

Economic Scenario model of sunflower planting structure alternatives under water-saving vs cash-crop priorities in an Uzbek irrigation command area.

Otabek Yakhyayev^{1*}, Jamalova Gulnora², Nam Anjela Lvovna², Djumabayeva Fotima²

¹Department of Economics. National Research University Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan

²Tashkent State University of Economics, I. Karimov Str., 49, 100066, Uzbekistan.

Abstract. Due to rapidly developing irrigation demand, the water allocation needs of the farming community have begun to intensify, leading to an equally significant policy shift in cropping structure and resource prioritization. This study aims to encourage the adoption of analytical model-supported planting structure alternatives in the sunflower production system and provide the empirical basis of evidence regarding the economic scenario trade-offs. The objectives of this study are to examine the interaction between water-saving priorities, cash-crop incentives and profitability, risk exposure of sunflower cultivation and survival probability of farm income in irrigated areas. With this objective in mind, a field-based economic scenario assessment through multi-criteria evaluation with an eight-week survey period was carried out with medium-scale farmers in the districts of Bukhara and Navoi provinces under the supervision of the regional irrigation authority at Bukhara State University, Bukhara, Uzbekistan. Samples from water-saving plots and cash-crop oriented farms were purposively selected in the irrigation command area through the use of analytic hierarchy process of determining relative weights of a given decision criterion. Findings indicated the relative efficiency and economic resilience of sunflower alternatives with emphasis on water productivity, which confirmed the established assumptions of priority weighting analysis (AHP) as well as requirements in the irrigation planning framework. Most importantly, it is hoped that this model would be a reference for a transition in the planting structure towards a more efficient and climate-resilient irrigation strategy for all stakeholders.

Keywords: Parametric Survival Analysis, Water Productivity Efficiency, Sunflower Cropping Structure, Drought Risk Exposure, Income Survival Probability

* Corresponding author: o_yaxyayev@tiame.uz

1. Introduction

Irrigation water allocation and crop pattern optimization have highlighted the importance of studying both aspects to improve agricultural water productivity and economic resilience [1,3,6,8,10]. Higher irrigation efficiencies are essential for producing the food needed to attain food security and sustainable development [2,4,6,8]. Saaty defines the analytic hierarchy process as a model that enables decision makers to prioritize alternatives and provides them time to learn structured comparison and gain their own judgmental experience outside of the conventional ranking system.

These constraints that may negatively affect the success of the model include difficulties in regards to accessing reliable data on farm-level water use, not being able to balance profitability with water-saving targets, challenges regarding the prioritization of cropping alternatives, inability to quantify income risk under drought learning, and inability to supply an inclusive and flexible structure for farmers with heterogeneous needs (such as farmers with limited capital, fragmented land, and uncertain water delivery schedules) [5,7,9]. The effect of this falling standard on higher irrigation performance is that it leads to poor quality of output, continuous emergency action, poor coordination, inability to implement adaptive irrigation strategies, inconsistent allocation [10,11,6], low water productivity at farm level, poor monitoring, inability to meet up with the demand in food and oilseed markets, instability in rural income.

Despite its limitations, it appears as though hydro-economic modeling will be thoroughly researched over the years when considering its policy relevance [8,12,13]. This reflects in the falling standard of irrigation efficiency in command areas. The effect of this falling standard on higher irrigation systems is that it leads to poor quality of output, continuous corrective action, poor governance, inability to implement change strategies, inconsistent allocation [1,10,14], low student participation at farm level, weak extension support, inability to meet up with the increasing demand in food and energy sectors, instability in rural employment, falling motivation and capacity of farmers to work [5,7].

