PROPOSING SOLUTIONS TO DEVELOP SUSTAINABLE AGRICULTURE TO ADAPT TO CLIMATE CHANGE USING THE T-FANP MODEL

Nguyen Hoang Tuan
University of Science, Viet Nam National University
Ho Chi Minh City,
Viet Nam
nhtuansg@gmail.com

Truong Thanh Canh
University of Science, Viet Nam National University
Ho Chi Minh City,
Viet Nam
ttcanh@hcmus.edu.vn

ABSTRACT

The aim of this study is to propose priority strategies for agricultural development amidst drought in Ninh Thuan province, Vietnam. In the context of drought, the agricultural sector faces significant challenges due to the impact of both natural and socio-economic factors. In order to conduct this research and propose effective strategies, the study utilized the SWOT analysis model via the TOWS matrix, delineating 15 strategies to pinpoint the most fitting approach for the agricultural sector. The study quantified and ranked factors within the SWOT analysis and prioritized strategies using the Fuzzy Analytic Network Process (FANP). The outcomes identified advantageous strategies for agricultural production, emphasizing the evaluation and identification of drought while focusing on market development for economically valuable agricultural products based on primary crops. The step-by-step application of these prioritized strategies aims to contribute to the sustainable development of agricultural production in Ninh Thuan province and facilitate the utilization of a multi-criteria decision-making model in resource and environmental management.

Keywords: MCDM; SWOT; ANP; FANP; climate change; fuzzy logic

1. Introduction

Agriculture is an industry that plays a critical role in economic growth and development and is also the foundation for the development of human society (Blandford, 2011). It is an essential industry in transforming economies, ensuring food security, and improving nutrition (Lin, 2018). According to Food and Agriculture Organization (FAO) statistics,

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2019 the main crop output reached 9.5 billion tons and contributed significantly to ensuring global food security (FAO, 2021). According to the FAO's forecast, food production demand will increase by about 70% with the population by 2050 worldwide (FAO, 2011). With the impact of climate change, agricultural production is facing many difficulties and is also a vulnerable sector (FAO, 2013; Gil et al., 2013; Zhai & Zhuang, 2012).

In addition to the impact of climate change, drought is a natural disaster that affects livelihoods and food security in the world (Bordi & Sutera, 2007; GSA, 2006; Jenkins, 2011; Tadesse et al. al., 2008; Tannehill, 1947; UNDP, 2012; UNISDR, 2009). Because the mechanism of action of drought is very complex (Bordi & Sutera, 2007; UNISDR, 2009; Wilhite, 2014), controlling drought and its timing is not possible (Correia, 2007). Because drought is a severe escalator, this natural disaster causes significant losses worldwide (Esfahanian et al., 2017; Gillette, 1950; Jahangir et al., 2013; Wilhite, 2000; Wilhite, 2014). From 1970-2000, the drought rate increased by 30% worldwide (Dai et al., 2004); in 1960, drought caused up to 40 billion USD of damage, and in 1980 it caused up to 120 billion USD of damage (Domeisen, 1995). In Australia, from 1993-2006, the incidence of drought increased by an average of 20% per year (Henry et al., 2007) and had periods of loss of up to 3 billion Australian dollars (ABARES, 2012). In the European Union, the total economic loss over 30 years was at least 100 billion euros, and in Spain, cereal production is down 42% with a loss of almost 8 billion euros (Correia, 2007). In the United States, an average annual loss of 6 to 8 billion dollars (Wilhite, 2000) is due to drought, and more than 17,000 people were unemployed as a result (Koba, 2014).

According to an Intergovernmental Panel on Climate Change (IPCC) report, the global climate will continue to change. The earth will become warmer, and higher temperatures will increase the risk of drought at high levels on the global level (IPCC, 2007). Climate change makes drought conditions more prevalent and severe (Cancelliere et al., 2007), while also impacting rainfall patterns worldwide (UNESCO, 2014). Therefore, considering the effects of climate change and drought, it is necessary to find solutions to help each country's agricultural activities adapt well. Solutions to help stabilize agricultural production must be based on an overall assessment of the region's conditions and must identify an interdisciplinary role in proposing solutions.

MCDM methods are easy to combine with other methods to produce the best results for the analyst. SWOT analysis and fuzzy logic are good examples of a beneficial combination. A SWOT analysis is a qualitative method through MCDM to quantify the weights in each factor of the SWOT group. Combining fuzzy logic and MCDM helps remove uncertainties and creates better specific results (Kaya et al., 2019). Arsić et al. (2017) is one typical study that combines SWOT, Fuzzy, and MCMD by using a combined SWOT-ANP-FANP model to determine priority strategies for the sustainable development of ecotourism in Djerdap National Park Serbia. The study filled a gap in the literature by promoting the concept of ecotourism strategy and contributes to expanding

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the methodology in ecotourism. It provides valuable insights for decision-makers dealing with similar challenging situations. However, the article's limitation lies in its narrow discussion of the challenges or potential constraints in implementing strategies and its lack of comprehensive analysis of ecological impacts and measures to mitigate any adverse effects. Aghasafari et al. (2020) identified the best strategies for developing organic agriculture by combining SWOT-FANP. The article highlights the challenges involved in meeting the increasing food demand due to population growth and limitations in efficiently utilizing natural resources, energy, and agricultural land. However, this study lacks a detailed discussion of the limitations of these methods or potential biases that may arise from their application. Another research study sought to develop a science and technology strategy based on SWOT and FMADM analysis in Iran (Khatir & Akbarzadeh, 2019). The article introduced a comprehensive approach that combined the Decision-Making Trial and Evaluation Laboratory (DEMATEL) with the Fuzzy Network Process (ANP), termed FDANP, to assess the shortcomings of SWOT analysis in prioritizing sub-factors and strategies.

The article did not explicitly address any other limitations or constraints of the proposed FDANP method or the study itself. The findings and conclusions might not directly translate to other organizations or industries, necessitating further research to assess its effectiveness in different contexts. Ligus and Peternek (2018) identified low-emission energy technology development in Poland using the integrated fuzzy AHP-TOPSIS method. The study also proposed a hybrid MCDM model based on the FAHP and FTOPSIS to evaluate and prioritize low-emission energy technologies in Poland. The results obtained from the hybrid MCDM model were compared with outcomes from conventional decision-making models and the combined FAHP model, demonstrating the applicability and consistency of the proposed approach.

