AGRICULTURAL IRRIGATION MATHEMATICAL MODELING USING GAME THEORY FOR NEXT GENERATION FARMING

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Abstract

Scientific transform is a next source of skepticism. Transformation in production approaches, improvement associated with new products or advices, and benefits of various other innovative developments cannot be precisely forecasted. These kinds of advancements may possibly have an impact on the desirability of substitute ideas which farmers may make. Because of the time lag among expenditure and benefit, the price-taking characteristics of farming, stochastic conditions factors along with other elements, the uncertainty confronted by decision makers in farming is higher than and various from that facing supervisors of most some other industries of economic system. Within this paper, game theory model is used on the issue of decision making within uncertainness in farming irrigation system. In this study, applications are designed to the decision of sort of irrigation system and through this the best possible serving of fertilizer too. Farmers must monitor, consider suggestions, come to a decision, and carry out their particular plan.

1. INTRODUCTION

Game Theory has become crucial in its share towards the evaluation of significant elements associated with water sources. In numerous circumstances water is recognized as a typical share source, launching the threshold for organizing actions of the users [1]. Next as well as typically associated, water assets are governed by numerous kinds of externalities. Farming is the greatest consumer of water. Due to the fact water requirement for irrigational reasons is anticipated to increase and also presented the belief that freshwater just isn't an unrestricted source, issues concerning the application of water and allocation concerns are getting to be much more intensive [2]. In a speedily transforming globe, with increasing inhabitants, fast-rising world foodstuff requirement, speedy urbanization as well as industrialization, enlargement associated with farming activities and scientific advancement, raise of polluting of the environment and deforestation and exhaustion of water assets and water quality degeneration, you will discover escalating messages concerning water crisis. Having access to trustworthy and protected water turns into among the important difficulties of the 21st century [3].

The present paper investigates issues which occur around irrigation water. The subsequent strategy is within game theoretical point of view. Game theory provides observations into drip irrigation water flow distribution, emitter pressure management and geometrical layout for optimum water (or soil fertilizers mixed with water) droplet discharge. Proposed research help farmers to produce a right decision which automatically handles the water/fertilizer dosage based on mathematical decision modeling using game theory approach.

2. LITERATURE REVIEW

Issues in irrigation are as older as the irrigation farming alone. In fact, revealing a system of water, for farming reasons, dates through the time period of very first land-holding farmers [4-6]. Game theory offers statistical principles and methods for modeling as well as inspecting interactive predicaments. The core idea for non-cooperative games is the Nash equilibrium which often prescribes a method for each and every player which is ideal in the event the various other players maintain their particular recommended approaches preset. Every single specific game has a balance when players are permitted to mix (randomize) their own activities [7-10].

The conventional method of discovering equilibria of a considerable game is to transform it to strategic type, and also to employ the related algorithms. Even so, the amount of real approaches increases commonly exponentially in the length of the action tree. As opposed, the series type is a proper explanation which includes similar dimensions as the game tree, and that is employed in payoff matrix formation. Thus, to predict or manage any activity it is important to know particular system's payoff matrix [11-14].

Evolutionary game theory is a effective statistical platform aimed at comprehending the discerning challenges that have an effect on the development of the approaches of agents involved in communications with possible issues. Even though a mathematical treatment of the expenses and advantages of selections can forecast the suitable approach with uncomplicated configurations, more practical configurations like specific parameters, mutations rates, appropriate decisions, conversation among providers, and spatial relationships, need of agent-based approaches in which every agent is modeled being an specific entity, provides a unique genes that figure out its decisions, and in which the evolutionary end result can merely be determined by changing the population of agents frontward over time [15-18].

Many fresh or enhanced approaches are recommended to reduce these kinds of counter-intuitive outcomes according to points of views, like lessening the data loss or change. Influenced by evolutionary game theory Dempster-Shafer facts hypothesis is a key method for multi-source data combination since it is effective in coping with unstable data. This hypothesis offers a Dempster's rule of blend to synthesize numerous evidences through different data sources. Even so, in some instances, counter-intuitive outcomes could be acquired according to that combination rule [19-20].

A hybrid soft determination design has been formulated within this existing research to take decision on farming harvest which can be discriminating in a offered experimental area by bringing in several mathematical techniques. The recommended model consists of 3 areas, such as weight calculations, classification and conjecture [21].