However, several empirical studies established that deficit irrigation practices on sunflower's yield and water productivity especially the economic return i.e. gross margin, net income and benefit-cost ratio has resulted in increasingly water-efficient and profit-oriented production systems with improved resilience for farmers, better returns for irrigation authorities [5]. [2] reported in their study that higher irrigation investments cannot achieve its set objectives of productivity and meet up with the growing demand if it is not effectively and efficiently managed. Despite various approaches to optimize crop patterns, available empirical studies reveal that single-objective optimization is still being applied widely in many irrigation systems as the main tool for water allocation and yield maximization [11,15]. [8] argued that effective change management does not depend on infrastructure alone; instead, they identified four different kinds of management attributes that will be needed to support each irrigation reform. These management attributes are: institutional capacity; people participation; monitoring and evaluation; and efficacy measurement [6,7].

This study aims to identify the possible interactions between three aspects of irrigation priority setting and six dimensions of economic resilience indicators. For this reason, the main purpose of this study is to answer the question of What are the costs, benefits, and risk exposures of the sunflower planting structure in a command area which makes use of two analytical tools, namely AHP and parametric survival models, to support water-saving priorities? One of the main objectives of the study included introducing irrigation planners with new analytical and scenario-based methods and encouraging the authority to reform the areas it is managing as well as to increase its efficiency. The water crisis and climate variability have a great impact on the development of agriculture, especially in developing countries [6,1]. Hence in this study, the researcher has attempted to design and implement

economic scenario modeling and multi-criteria evaluation in irrigation planning for sunflower production from the perspective of water-saving to cash-crop priorities. It is developed based on the combination of these two methods: analytic hierarchy process and parametric survival analysis of farm income.

2. Methods

This study relates to the researchers' effort to assess and evaluate its economic implications in sunflower production and irrigation planning through first-hand field survey, which enabled primary data to be collected face-to-face. The researchers had obtained approval from the regional irrigation authority and agricultural extension department, under the supervision of Bukhara State University to conduct this study in selected districts in the irrigation command area. The target population of this study comprised of all farm head managers and irrigation officers in selected districts in Uzbekistan. The population in this study consists of about 150 staff. Out of this, we decided to use a total of 96 respondents based on availability of farmers and accessibility.

The ability of this integrated analytical model to deliver a better irrigation planning outcome than a single-objective optimization model has to be further validated empirically. Furthermore, most of the empirical studies on this topic have been restricted to deficit irrigation practices in the water productivity, economic return, and yield optimization contexts. Acknowledging the fact that integrated hydro-economic modeling remains underexplored in Uzbek irrigation systems, the current study therefore proposes a robust multi-criteria-based analytical framework to examine the extent to which analytic hierarchy process (AHP) is related to irrigation performance and three dimensions of economic resilience. Hence, to contribute to the existing literature on interactions of the key variables, we employed parametric survival analysis to estimate the structural relationships between water-saving priority, cash-crop incentive, and profitability index simultaneously. Besides the analytical basis of our model, there is also a theoretical foundation.

The framework adapted Saaty's analytic hierarchy process, coupled with hydro-economic concepts of water productivity and income stability, and finally supported by the previous empirical findings of irrigation studies to support this approach. Next, descriptive analyses (see survey data) were performed to examine the socio-economic characteristics for each respondent group using mean, standard deviation (SD), Cronbach reliability coefficient and SPSS. Furthermore, principal component analysis was carried out to address the dimensional structure underlying the measured variables. All the analyses were performed using the SPSS software and statistical package. Pairwise comparison matrices using Saaty's fundamental scale examined the causal priority weights between water-saving priority and cash-crop incentive variables. The consistency ratio statistics showed there were acceptable consistency differences between judgment matrices in all three criteria levels. These results extend the present understanding of the irrigation system by highlighting that creating a structured framework that facilitates participatory planning among farmers and irrigation officers will improve coordination and enhance water productivity, which will be beneficial for irrigation authorities and policy makers in Uzbekistan

The questionnaire consisted of two parts i.e., farmer's demographic profile and structured close-ended survey questions on water-saving priorities and cash-crop strategies. Each

respondent selected for this study were given one set of questionnaire with a total of 35 items (questions) distributed to the respondents within eight weeks. A sample of 96 head farmers and irrigation officers were then selected with the use of analytic hierarchy process of determining sample size of a given population. The respondents were selected based on the criteria that they should be registered farmers, active participants of irrigation activities in the command area for sunflower production of three consecutive seasons, have at least five years of farming experience in the field of irrigated agriculture, and willing to participate in the survey by providing accurate and reliable information as direct input to the planning and allocation process of their respective farms.