In summary, several prominent studies have effectively applied a MCDM approach in various fields. These studies involved experts to assess criteria through quantitative and qualitative analyses, often leveraging fuzzy logic. The studies demonstrated the extent of using algorithms within MCDM and their integration with diverse methodologies. However, a less explored aspect in these studies is the comprehensive analysis of the impact of natural and socio-economic factors on strategies based on in-depth discussions.

2. Research organization

Based on these exemplary studies, MCDM models were chosen for this research because the methods within MCDM are easily applicable and allow for comprehensive evaluation of both natural and socio-economic factors. Applying MCDM models is significant as it provides local authorities and policymakers with a more objective tool for strategic selection. The use of fuzzy logic allows for uncertainty when assessing criteria. Fuzzy MCDM models can handle imperfect and uncertain data and information, aiding policymakers in making more informed decisions. Additionally, applying MCDM models with fuzzy logic aids in the holistic evaluation and assessment of specific natural and socio-economic conditions, demanding agricultural policies be flexibly constructed and aligned with reality. Policies must address the overall complexities and conflicts in arid agricultural regions by accessing various factors. The Analytic Network Process (ANP) method is suitable for complex decision-making scenarios with multiple interacting criteria. Lastly, the ANP efficiently handles these relationships and considers quantitative and qualitative factors elicited from expert judgments.

To determine priority solutions for agricultural production in Ninh Thuan, Vietnam, the study utilized a combined model of SWOT analysis with fuzzy logic and ANP called T-FANP. Figure 1 describes the basic steps involved in the study.

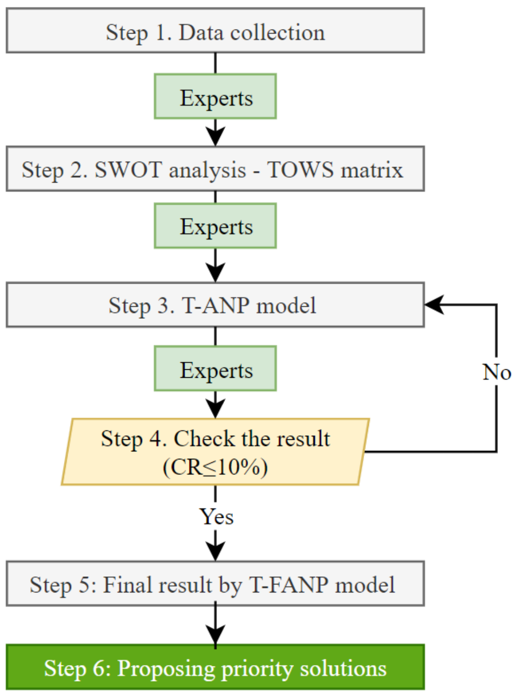

Figure 1 Research framework

3. Solutions for agricultural development in Ninh Thuan

Ninh Thuan is a province on the south-central coast of Vietnam. Ninh Thuan has a geographical coordinate system: 110 18’14” to 110 09’45” North latitude and 108 39’ 08” to 1090 14’ 25” East longitude (Figure 2). It borders Khanh Hoa province to the north, Binh Thuan to the south, Lam Dong to the west, the East Sea to the east, and about 350 km southwest of Ho Chi Minh City center.

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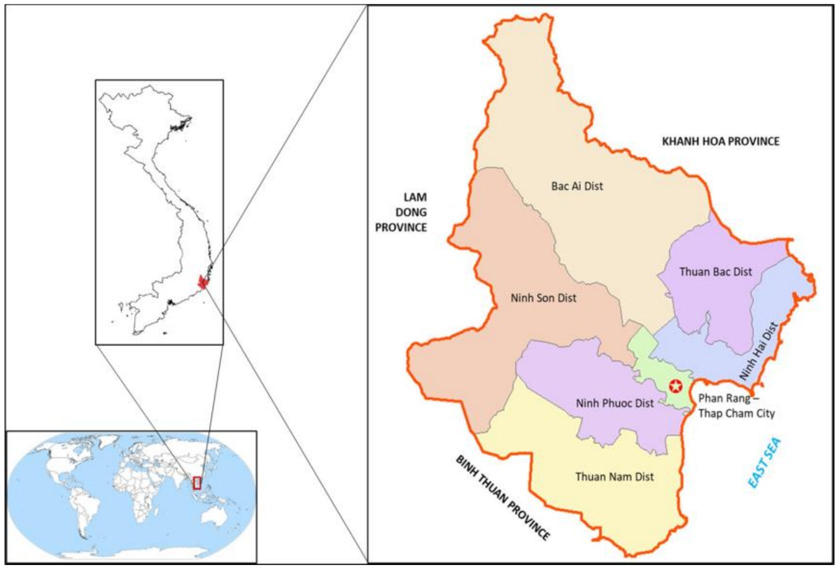

Figure 2 Map of Ninh Thuan Province, Viet Nam

Agriculture is an important economic sector in Ninh Thuan province and contributes to more than 30% of the GDP of the economic base (Ninh Thuan General Statistics Office, 2020). However, in recent years, the agricultural sector has faced many difficulties related to the impact of drought. According to Vietnamese scientists, Ninh Thuan is one of the provinces in Vietnam with the most drought and desert, and this has an enormous impact on the agricultural sector (Vinh & Huong, 2013). During the Winter-Spring crop of 2012-2013, Ninh Thuan province experienced drought and prolonged sunny spells, which significantly impacted production. The total damage amounted to 4,486 hectares out of a total area of 6,590 hectares. The crop damage rate ranged from 30% to 70%, with all tobacco plants being affected (DARD, 2017). During the 2014-2015 Winter-Spring crop, the drought in Ninh Thuan caused significant damage resulting in 6,100 hectares of unproductive crops, including 3,214 hectares of rice crops and 2,886 hectares of short-term crops, and indirectly over 30 trees (DNRE, 2015). According to a report by the Ninh Thuan Provincial People's Committee (2016), the drought caused 1,066 hectares of tree damage, of which 204 hectares were lost, and 862 hectares had reduced yield. According to statistics showing a lack of water resources, the integrated production of the Winter-Spring crop of 2019-2020 was 7,873.8 hectares (rice: 4,556.5 hectares, cash crops: 3,317.3 hectares), with 397.8 hectares of damaged rice area due to drought in the province (Binh, 2020).

Due to the severe effects of drought on agricultural production, many government agencies, localities, and scientists have proposed multiple solutions for the agricultural sector of Ninh Thuan. The national level has proposed the promotion of science and

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technology and new technology in agriculture and a national program on desertification prevention. At the local level, irrigation development and policies to form specialized agricultural areas with high-technology applications, solutions for developing local staple crops and adaptive crops have been proposed (DARD, 2014). The solutions offered to Ninh Thuan during the drought period have been specific rather than general solutions.