Drip irrigation system creates the effective usage of water and fertilizer. Water is gradually dripped to the root base of the crops by means of small pipes and valves. Water is given straight away to the beds base of the crops that is an ideal approach to water crops. There must be appropriate drainage within the grounds to prevent any kind of water logging which often in the event may possibly have an effect on the productiveness. Presently there currently exist automated drip irrigation techniques that water crops dependant on soil dampness, pH value of land, temperatures and light. These kinds of variables are expected in massive farming areas where productiveness of the crop concerns. In modest regions like workplace areas, houses, residence back yards etc. where watering plants at typical period of time is important. Author claimed that suggested irrigation program will likely be very productive [22].

3. RESEARCH METHODOLOGY

The proposed game theory mathematical model is designed to increase utilization of droplets and efficiency of irrigation system. There are various game theory models are available with existing research but, proposed design is developed using Wald's maximin criterion.

3.1 Wald's maximin criterion

In decision theory and game theory, Wald's maximin model is a non-probabilistic decision making design in accordance with which selections are positioned by their particular worst-case results the suitable decision is one particular with the minimum worst result. It is amongst the most critical designs in effective decision making generally and powerful optimization particularly.

Additionally it is identified by a number of some other titles, like Wald's maximin principle, Wald's maximin theory, Wald's maximin paradigm, and also Wald's maximin qualifying criterion. Frequently 'minimax' is employed rather than 'maximin'. The following mathematical model is the base for the proposed method:

…………………………………………………..(1)

Where denotes the decision space;) denotes the set of states associated with decision and denotes the payoff (outcome) associated with decision and state

This model represents a 2-person game in which the max player plays first. In response, the second player selects the worst state in , namely a state in that minimizes the payoff over in In many applications the second player represents uncertainty. However, there are maximin models that are completely deterministic.

The above model is the classic format of Wald's maximin model. There is an equivalent mathematical programming (MP) format:

…………………………………………(2)

Where denotes the real line.

As in game theory, the worst payoff associated with decision , namely

…………………………………………………………(3)

is called the security level of decision .

The minimax version of the model is obtained by exchanging the positions of the max and min operations in the classic format:

…………………………………………………………(4)

The equivalent MP format is as follows:

…………………………………………(5)

The payoff matrix calculation is represented in table-1 in next section.

4. RESULT AND ANALYSIS

In math concepts, a saddle point or minimax point is a place on the surface of the chart of a function the spot that the slopes (derivatives) in orthogonal directions are zero (a critical point), yet that is not a neighborhood extremum of the function. An illustration of this a saddle point demonstrated on the right is when there is a critical level with a comparative minimum along one axial path (between peaks) and at a relative maximum across the traversing axis.

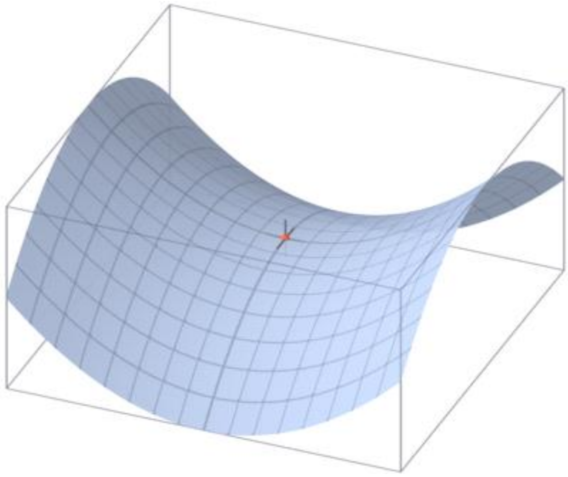

Figure 1: Representation of saddle point

The optimal solution is the (red) saddle point (x,y)=(0,0).

In static games of total, ideal data, the normal-form manifestation of a game is a standard of players' approach areas and payoff characteristics. A technique area for a player will be the group of all approaches accessible to that player, although a method is a comprehensive approach for each and every phase of the game, irrespective of whether that phase actually comes up in play. A payoff functionality for a player is a mapping from the cross-product of players' approach areas to that player's set of payoffs which commonly the group of real numbers, where the number signifies a cardinal or ordinal utility often cardinal in the normal-form manifestation of a player, i. e. the payoff functionality of a player requires as its input a method profile that is the standards of approaches for each and every player and brings a representation of payoff as its result.