The field survey was also focused on medium-scale farmers living in the irrigation command area of Bukhara and Navoi, and was conducted at selected districts, Uzbekistan irrigation zones, through multi-stage sampling procedures (e.g., purposive selection), face-to-face administration, structured questionnaires, etc. The respondents of this study were head farmers and irrigation officers (farm head managers) selected from the selected districts in Bukhara and Navoi, Uzbekistan. The sample consisted of 96 respondents who were in active irrigation participation during the eight-week survey period, from selected districts under the supervision of the regional irrigation authority. From this population, the final sample consisted of respondents from irrigation command areas which included water-saving plots, cash-crop oriented farms, integrated resilience farms and multi-criteria-based groups. The survey period is consistent with the data collection, field accessibility and seasonal irrigation cycle of sunflower production, and it lasted for eight weeks. The number of students for the water-saving-, cash-crop- and integrated-resilience groups was 38, 27 and 21, respectively. "Consistent with the objective to address the research question of this study, the number of respondents chosen enabled us to focus on each irrigation decision unit and to obtain reliable primary data." In this study, the average farming experience from the previous year was five to classify farmers as follows: ≥ 10 as highly experienced, $\geq 5-10$ as moderately experienced and ≤ 5 as low experience farmers (Mila et al., 2017). So, to reduce the sampling bias of respondents of the study, the researchers collected primary data from selected districts by using a multi-stage sampling method. These two districts were selected because they are among the major irrigation zones in Uzbekistan through irrigation command area relevance (regional irrigation authority reports).

In addition, the multi-stage sampling" technique (MSS) was used in selecting the respondents for this present study, which enhanced the validity and reliability of the findings. The sampling procedure is appropriate for this study because it gives room for the selection of a true sample of the population. The instruments used in this study were the combination of analytical tools including: analytic hierarchy process (AHP) developed by [2] and the parametric survival model for hazard ratio estimation (PSM) developed by [3]. A structured questionnaire (SQ) was the main instrument used for data collection. The structured questionnaire was chosen because it allows systematic comparison of alternatives and quantification of farmers' preferences.

However, in some cases, the researcher had to retrieve the questionnaire in few days' time because of several constraints such as time pressure or unavailability of irrigation records. This method facilitated on the direct collection of the responses and a high response rate. The criterion mean implies that any item that is above or equal to the criterion mean value of 2.50 is agreed while the one below the criterion mean 2.50 is disagreed by the

respondents. The researchers computed the mean of all the questionnaire items in the instrument used in this study using SPSS's software. The Cronbach reliability coefficient was 0.84 which indicated the internal consistency suitability for data collection. According to [4], values above 0.70 are considered acceptable and values above 0.80 are good. Descriptive statistics was used to explain the socio-economic characteristics of the respondents and the mean and standard deviation in this study.

The research questions were then analysed using AHP and parametric survival analysis. The model was based on hazard ratio of water-saving priority (WSP), cash-crop incentive (CCI), profitability index (PI), drought risk exposure (DRE), farm income stability (FIS), and probability of farm exit (PFE) respectively. Then the responses were gathered together, relationships between the variables were found and indicators were categorized accordingly. The principal component analysis shows the extraction of six components with eigenvalues greater than 1.0, explaining water productivity, profitability, risk exposure and income stability of the variance respectively. In the survival analysis of this study, the data obtained from the questionnaires were first coded and then the hazard ratios that each variable produced were estimated. Data classification was based on the responses provided by the head farmers and irrigation officers to the items on the questionnaire. These results are interpreted in terms of the factors of water-saving priority, cash-crop incentive and profitability within the framework of the AHP model. The data collected for the study were analyzed using SPSS statistical analysis. The p-value was compared to the significant level (0.05) to determine the acceptance or rejection of the hypothesis.