This study conducted an expert survey using two online and in-person forms to select local solutions. The expert survey involved interviewing 15 experts, including four experts who make policies for agricultural development in Ninh Thuan province and 11 experts with extensive experience in resource management, irrigation, and agriculture who have conducted national-level research for agricultural development in Ninh Thuan. The online survey was conducted over a period of two months, and the face-to-face interviews were conducted over two weeks. This research proposes 15 alternative solutions:

1. Focus on investing in crops with high economic value.
2. Expand the market for agricultural products.
3. Re-plan cultivation areas according to the strengths of each locality.
4. Develop a policy framework and crop conversion for drought-stricken areas.
5. Call for scientific research projects in the field of agriculture adaptation.
6. Call for investment in irrigation systems according to key areas of cultivation
7. Change the farming model for crops to suit irrigation water conditions.
8. Increase investment and expand and upgrade irrigation systems.
9. Support businesses to invest in applying science and technology to hi-tech agricultural production.
10. Promote the people’s ability for and experience of self-adaptation in agricultural production.
11. Adjust planting time.
12. Develop insurance policies in agricultural production.
13. Train human resources, increasing investment in disaster warning and monitoring systems.
14. Assess the impact of drought for each region, each type of farming
15. Identify drought risks for each locality and each type of farming.

4. Development of T-FANP model for priority solution

The T-FANP model combines many different methods and algorithms in MCDM, including the SWOT analysis method with the TOWS matrix and the network analysis process method with fuzzy logic.

4.1. SWOT analysis and TOWS matrix

The SWOT analysis was established in the business sector in the 1960s and 1970s and is used worldwide (Humphrey, 2005; Sidharth Thakur, 2010). The basic foundation of the

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SWOT analysis is to exploit internal (strengths, weaknesses) and external (opportunities, threats) factors based on the assessment of the characteristics of a particular sector. The analysis of the internal factors of the SWOT group will help analysts obtain an overview of their specific problem in order to propose solutions to adapt and develop in the future. Currently, the SWOT analysis is used not only in the economic field but also in the social and environmental fields (Arabzad et al., 2015; Catron et al., 2013; Dyson, 2004; Hung, 2013; Kallioras et al., 2010; Nathan, 2007). A SWOT analysis is very important for organizations because strategic factors within the SWOT group can affect the future of that organization (Kabak et al., 2016). The weakness of the SWOT analysis is that it does not assess the importance of the factors. Failure to quantify the importance of factors can lead to a lack of assessment of each sub-factor's impact on the SWOT group's components (Arsić et al., 2017; Haque et al., 2020; Hill & Westbrook, 1997; Wickramasinghe & Takano, 2009).

Weihrich (1982) developed the TOWS matrix through SWOT analysis for developing alternative solutions. The TOWS matrix helps align a company's strengths and weaknesses, and opportunities, and threats (Kabak et al., 2016). The analyst can develop solutions through the matrix by linking the external components to the internal and vice versa (Sevkli et al., 2012). The TOWS matrix allows analysts to develop multiple strategies based on four pairs of strategies, namely SO (strengths – opportunities), WO (weaknesses – opportunities), ST strategies (strengths – threats), and WT strategy (weaknesses – threats) (Arsić et al., 2017; Asadpourian et al., 2020; Sevkli et al., 2012). With the TOWS matrix, it is possible to see the priority on external factors (T-O), and when performing the analysis, it is necessary to pay attention to the change in the internal environment because this change will entail a change in other factors. (Arsic et al., 2017; Weihrich, 1982)

4.2. Fuzzy Analytic Network Process (FANP*)*

Zadeh introduced the theory of fuzzy sets and fuzzy numbers in 1965 to solve problems of an uncertain nature due to inaccuracies or lack of clarity in information (Linh et al., 2016). This theory has been studied in science, hypothesis testing, management science, and applied techniques for analyzing uncertain information (Dağdeviren & Yüksel, 2010). Along with fuzzy logic, the ANP rescue analysis is a nonlinear cluster and network approach that covers all directions (Sevkli et al., 2012). This method helps the analyst consider the interdependence between the primary and secondary indicators and rank the criteria (Shakoor et al., 2014). The FANP model combines an ANP algorithm and a fuzzy logic process. The FANP is a quantitative method in MCDM (Koupaei et al., 2015). People's perceptions and judgments are often unclear, so there is a need for fuzzy descriptions in multi-criteria analysis (Sevkli et al., 2012). The FANP uses the concept of fuzzy set theory to handle the uncertainty of the input documents during data analysis (Kahraman, 2012). The ANP algorithm using fuzzy theory (F) is a meaningful choice to replace the word discrete scale of the ANP with the Triangular Fuzzy Number (Arsic et al., 2017). In MCDM research, most triangular fuzzy numbers are used because they

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allow simple calculations and are not too complicated compared to trapezoids, pentagons and spheres.

4.3. T-FANP model

The T-FANP model used in this study is a combination of two qualitative and quantitative methods. FANP analysis makes it easier to quantify the factors in the TOWS matrix. This MCDM model has been used in many areas of research, such as energy policy in Turkey (Kabak et al., 2016), strategic decision support in a complex biopharmaceutical industry situation in Taiwan (Lee, 2013); a model for prioritizing strategies for sustainable development of ecotourism in Djerdap National Park, Serbia (Arsic et al., 2017); field installation of water projects and energy in Tehran (Partani et al., 2013); and prospective assessment of methanol vehicles in China (Li et al., 2020). The research employs both Saaty's 9-point scale and the fuzzy triangular scale in Sevkli and Arsić's study (Saaty, 1996; Sevkli et al., 2012; Arsić et al., 2017) (Table 1).

Table 1
Values of the Saaty scale and Triangular Fuzzy Number (TFN)

Definition scale for the importance	**Saaty scale**	**TFN**	**TFN scale**		
			Bottom	**Medium**	**Top**
Equally important	1	$\tilde{1}$	1	1	1
Equal to moderate importance	2	$\tilde{2}$	1	3/2	3/2
Moderately important	3	$\tilde{3}$	1	2	2
Moderately to strongly important	4	$\tilde{4}$	3	7/2	4
Strongly important	5	$\tilde{5}$	3	4	9/2
Strongly to very strongly important	6	$\tilde{6}$	3	9/2	5
Very strongly important	7	$\tilde{7}$	5	11/2	6
Very strongly to extremely important	8	$\tilde{8}$	5	6	7
Extremely important	9	$\tilde{9}$	5	7	9

Because the consistency ratio (CR) is used to assess the degree of inconsistency of the assessments in the ANP method, the CR calculation results also reflect the extent of scoring or evaluating components in the ANP analysis. CR results of 0.1 (< 10%) are acceptable and if CR > 0.1 (≥ 10%), the results need to be reviewed in the previous evaluation process (Hussey, 2014; Mu, 2021; Saaty & Vargas, 2012; Yavuz & Baycan, 2014). The process and steps to apply the T-FANP model to agriculture in Ninh Thuan province are listed below and depicted in Figure 3.