As a case study, we considered Irrigationglobal's layout as demonstrated in figure x. Specialist designers will put together and design an irrigation technique which is tailored pertaining to the exact specifications of one's set up. This kind of style and design seek to discover the balance among primary expenses along with functional expenses although optimizing the usage of the water. The best option considers the mix of vegetation, form of soil, topography, obtainable water, climate conditions, typical approaches and many more. Considering the comprehensive irrigation layout with game theory model can be a very effective solution for such irrigation systems.

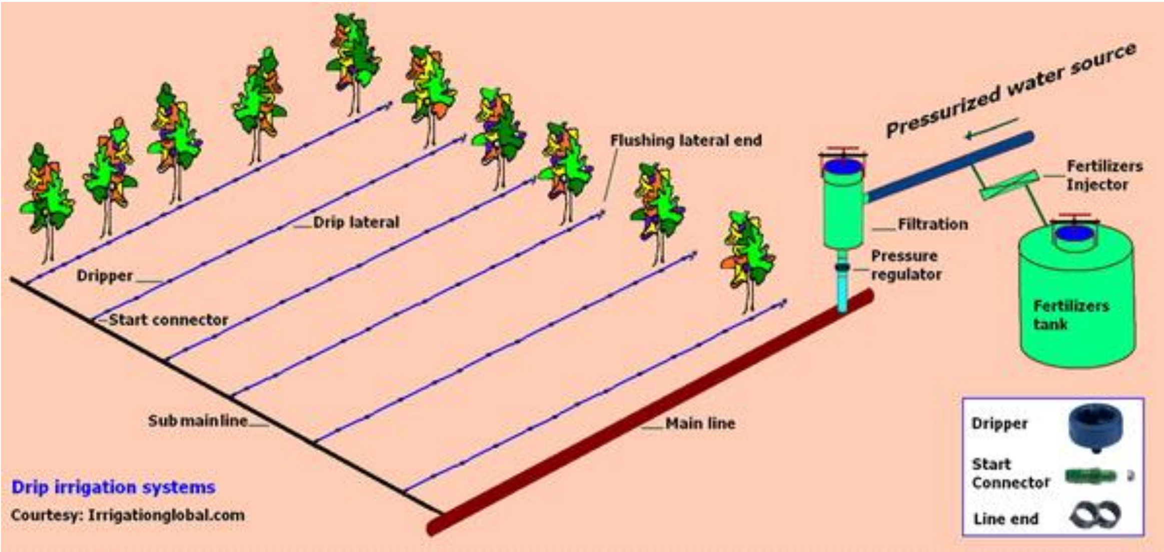

Figure 2: Drip irrigation layout (Source: Irrigation Global)

Consider, the drip irrigation pipe may deliver water drops from all holes, or it may not able to deliver. We must check "payoff matrix", viewing this as a Maximin game as shown below in table-1.

Table 1: Payoff Matrix for irrigation system

	Droplet delivery	Droplet insufficiency	Worst Payoff	Best Worst Payoff
Optimum Drip pressure	8	-8	-8	
Low Drip pressure	2	-2	-2	-2

The worst case, if no droplet discharge due to low drip pressure, is definitely worse than the (best) worst case when optimum drip pressure but droplet insufficiency. Therefore, drip pressure must be monitored with good water supply pressure.