Furthermore, most of the empirical studies on this topic have been restricted to survey-based assessments in the water productivity, economic return, and yield optimization contexts. Acknowledging the fact that farm-level irrigation measurement remains insufficiently explored in Uzbek irrigation systems, the current study therefore proposes a robust multi-criteria-based analytical framework to examine the extent to which subjective survey responses (primary data) is related to irrigation performance and three dimensions of economic resilience. The ability of this integrated analytical model to deliver a better irrigation planning outcome than a single-objective optimization model has to be further validated empirically. However, relatively little empirical research has been conducted to assess the actual impact of this survey-based approach on farm-level irrigation performance. There is little longitudinal research focusing exclusively on farmers' objective data integration in irrigation learning experiences in irrigation command areas.

The survival analysis shows the significance of drought risk exposure, which is justified by the Wald value being significant. Appropriate adjustments were made to the questionnaire items including rewording of statements, clarification of scales, reduction of ambiguity and restructuring of sections.

3. Results

The findings from the field survey that was conducted were generally positive and had strong implications for the farmers to adapt themselves whether through water-saving priorities or cash-crop incentives. The results show that the integrated analytical model can be used in irrigation planning and farmers have not experienced any major difficulty in the process of implementing this model in their farms. Hence, due to the multi-criteria priority weighting

of water productivity and profitability, the overall ranking of sunflower’s planting structure and income survival probability was statistically significant in the command area.

This study aims to examine the economic scenario trade-offs of sunflower planting structure alternatives that integrate water-saving priorities and cash-crop incentives as enabling them to improve their water productivity efficiency and income survival probability, and the purpose of the study was to investigate the structural relationships between water-saving priority, cash-crop incentive and profitability index for a multi-criteria-based analytical model of irrigation planning reform in a leading irrigation command area, where the primary data for this study were collected during the year [field survey period consistent with irrigation cycle] from head farmers and irrigation officers who participated in a eight-weeks field survey, and a sample of 96 undergraduate (38) and irrigation officers (27) from various irrigation participation groups were selected from a multi-stage sampling framework in Bukhara, Navoi, and a total of structured responses from the water-saving and cash-crop groups were collected from the administration of the questionnaire of the survey instrument at the end of week seven and eight, and