Step 1: SWOT analysis identity and TOWS matrix.
Step 2: Quantify a fuzzy matrix of factors in the SWOT group: $\widetilde{w}_1$
Step 3: Calculate the dependent matrix inside the SWOT group: $\widetilde{w}_2$
Step 4: Quantify a fuzzy matrix: $\widetilde{w}_{factor\_SWOT} = \widetilde{w}_2 \times \widetilde{w}_1$

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Step 5: Weight the local matrix: $\widetilde{W}_{sub\_SWOT(local)}$

Step 6: Weight the global fuzzy matrix: $\widetilde{W}_3 = \widetilde{W}_{sub\_SWOT(Global)} = \widetilde{W}_{factor\_SWOT} \times \begin{bmatrix} \widetilde{W}_{sub\_factors(S)} \\ \widetilde{W}_{sub\_factors(W)} \\ \widetilde{W}_{sub\_factors(O)} \\ \widetilde{W}_{sub\_factors(T)} \end{bmatrix}$

Step 7 Employ a fuzzy weighted matrix to assess the importance of alternative strategies: $\widetilde{W}_4$

Step 8: Calculate overall fuzzy solution: $\widetilde{W}_{alternatives} = \widetilde{W}_4 \times \widetilde{W}_3$

Step 9: Normalize values: $\acute{W}_{alternative} = W_{alternatives} \times \widetilde{W}_{alternative(factors)}$

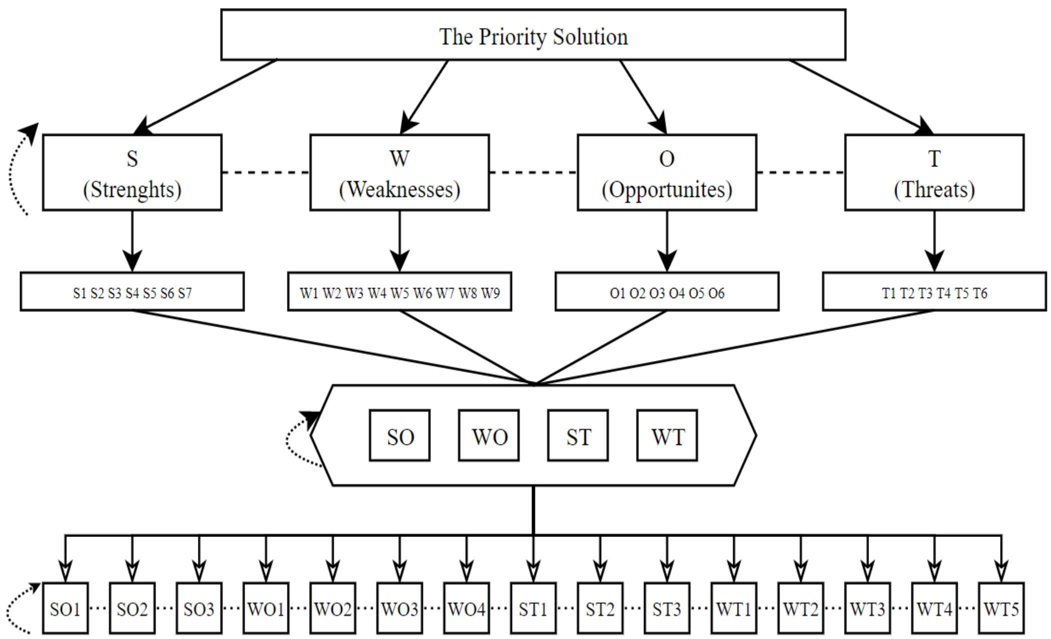

Figure 3 Process of the T-FANP model

4.4. Applying the T-FANP model

Step 1

This is the first and critical step in selecting priority alternatives in agriculture in Ninh Thuan. The TOWS matrix was built based on an assessment of internal and external documents from Ninh Thuan, a survey of experts, and the selection of factors in each component of the SWOT sub-factors. In particular, the research focused on essential data from the locality, that is, data on local planning and agricultural area development projects, and local scientific research work (Tuan et al., 2012; DARD, 2014; Tuan & Canh, 2021a, 2021b).

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Based on the above data sources, the study proposed a TOWS matrix for the agricultural sector in Ninh Thuan (Table 2). Table 2 illustrates that the research area has nine weaknesses (W), seven strengths (S), six opportunities (O), and six challenges (T). Through the TOWS matrix, the evaluation of the network of internal and the external factors of the SWOT factor, the research proposed 15 alternative solutions. Within the SO solution group, the research proposed three solutions focusing on the production of crops with high economic value (SO1), expanding the market (SO2), and re-planning the agricultural area according to local strengths (SO3). Within the ST solution group, the study proposed three solutions including upgrading the irrigation system (ST1), investing in science-technology (ST2), and promoting farmers' experience (ST3). Within the group of WO solutions, the study proposed four solutions to minimize the weaknesses including building production conversion policies (WO1), strengthening agricultural scientific research (WO2), investing in watering systems (WO3), and changing farming patterns to water sources (WO4). Within the group of WT solutions, the study proposed five solutions which focus on adjusting production time (WT1), insurance for agriculture (WT2), training human resources (WT3), assessing the impact of drought at the local level (WT4), and determining drought risk for each cultivating (WT5).

