetable Market Development Based on the Supply Chain Strategy in the Republic of Uzbekistan International Journal of Supply Chain Management (IJSCM) 8(5) 864-874
- Durmanov A, Li M, Khafizov O, Maksumkhanova A, Kilicheva F & Jahongir R 2019 Simulation modeling, analysis and performance assessment In International Conference on Information Science and Communications Technologies: Applications, Trends and Opportunities, ICISCT Institute of Electrical and Electronics Engineers Inc. <https://doi.org/10.1109/ICISCT47635.2019.9011977>
- Durmanov A, Kalinin N, Drobyazko S, Yanishevskaya K, Shapovalova I 2019 Strategic support of innovative activity of modern enterprises 34th IBIMA Conference: 13-14 November 2019 (Spain)
- Durmanov A, Kalinin N, Stoyka A, Yanishevskaya K & Shapovalova I 2020 Features of application of innovative development strategies in international enterprise International Journal of Entrepreneurship Issues 1(24) 1-9

21. Durmanov A, Bayjanov S, Khodjimukhamedova S, Nurimbetov T, Eshev A, Shanasirova N. 2020 Issues of accounting for organizational and economic mechanisms in greenhouse activities Journal of Advanced Research in Dynamical and Control Systems 12 07-Special Issue 114-126 doi: 10.5373/jardcs/v12sp7/20202089
22. Khaustova Y, Durmanov A, Dubinina M, Yurchenko O, Cherkesova E 2020 Quality of Strategic Business Management in the Aspect of Growing the Role of Intellectual Capital Academy of Strategic Management Journal 19 (5) 1-7
23. Nurimbetov T, Umarov S, Khafizova Z, Bayjanov S, Nazarbaev O, Mirkurbanova R, Durmanov A 2021 Optimization of the main parameters of the support-lump-breaking coil EasternEuropean Journal of Enterprise Technologies 2 (1 (110)) 27-36 <https://doi.org/10.15587/17294061.2021.229184>
24. Durmanov A, Umarov S, Rakhimova K, Khodjimukhamedova S, Akhmedov A & Mirzayev S 2021 Development of the Organizational and Economic Mechanisms of Greenhouse Industry in the Republic of Uzbekistan Journal of Environmental Management and Tourism 12(2) 331-340 doi:10.14505//jemt.v12.2(50).03
25. Shaulska L, Kovalenko S, Allayarov S, Sydorenko O & Sukhanova A 2021 Strategic enterprise competitiveness management under global challenges Academy of Strategic Management Journal 20(4) 1-7
26. Shamborovskyi G, Shelukhin M, Allayarov S, Khaustova Y & Breus S 2020 Efficiency of functioning and development of exhibition activity in international entrepreneurship Academy of Entrepreneurship Journal 26(Special Issue 4) 1-7
27. Bhatnagar, P. R. (2014). Strategies for protected cultivation for small and marginal farmers in India. In Agriculture: Towards a new paradigm of sustainability. New Delhi, India: Excellent publishing house.
28. Reddy P. P. 2006. Sustainable crop production under protected cultivation. New York, NY: Springer Science + Business Media.