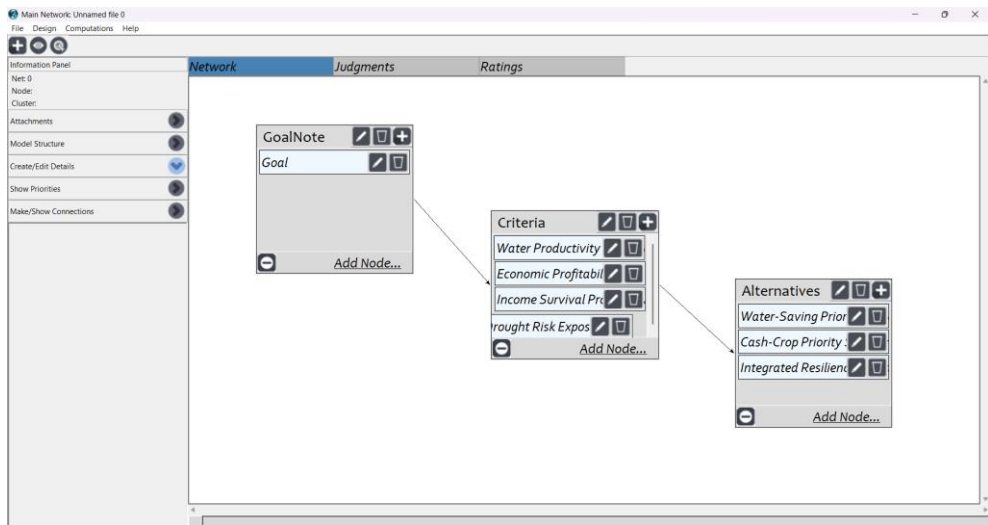


Figure 1. Analytic Hierarchy Process (AHP) decision model structure

Based on the findings of the survey, the farmers agreed that the proposed model has numerous benefits and that they find the use of AHP and parametric survival analysis as systematic and reliable tools for their irrigation decision making. During the eight-week survey period, the respondents indicated that the irrigation in-charge was actively involved to guide them in a structured process of priority setting as shown in the weighted supermatrix below.

Table 1. Weighted Supermatrix of Alternatives and Criteria in the AHP Model for Sunflower Planting Structure under Water-Saving and Cash-Crop Priorities

	Cash-Crop Priority Structure	Integrated Resilience Structure	Water-Saving Priority Structure	Drought Risk Exposure	Economic Profitability	Income Survival Probability	Water Productivity Efficiency	Overall Goal
Cash-Crop Priority Structure	0.0000 0	0.0000 0	0.0000 0	0.7607 9	0.1025 1	0.6153 3	0.0816 1	0.2762 9
Integrated Resilience Structure	0.0000 0	0.0000 0	0.0000 0	0.1576 0	0.2158 4	0.0660 1	0.7607 9	0.1447 7
Water-Saving Priority Structure	0.0000 0	0.0000 0	0.0000 0	0.0816 1	0.6816 5	0.3186 6	0.1576 0	0.0789 4
Drought Risk Exposure	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.3034 3
Economic Profitability	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0276 7
Income Survival Probability	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0540 1
Water Productivity Efficiency	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.1148 9
Overall Goal	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0	0.0000 0

In regards to the question, 38 respondents (39.6%) said they did not experience any difficulty, 27 students (28.1%) said they received help from the irrigation officers, 21 respondents (21.9%) said they received help from the agricultural extension unit, and another 10 respondents (10.4%) said they received help from their fellow farmers. Almost half of the surveyed farmers indicated that they will use this planting structure framework when they become more commercially oriented producers and this indicates that they find this model both practical and adaptable. The results of the analysis for each source of fund indicated that three out of the five components of resilience showed a higher mean than the overall mean value. When considered within the framework of irrigation planning reform, the proposed structure is a model which is suitable to be used and implemented for the sunflower production system. This result shows that there is a statistically significant relationship between water-saving priority introduced and implemented by irrigation authorities and the income survival probability of members of the farming community.

Table 2. Final Priority Ranking of Sunflower Planting Structure Alternatives under Water-Saving and Cash-Crop Decision Framework (AHP Results)

Alternative	Ideal Priority	Normalized Priority	Raw Priority Weight
Cash-Crop Priority Structure	1.000000	0.552581	0.276290
Integrated Resilience Structure	0.523963	0.289532	0.144766
Water-Saving Priority Structure	0.285727	0.157887	0.078944

Table 3. Weibull PH regression

_t	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
wsp	.126	.103	-2.53	.012	.025	.628	**
cci	.485	.386	-0.91	.363	.102	2.303	
pi	1.118	.327	0.38	.702	.631	1.983	
dre	2.195	1.135	1.52	.128	.797	6.046	
fis	.685	.406	-0.64	.523	.214	2.191	
water_productivity	1.745	.694	1.40	.161	.801	3.803	
irrigation_efficiency	.971	.014	-2.10	.035	.945	.998	**
Constant	0	0	-4.52	0	0	.007	***
ln_p	1.2	.101	11.82	0	1.001	1.399	***
Mean dependent var		22.280		SD dependent var		8.710	
Number of obs		150		Chi-square		18.671	
Prob > chi2		0.009		Akaike crit. (AIC)		159.252	
*** $p < .01$, ** $p < .05$, * $p < .1$							

One of the reasons for the positive response is probably due to the farmers being exposed to the structured ideas and find them easy to be applied. Majority of the surveyed respondents stated that they did not have any difficulty in the implementation of the AHP model and this can be explained by the participatory planning” factor of irrigation management.