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Table 2
TOWS matrix for agriculture in Ninh Thuan

Internal factors		
Strengths (S) S1. Diverse terrain and soil S2. Number of days and hours of sunshine are favorable for growing annual crops. S3. Irrigation system has been gradually upgraded and invested in. S4. People have extensive experience producing in drought conditions. S5. Policies exist to attract and apply science and technology to the agricultural sector. S6. Policy on planning high-tech agricultural clusters S7. Many critical crops with high economic value	*Weaknesses (W)* W1. Water resources in reservoirs and groundwater are increasingly depleted. W2. Dry season is long, and the potential evapotranspiration is high. W3. Average annual rainfall is low and very unevenly distributed. W4. Drought often occurs in the dry season, and soil degradation is ongoing. W5. Agricultural production is also very dependent on nature W6. People's ability to proactively prevent and mitigate the impacts of natural disasters is still low. W7. Agricultural land is decreasing due to industrialization and urbanization. W8. Forecasting and warning of natural disasters are still limited and not close to reality. W9. Shortage of qualified human resources in disaster management.	
External factors		
Opportunities (O) O1. Support crop conversion for drought areas. O2. Trend of applying science-high technology to sustainable agricultural production and adapting to drought O3. Policy on restructuring the agricultural sector and forming regional linkage chains for critical products. O4. Close to the large agricultural product consumption market in Ho Chi Minh City. O5. Linking domestic and foreign scientific research in the field of climate change O6. Concerns of NGOs about the impact of drought and climate change on socio-economics.	*SO- Solution* SO1. Focus on investing in crops with high economic value. SO2. Expand the market for agricultural products. SO3. Re-planning cultivation areas according to the strengths of each locality	*WO - Solution* WO1. Policy framework development and crop conversion for drought-stricken areas WO2. Call for scientific research projects in the field of agriculture adapt. WO3. Call for investment in irrigation systems according to key areas of cultivation WO4. Changing the farming model for crops to suit irrigation water conditions.
Threats (T) T1. Trend increase in weather extremes in the context of climate change T2. Flow volume in the dry season tends to decrease. T3. Drought and desertification are on the rise. T4. Irrigation development policies of neighboring areas affect water resources. T5. Trend of shifting labour in agriculture to other fields T6. No insurance policy for agriculture	*ST- Solution* ST1. Increase investment, expand and upgrade irrigation systems. ST2. Supporting businesses to invest in applying science and technology to hi-tech agricultural production. ST3. Promote the people's ability and experience of self-adaptation in agricultural production.	*WT- Solution* WT1. Adjust planting time. WT2. Develop insurance policies in agricultural production WT3. Train human resources, increasing investment in disaster warning and monitoring systems. WT4. Assess the impact of drought for each region, each type of farming WT5. Identify drought risks for each locality and each type of farming

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Step 2

In constructing a set of weights for factors in SWOT analysis, we compared matrices of pairs with relative importance according to TFN with scores ranging from 1 to 9 (Table 3). In this step, based on a review of the SWOT aspects, experts compared each factor in pairs and compared the factors of the S with the factors of the W, O, and T, respectively. The study compared and assigned scores to each pair. The resulting weight calculation for the SWOT factors is the matrix $\tilde{\boldsymbol{w}}_{\mathbf{1}}$.

Table 3
Triangular fuzzy scale of SWOT factors

SWOT Group	**S**	**W**	**O**	**T**	**TFN of SWOT factors**		
					Bottom	**Medium**	**Top**
Strengths (S)	$\tilde{1}$	$\tilde{2}$	$\tilde{2}$	$\tilde{3}$	0.22439	0.35352	0.39757
Weaknesses (W)		$\tilde{1}$	$\widetilde{0,5}$	$\tilde{2}$	0.20276	0.21933	0.27297
Opportunities (O)			$\tilde{1}$	$\tilde{1}$	0.22439	0.24272	0.27297
Threats (T)				$\tilde{1}$	0.17050	0.18443	0.27297
CR: 0.06							

A matrix $\tilde{\boldsymbol{w}}_{\mathbf{1}}$ is defined as follows: $\tilde{w}_1 = \begin{bmatrix} 0.22439 & 0.35362 & 0.39757 \\ 0.20276 & 0.21933 & 0.27297 \\ 0.22439 & 0.24272 & 0.27297 \\ 0.17050 & 0.18443 & 0.27297 \end{bmatrix}$

Step 3

In this step, the research compared the internal dependence of the factors in the SWOT group by comparing each factor based on the TFN value. Combining the SWOT and ANP analyses helps assess the value of the factors more appropriately because the values of SWOT are not always independent. Experts calculated the interdependencies between the SWOT criteria using phased assessments. If a factor was missing in the SWOT analysis, experts scored its position on a scale of 1 to 9. A matrix $\tilde{w}_2$ was built based on the evaluation of the internal dependence according to the pairwise comparison of each element S – WOT, W – SOT, O – SWT, and T – SWO. The results of this step are shown in Tables 4-7.

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Table 4
Internal interdependence matrix of SWOT group concerning Strengths (S)

Strengths (S)	W	O	T	TFN relative weight of importance		
				Bottom	Medium	Top
Weaknesses (W)	$\tilde{1}$	$\frac{\tilde{1}}{4}$	$\frac{\tilde{1}}{4}$	0.27792	0.15669	0.19515
Opportunities (O)		$\tilde{1}$	$\tilde{2}$	0.38540	0.47830	0.42958
Threats (T)			$\tilde{1}$	0.33668	0.36501	0.37527
CR:0.06						

Table 5
Internal interdependence matrix of SWOT group concerning Weaknesses (W)

Weaknesses (W)	S	O	T	TFN relative weight of importance		
				Bottom	Medium	Top
Strengths (S)	$\tilde{1}$	$\tilde{3}$	$\tilde{4}$	0.37577	0.56315	0.71781
Opportunities (O)		$\tilde{1}$	$\tilde{3}$	0.20680	0.26747	0.41084
Threats (T)			$\tilde{1}$	0.14338	0.16938	0.24885
CR: 0.09						

Table 6
Internal interdependence matrix of SWOT group concerning Opportunities (O)

Opportunities (O)	S	W	T	TFN relative weight of importance		
				Bottom	Medium	Top
Strengths (S)	$\tilde{1}$	$\tilde{3}$	$\tilde{3}$	0.39458	0.52454	0.63399
Weaknesses (W)		$\tilde{1}$	$\tilde{2}$	0.23900	0.30181	0.39939
Threats (T)			$\tilde{1}$	0.15056	0.17365	0.24191
CR: 0.01						

Table 7
Internal interdependence matrix of SWOT group concerning Threats (T)

Threats (T)	S	W	O	TFN relative weight of importance		
				Bottom	Medium	Top
Strengths (S)	$\tilde{1}$	$\tilde{3}$	$\tilde{2}$	0.30225	0.48687	0.54845
Weaknesses (W)		$\tilde{1}$	$\frac{\tilde{1}}{3}$	0.23990	0.17555	0.24915
Opportunities (O)			$\tilde{1}$	0.33267	0.33758	0.34550
CR: 0.06						