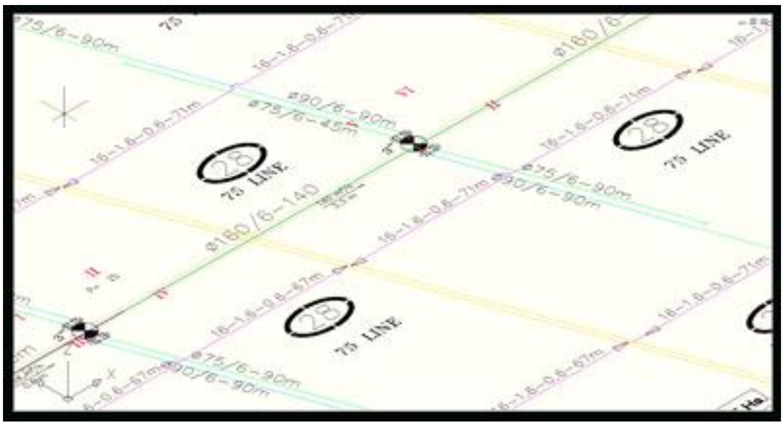

Figure 3: Irrigation system blueprint

The particular irrigation layout collection analyzes the data, specifies the actual harvest water needs, can perform calculations to be able to establish the parts and framework of the irrigation system, the water pressure which often might be used all the way through the irrigation system, and also the irrigation scheduling. Additionally, the proposed mathematical model produces a thorough approach of processes that consider each of the pipeline geometry and droplet discharge schedule. In such layout computational method system can makes use of tools like Autodesk, CAD software and proposed game theory model discussed in section 3 previously.

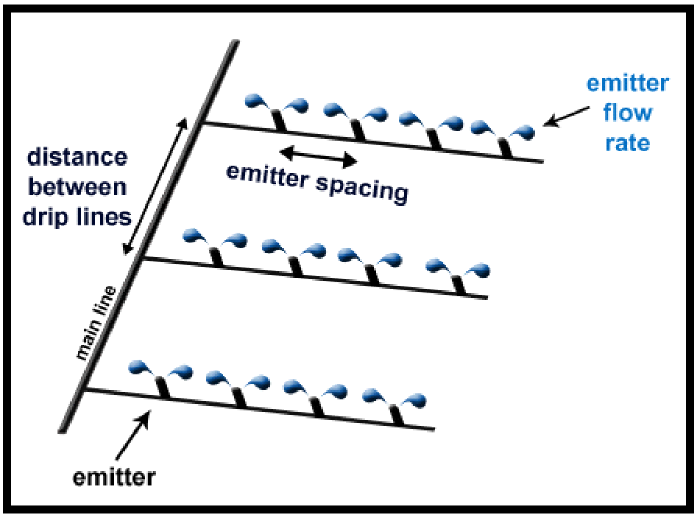

Figure 4: Emitter droplet flow rate and distance ratio

The proposed research may be the extension for such system with mathematical modeling to resolve farmer's issue of insufficient droplet count which in turn contributes too wastage of water. As shown in figure 4 above, emitter droplet flow rate need to be known to calculate payoff matrix. In above figure 4 the drip geometry is traditional i.e. parallel system. This can be in a diagonal fashion in order to cover more emitters which can make droplet utilization to maintain moisture beneath plat or surrounding to root spread area. The T-junction of emitter flow is shown in figure 5 below.

Rate of a drip line irrigation system can be hence calculated using [23]:

Where

=Precipitation rate (in/hr)

=Drip Emitter flow rate (gal/hr)

=Irrigation Efficiency (decimal) (use 0.95 for Drip)

=Distance between drip rows (line)(in)

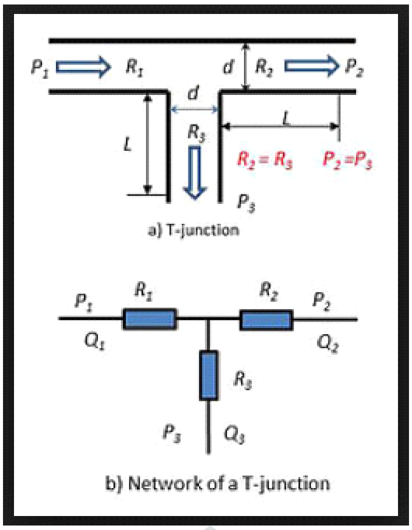

Figure 5: Flow Distribution

Combining Wald's maximin criterion with T-junction water flow distribution will provide efficient payoff matrix. The pressure gauge can be used to test the flow rate of droplet. As shown in table-1, payoff matrix can play vital role for irrigation system.

5. CONCLUSION

This paper presented the game theory model and design elements of emitter pressure management for drip irrigation system with a T-junction flow analysis using payoff matrix. A reduced Best Worst Payoff, or activation pressure, results in a seamless drip irrigation system. The mathematical model presented in this paper can be further used as an extension for designing tool. The proposed game theory model is used to resolve the issue of decision making in farming irrigation system by calculating Best Worst Payoff. Proposed study demonstrated the model for automatic decision for water flow distribution and emitter pressure management. This can be used for serving minimal soil fertilizer too. This solution can be further developed to assist next generation farming.

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