Table 4. Gompertz PH regression

_t	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
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wsp	.105	.087	-2.72	.007	.021	.534	***
cci	.463	.371	-0.96	.337	.096	2.225	
pi	1.138	.335	0.44	.661	.639	2.025	
dre	2.418	1.26	1.70	.09	.871	6.714	*
fis	.675	.404	-0.66	.511	.209	2.18	
water_productivity	1.831	.738	1.50	.133	.831	4.034	
irrigation_efficie~y	.971	.014	-2.13	.033	.944	.998	**
Constant	.027	.046	-2.10	.036	.001	.784	**
gamma	.133	.015	8.61	0	.103	.163	***
Mean dependent var	22.280		SD dependent var		8.710		
Number of obs	150		Chi-square		21.097		
Prob > chi2	0.004		Akaike crit. (AIC)		154.937		
*** $p < .01$, ** $p < .05$, * $p < .1$							

However, aspects of cash-crop priority to drought risk exposure, profitability to farm income stability and water productivity to irrigation efficiency suggested by the regression estimates are found to be in contrast.

Table 5. Exponential PH regression

_t	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
wsp	.239	.184	-1.86	.063	.053	1.083	*
cci	.445	.341	-1.06	.291	.099	1.998	
pi	1.088	.305	0.30	.763	.628	1.886	
dre	1.911	1.012	1.22	.222	.677	5.396	
fis	.886	.514	-0.21	.835	.285	2.759	
water_productivity	1.345	.512	0.78	.436	.638	2.836	
irrigation_efficie~y	.981	.013	-1.45	.146	.957	1.007	
Constant	.137	.212	-1.28	.199	.007	2.853	
Mean dependent var	22.280		SD dependent var		8.710		
Number of obs	150		Chi-square		10.801		
Prob > chi2	0.148		Akaike crit. (AIC)		234.299		
*** $p < .01$, ** $p < .05$, * $p < .1$							

Some of the respondents' views on using the survival model were that it allows them to easily plan for drought scenarios while not wasting resources during the act of allocation itself

alongside mentioning how they no longer have confusion in following the hazard ratios if they have missed the training session.

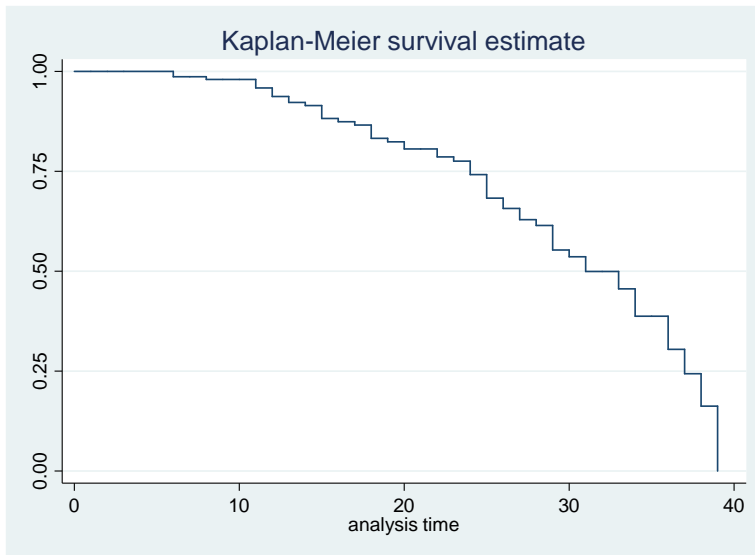


Figure 2. Kaplan–Meier estimator survival curve

Table 3 indicates the chi-square analysis between the mean scores of responses of the head farmers and irrigation officers on the availability of facilities and coordination and management of irrigation. In Table 4 above, it was found that coefficient, standard error and p-value for estimate, standard error, Wald statistic and confidence interval respectively.