The dependency matrix of factors in the SWOT analysis was in the matrix $\widetilde{w}_2$:

$$\widetilde{w}_2 = \begin{bmatrix} 1.00000 & 1.00000 & 1.00000 & 0.37577 & 0.56315 & 0.71781 & 0.39458 & 0.52454 & 0.63399 & 0.30746 & 0.45996 & 0.47231 \\ 0.27792 & 0.15669 & 0.19515 & 1.00000 & 1.00000 & 1.00000 & 0.23900 & 0.30181 & 0.39939 & 0.24403 & 0.17551 & 0.22706 \\ 0.38540 & 0.47830 & 0.42958 & 0.20680 & 0.26747 & 0.41084 & 1.00000 & 1.00000 & 1.00000 & 0.38737 & 0.40181 & 0.32748 \\ 0.33668 & 0.36501 & 0.37527 & 0.14338 & 0.16938 & 0.24885 & 0.15056 & 0.17365 & 0.24191 & 1.00000 & 1.00000 & 1.00000 \end{bmatrix}$$

Step 4

In this step, the values of the SWOT factor and the values of the internal dependencies of the factors together were adjusted through the matrix $\widetilde{W}_{factors}$. The adjustment matrix $\widetilde{W}_{factors}$ is calculated by multiplying the matrix $\widetilde{W}_1$ with the matrix $\widetilde{W}_2$.
The matrix $\widetilde{W}_{factors}$ is shown below:

$$\widetilde{W}_{factors} = \widetilde{W}_2 \; x \; \widetilde{W}_1 =$$

$$\begin{bmatrix} 1.00000 & 1.00000 & 1.00000 & 0.37577 & 0.56315 & 0.71781 & 0.39458 & 0.52454 & 0.63399 & 0.30746 & 0.45996 & 0.47231 \\ 0.27792 & 0.15669 & 0.19515 & 1.00000 & 1.00000 & 1.00000 & 0.23900 & 0.30181 & 0.39939 & 0.24403 & 0.17551 & 0.22706 \\ 0.38540 & 0.47830 & 0.42958 & 0.20680 & 0.26747 & 0.41084 & 1.00000 & 1.00000 & 1.00000 & 0.38737 & 0.40181 & 0.32748 \\ 0.33668 & 0.36501 & 0.37527 & 0.14338 & 0.16938 & 0.24885 & 0.15056 & 0.17365 & 0.24191 & 1.00000 & 1.00000 & 1.00000 \end{bmatrix}$$

$$x$$

$$\begin{bmatrix} 0.22439 & 0.35362 & 0.39757 \\ 0.20276 & 0.21933 & 0.27297 \\ 0.22439 & 0.24272 & 0.27297 \\ 0.17050 & 0.18443 & 0.27297 \end{bmatrix}$$

$$=$$

$$\begin{bmatrix} 0.28866 & 0.34341 & 0.34199 \\ 0.23558 & 0.18952 & 0.19918 \\ 0.27382 & 0.27136 & 0.24644 \\ 0.20194 & 0.19571 & 0.21239 \end{bmatrix}$$

Step 5

The priority of the criteria in each component $\widetilde{W}_{sub\_factors}$ was calculated. In this step, pairwise comparisons of each factor within S, W, O, and T of the SWOT analysis were made and the results are presented in Tables 8-11

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Table 8
Internal interdependence matrix of S ($\widetilde{W}_{sub_{factors(S)}}$)

S	S1	S2	S3	S4	S5	S6	S7	TFN relative weight of importance		
								Bottom	Medium	Top
S1	$\tilde{1}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	$\tilde{3}$	$\tilde{2}$	$\tilde{2}$	0.12975	0.14293	0.16021
S2		$\tilde{1}$	$\tilde{2}^{-1}$	$\tilde{2}$	$\tilde{2}$	$\tilde{3}$	$\tilde{3}$	0.13749	0.18775	0.19861
S3			$\tilde{1}$	$\tilde{3}$	$\tilde{3}$	$\tilde{2}$	$\tilde{3}$	0.14569	0.21966	0.21928
S4				$\tilde{1}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	$\tilde{2}$	0.11752	0.11725	0.14510
S5					$\tilde{1}$	$\tilde{2}^{-1}$	$\tilde{1}$	0.10644	0.10619	0.14510
S6						$\tilde{1}$	$\tilde{2}$	0.11752	0.13165	0.16293
S7							$\tilde{1}$	0.08946	0.09458	0.15376
CR: 0.07										

Table 9
Internal interdependence matrix of W ($\widetilde{W}_{sub_{factors(w)}}$)

W	W1	W2	W3	W4	W5	W6	W7	W8	W9	TFN relative weight of importance		
										Bottom	Medium	Top
W1	$\tilde{1}$	$\tilde{2}$	$\tilde{2}$	$\tilde{3}$	$\tilde{3}$	$\tilde{2}$	$\tilde{2}^{-1}$	$\tilde{3}^{-1}$	$\tilde{2}^{-1}$	0.10460	0.12471	0.15343
W2		$\tilde{1}$	$\tilde{2}$	$\tilde{3}$	$\tilde{3}$	$\tilde{2}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	0.11298	0.11376	0.14861
W3			$\tilde{1}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	$\tilde{2}$	$\tilde{3}^{-1}$	$\tilde{4}^{-1}$	$\tilde{3}^{-1}$	0.09559	0.06978	0.09120
W4				$\tilde{1}$	$\tilde{3}$	$\tilde{2}$	$\tilde{3}^{-1}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	0.07117	0.07605	0.09120
W5					$\tilde{1}$	$\tilde{2}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	$\tilde{3}^{-1}$	0.07117	0.07605	0.09540
W6						$\tilde{1}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	$\tilde{5}^{-1}$	0.08735	0.06365	0.09120
W7							$\tilde{1}$	$\tilde{3}^{-1}$	$\tilde{3}^{-1}$	0.12599	0.12492	0.11129
W8								$\tilde{1}$	$\tilde{2}^{-1}$	0.16605	0.17521	0.10639
W9									$\tilde{1}$	0.16509	0.18255	0.11129
CR: 0.09												

Table 10
Internal interdependence matrix of O ($\widetilde{W}_{sub_{factors(o)}}$)