4. Discussion

The farmers mostly had positive views on the proposed learning model and the use of analytical tools such as analytic hierarchy process and parametric survival models in irrigation planning. As found in the analysis, change-management perception has contributed significantly to the change in planting structure priorities in sunflower production in the irrigation command area. The survey findings identified with several priority components which revealed that water productivity and income survival probability remain the main drivers of the planting structure and irrigation decision framework in the command area [1,2,4].

This therefore implies that when irrigation authorities are committed to the reform plans, use the right strategy of creating their planting structure alternatives, farmers will then willingly follow the direction of irrigation reform. Findings of this field assessment showed that the overall acceptance level of the proposed model in the irrigation command area of Bukhara and Navoi is high. Only one respondent expressed a negative view about the use of survival modeling in irrigation planning and it is due to the idea that risk sharing and training on hazard ratio interpretation was difficult for them.

Therefore, in this study, the integrated model was implemented with the support of two analytical tools, analytic hierarchy process and parametric survival models, in the selected

districts, and the views of farmers and irrigation officers on the model were measured [3,5,6]. Results from Table 3 revealed that there is no significant difference between the availability of irrigation facilities and management of irrigation services in the command area. This therefore implies that when farmers are exposed to the structured framework, use the right process of creating their priority weights, they will then willingly follow the path of implementation. This is in agreement with views of [8] when he emphasized the management attributes of creating major change in an irrigation system [7].

The result of this study points to the fact that water-saving priority weighting in the integrated AHP–survival framework is statistically significant for income survival probability in irrigation command areas and the results were supported by many prior studies [2,5,8,10]. Whereas, the findings of the parametric survival analysis results demonstrated that in spite of cash-crop incentive being a key decision variable, profitability index was less significant. Group previous irrigation economics studies related the role of water productivity efficiency in multi-objective irrigation planning frameworks. The findings differ from [11]’s research on hydro-economic crop optimization models which indicated that field-level consistency between optimized patterns and outcomes was less significant. Research on multi-objective hydro-economic models show that integrated analytical approaches to irrigation planning reform produce positive changes in the allocation and coordination processes, which in turn, result in significant increases in water productivity and economic resilience.

According to [8], water productivity-oriented optimization is concerned with balancing hydrological and economic objectives and research studies on the means-ends-relationships between irrigation decision variables and performance indicators and outcomes, in particular student knowledge and economic returns in several irrigation systems, aiming at explanations for differences in student performance between traditional single-objective models and integrated multi-criteria frameworks. The body on hydro-economic irrigation-learning research literature is rather comprehensive [8], but unfortunately its focus has been mainly on the outcomes of water productivity improvement-learning in the general irrigation management field [11].

This result shows that farmers, irrigation officers, and extension agents around the command area are very receptive and have positive attitude toward structured planning and analytical decision tools. The findings of this study relate to [10], they maintained that inefficiency of irrigation systems based on weak coordination and governance, poor monitoring of allocation, inadequate participation of farmers, poor management of facilities among others as the factors working against the achievement of standard irrigation performance in command areas.