O	O1	O2	O3	O4	O5	O6	TFN relative weight of importance		
							Bottom	Medium	Top
O1	$\tilde{1}$	$\tilde{2}$	$\tilde{2}$	$\tilde{3}$	$\tilde{4}$	$\tilde{5}$	0.18635	0.29476	0.38743
O2		$\tilde{1}$	$\tilde{3}^{-1}$	$\tilde{2}$	$\tilde{3}$	$\tilde{3}$	0.12077	0.16586	0.22368
O3			$\tilde{1}$	$\tilde{3}$	$\tilde{4}$	$\tilde{3}$	0.16280	0.24067	0.29566
O4				$\tilde{1}$	$\tilde{3}$	$\tilde{3}$	0.09585	0.13811	0.23467
O5					$\tilde{1}$	$\tilde{3}$	0.06461	0.08671	0.14496
O6						$\tilde{1}$	0.06335	0.07388	0.15509
CR: 0.07									

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Table 11
Internal interdependence matrix of T ($\widetilde{W}_{sub_{factors(T)}}$)

T	T1	T2	T3	T4	T5	T6	TFN relative weight of importance		
							Bottom	Bottom	Bottom
T1	$\tilde{1}$	$\tilde{2}^{-1}$	$\tilde{2}$	$\tilde{2}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	0.14144	0.14790	0.17611
T2		$\tilde{1}$	$\tilde{2}$	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	$\tilde{3}^{-1}$	0.15133	0,14097	0.15711
T3			$\tilde{1}$	2	$\tilde{2}^{-1}$	$\tilde{2}^{-1}$	0.12356	0.12920	0.17635
T4				$\tilde{1}$	$\tilde{3}^{-1}$	$\tilde{4}^{-1}$	0.13220	0.10693	0.13342
T5					$\tilde{1}$	$\tilde{3}^{-1}$	0.19445	0.19380	0.16809
T6						$\tilde{1}$	0.25702	0.28120	0.18868
CR: 0.09									

The matrix of $\widetilde{W}_{sub\_factors}$ was defined as:

$$\widetilde{W}_{sub\_factors(S)} = \begin{bmatrix} 0.12975 & 0.14293 & 0.16021 \\ 0.13749 & 0.18775 & 0.19861 \\ 0.14569 & 0.21966 & 0.21928 \\ 0.11752 & 0.11725 & 0.14510 \\ 0.10644 & 0.10619 & 0.14510 \\ 0.11752 & 0.13165 & 0.16293 \\ 0.08946 & 0.09458 & 0.15376 \end{bmatrix} ; \widetilde{W}_{sub\_factors(W)} = \begin{bmatrix} 0.10460 & 0.12471 & 0.15343 \\ 0.11298 & 0.11376 & 0.14861 \\ 0.09559 & 0.06978 & 0.09120 \\ 0.07117 & 0.07605 & 0.09120 \\ 0.07117 & 0.06937 & 0.09540 \\ 0.08735 & 0.06365 & 0.09120 \\ 0.12599 & 0.12492 & 0.11129 \\ 0.16605 & 0.17521 & 0.10639 \\ 0.16509 & 0.18255 & 0.11129 \end{bmatrix}$$

$$\widetilde{W}_{sub\_factors(O)} = \begin{bmatrix} 0.18635 & 0.29476 & 0.38743 \\ 0.12077 & 0.16586 & 0.22368 \\ 0.16280 & 0.24067 & 0.29566 \\ 0.09585 & 0.13811 & 0.23467 \\ 0.06461 & 0.08671 & 0.14496 \\ 0.06335 & 0.07388 & 0.15509 \end{bmatrix} ; \widetilde{W}_{sub\_factors(T)} = \begin{bmatrix} 0.14144 & 0.14790 & 0.17635 \\ 0.15133 & 0.14097 & 0.15711 \\ 0.12356 & 0.12920 & 0.17635 \\ 0.13220 & 0.10693 & 0.13342 \\ 0.19445 & 0.19380 & 0.16809 \\ 0.25702 & 0.28120 & 0.18868 \end{bmatrix}$$

Step 6

The preferred fuzzy sum values of the values in the $SWOT_{sub\_factor(global)}$ were calculated by multiplying the interdependent fuzzy priority values of the $\widetilde{W}_{factors}$ by the internal criteria in each element in the he group SWOT in step 5. The fuzzy value $SWOT_{sub\_factor(global)}$ is shown in Table 12.

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Table 12
The values of global weights for SWOT$_{sub_factors}$

SWOT factors	Priority of the SWOT factors			SWOT$_{sub-factors}$	Priority of the SWOT$_{sub-factors}$			Overall priority of the SWOT$_{sub-factors}$		
	Bottom	Medium	Top		Bottom	Medium	Top	Bottom	Medium	Top
Strengths (S)	0.28866	0.34341	0.34199	S1	0.12975	0.14293	0.16021	0.03745	0.04908	0.05479
				S2	0.13749	0.18775	0.19861	0.03969	0.06448	0.06792
				S3	0.14569	0.21966	0.21928	0.04205	0.07543	0.07499
				S4	0.11752	0.11725	0.14510	0.03392	0.04026	0.04962
				S5	0.10644	0.10619	0.14510	0.03072	0.03647	0.04962
				S6	0.11752	0.13165	0.16293	0.03392	0.04521	0.05572
				S7	0.08946	0.09458	0.15376	0.02582	0.03248	0.05258
Weaknesses (W)	0.23558	0.18952	0.19918	W1	0.10460	0.12471	0.15343	0.02464	0.02363	0.03056
				W2	0.11298	0.11376	0.14861	0.02662	0.02156	0.02960
				W3	0.09559	0.06978	0.09120	0.02252	0.01322	0.01817
				W4	0.07117	0.07605	0.09120	0.01677	0.01441	0.01817
				W5	0.07117	0.06937	0.09540	0.01677	0.01315	0.01900
				W6	0.08735	0.06365	0.09120	0.02058	0.01206	0.01817
				W7	0.12599	0.12492	0.11129	0.02968	0.02368	0.02217
				W8	0.16605	0.17521	0.10639	0.03912	0.03321	0.02119
				W9	0.16509	0.18255	0.11129	0.03889	0.03460	0.02217
Opportunities (O)	0.27382	0.27136	0.24644	O1	0.18635	0.29476	0.38743	0.05103	0.07999	0.09548
				O2	0.12077	0.16586	0.22368	0.03307	0.04501	0.05512
				O3	0.16280	0.24067	0.29566	0.04458	0.06531	0.07286
				O4	0.09585	0.13811	0.23467	0.02625	0.03748	0.05783
				O5	0.06461	0.08671	0.14496	0.01769	0.02353	0.03572
				O6	0.06335	0.07388	0.15509	0.01735	0.02005	0.03822
Threats (T)	0.20194	0.19571	0.21239	T1	0.14144	0.14790	0.17635	0.02856	0.02894	0.03745
				T2	0.15133	0.14097	0.15711	0.03056	0.02759	0.03337
				T3	0.12356	0.12920	0.17635	0.02495	0.02529	0.03745
				T4	0.13220	0.10693	0.13342	0.02670	0.02093	0.02834
				T5	0.19445	0.19380	0.16809	0.03927	0.03793	0.03570
				T6	0.25702	0.28120	0.18868	0.05190	0.05503	0.04007