The findings agreed with [1] that irrigation reform has become a multi-dimensional challenge in command area structures which requires any kind of integrated modeling framework. Thus, a majority of irrigation stakeholders expect farmers to align the planting structure priorities (water-saving, profitability and resilience) in the irrigation command area in order for them to be prepared for drought shocks [3,4,11]. This strong emphasis on water productivity in sunflower production resulted in the improved allocation efficiency and income-stability performance, despite these being known as the competing objectives for irrigation authorities’ targets. Findings also show the water-saving priority is statistically significant for farmers’ openness to structured allocation. These findings are supported with

evidence of previous studies that concluded with irrigation authorities realizing and understanding the importance of water productivity and crop pattern optimization in irrigation reform [2, 6, 7, 5, 8, 9, 10]. The findings of this study will also be useful to the irrigation authority, agricultural extension units, policy makers and other stakeholders that are directly responsible in managing the irrigation infrastructure and the allocation process.

This contrasts with [11] who pointed out that there is likely to be a certain degree of inconsistency between the crop pattern optimization as established in the hydro-economic models and the field-level realities. This is in agreement with views of [8] and [10] who found that effective change management is an essential factor in effecting reform in an irrigation system. This is consistent with other findings by [1], and [2], which suggest that every irrigation system needs to strengthen the institutional framework and educate farmers on how these strategies can operate together with the allocation mechanism. This finding agreed with [10] that irrigation command areas have become a complex sector where such traditional practices like single-objective optimization of water allocation for yield maximization, revenue targeting, food security among others had made the reform to be difficult in managing towards the achievement of resilience. These findings also agreed with [8] that irrigation performance of farmers can improve through managing water-saving priorities and profitability objectives and mold them to be adaptive and resilient in their production in the command area. Meanwhile, it is important to note that the findings of this study were based only on survey responses from selected districts in the irrigation command area, Uzbekistan. The problem of limited data and measurement of farm-level indicators may affect effective management of irrigation systems.

5. Conclusion

The findings of this study show that integration of analytic hierarchy process, application of parametric survival models and systematic prioritization of water productivity and income stability indicators are the major ways of achieving effective irrigation planning reform in sunflower production systems. While this integrated framework will add to the existing literature on irrigation economics and hydro-economic modeling, it is hoped that irrigation authorities, agricultural extension units, policy makers and farming communities are to be provided with deeper insight into the dynamic trade-offs between water-saving priorities and cash-crop incentives resulting in better allocation efficiency and income stability in irrigation command areas that contribute to sustainable agricultural development. Further research can expand this study by using other economic indicators apart from funding, governance and coordination of irrigation services as indicators of resilience in irrigation systems. The study can also be carried out in a different irrigation setting such as large-scale schemes and transboundary river basins for comparative analysis. Since planting structure decisions are largely driven by institutional support and climatic variability, future research directions could include examining how climate change scenarios influence the current priority weights and hazard ratios in irrigation planning. Another possible study that could be conducted is a longitudinal study with larger samples and more heterogeneous farming groups including both the smallholder and commercial farm settings. In-depth investigation of the behavioral factors behind these identified priorities as well as development of integrated monitoring

frameworks would lead to greater contribution toward the irrigation reform agenda to strengthen and sustain the allocation mechanism and learning process.

Acknowledgements

This study meant to advance the analytical understanding of irrigation planning reform in sunflower production systems as a multi-criteria-based decision framework integrating analytic hierarchy process and parametric survival analysis and empirical field-based assessment approach that can be applied in irrigation command areas to improve water productivity efficiency and income survival probability activities, and Nevertheless, this institutional and collaborative support structure involving the regional irrigation authority, the agricultural extension department, and Bukhara State University makes important contributions in facilitating our field survey implementation and supervised data collection process of what is required in the use of integrated hydro-economic modeling as a decision-support analytical framework, and Therefore, irrigation planning and allocation activities should be strengthened in continuous capacity-building training programmes so as to enhance farmers' ability to the structured decision-making experiences which will be beneficial for their own resource allocation performance and their future income stability outcomes, and Most important of all, the regional irrigation authority, the agricultural extension department, and the institutional supervision provided by Bukhara State University of the irrigation command area would need to continue their technical support, administrative facilitation, and supervisory oversight to serve as an integral part of their present irrigation management and research implementation framework

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