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A fuzzy matrix $\widetilde{W}_3$ through SWOT$_{sub_factor(global)}$ is described:

$$\widetilde{W}_3 = SWOT_{sub\_factor(global)} = \begin{bmatrix} 0.03745 & 0.04908 & 0.05479 \\ 0.03969 & 0.06448 & 0.06792 \\ 0.04205 & 0.07543 & 0.07499 \\ 0.03392 & 0.04026 & 9{,}04963 \\ 0.03072 & 0.03647 & 0.04962 \\ 003392 & 0.04521 & 0.05572 \\ 0.02582 & 0.03248 & 0.05258 \\ 0.02464 & 0.02348 & 0.03056 \\ 0.02662 & 0.02156 & 0.02960 \\ 0.02252 & 0.01322 & 0.01817 \\ 0.01677 & 0.01441 & 0.01817 \\ 0.01677 & 0.01315 & 0.01900 \\ 0.02058 & 0.01206 & 0.01817 \\ 0.02968 & 0.02368 & 0.02217 \\ 0.03912 & 0.03321 & 0.02119 \\ 0.03889 & 0.03460 & 0.02217 \\ 0.05103 & 0.07999 & 0.09548 \\ 0.03307 & 0.04501 & 0.05512 \\ 0.04458 & 0.06531 & 0.07286 \\ 0.02625 & 0.03748 & 0.05783 \\ 0.01769 & 0.02353 & 0.03572 \\ 0.01735 & 0.02005 & 0.03822 \\ 0.02856 & 0.02894 & 0.03745 \\ 0.03056 & 0.02759 & 0.03337 \\ 0.02459 & 0.02529 & 0.03745 \\ 0.02670 & 0.02093 & 0.02834 \\ 0.03927 & 0.03793 & 0.03570 \\ 0.05190 & 0.05503 & 0.04007 \end{bmatrix}$$

Step 7

In this phase, the study used the TFN scale to score the importance of the alternatives $\widetilde{W}_{alternatives}$ and the sub-factors of the SWOT analysis. To measure the weight of SWOT factors with the alternative solutions, experts scored those solutions according to each factor and on a scale of 1 - 9. The value $\widetilde{W}_{alternatives}$ was calculated by multiplying the fuzzy matrix $\widetilde{W}_4$ with the fuzzy value's $SWOT_{sub\_factor(global)}$. The matrix $\widetilde{W}_4$ is built through the fuzzy value of comparing the criteria of the SWOT sub-factor. The results of $\boldsymbol{\widetilde{W}_{alternatives}}$ are shown in Tables 13a-c.

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Table 13a

Values of the $\widetilde{W}_{4_{bottom}}$ of the alternative solution $\widetilde{W}_{alternatives}$

$\widetilde{W}_4$ _bottom	Solutions														
	SO1	SO2	SO3	WO1	WO2	WO3	WO4	ST1	ST2	ST3	WT1	WT2	WT3	WT4	WT5
S1	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667
S2	0.05882	0.05882	0.05882	0.17647	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882
S3	0.14286	0.04762	0.04762	0.14286	0.04762	0.04762	0.04762	0.14286	0.04762	0.04762	0.04762	0.04762	0.04762	0.04762	0.04762
S4	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667
S5	0.05263	0.05263	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263
S6	0.17647	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882
S7	0.15789	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.05263
W1	0.04348	0.04348	0.04348	0.04348	0.04348	0.13043	0.13043	0.13043	0.04348	0.04348	0.13043	0.04348	0.04348	0.04348	0.04348
W2	0.04000	0.04000	0.04000	0.04000	0.04000	0.04000	0.04000	0.12000	0.04000	0.04000	0.12000	0.12000	0.04000	0.12000	0.12000
W3	0.03704	0.03704	0.03704	0.11111	0.03704	0.03704	0.03704	0.11111	0.03704	0.03704	0.11111	0.11111	0.03704	0.11111	0.11111
W4	0.04000	0.04000	0.04000	0.12000	0.04000	0.04000	0.04000	0.12000	0.04000	0.04000	0.04000	0.12000	0.04000	0.12000	0.12000
W5	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667
W6	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.15789	0.05263
W7	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667
W8	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667
W9	0.04762	0.04762	0.14286	0.04762	0.04762	0.04762	0.04762	0.04762	0.04762	0.04762	0.04762	0.04762	0.14286	0.14286	0.04762
O1	0.05263	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263
O2	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667
O3	0.05882	0.17647	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882
O4	0.05882	0.05882	0.17647	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882
O5	0.05882	0.05882	0.17647	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882
O6	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.15789	0.05263
T1	0.05263	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.15789	0.05263
T2	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.15789	0.05263	0.05263	0.05263	0.05263	0.05263	0.15789	0.05263
T3	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.05263	0.15789	0.15789
T4	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667
T5	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667	0.06667
T6	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.05882	0.17647	0.05882	0.05882	0.05882

Table 13b

Values of the $\widetilde{W}_{4_{medium}}$ of the alternative solution $\widetilde{W}_{alternatives}$

$\widetilde{W}_4$ _medium	Solutions														
	SO1	SO2	SO3	WO1	WO2	WO3	WO4	ST1	ST2	ST3	WT1	WT2	WT3	WT4	WT5
S1	0.09524	0.04762	0.04762	0.04762	0.04762	0.04762	0.09524	0.09524	0.04762	0.04762	0.04762	0.04762	0.09524	0.09524	0.09524
S2	0.08333	0.04167	0.06250	0.14583	0.04167	0.04167	0.08333	0.08333	0.04167	0.04167	0.04167	0.04167	0.08333	0.08333	0.08333
S3	0.14545	0.03636	0.03636	0.12727	0.03636	0.03636	0.03636	0.12727	0.03636	0.03636	0.09091	0.03636	0.07273	0.07273	0.07273
S4	0.07317	0.04878	0.07317	0.07317	0.04878	0.04878	0.07317	0.04878	0.04878	0.04878	0.07317	0.04878	0.09756	0.09756	0.09756
S5	0.05882	0.03922	0.03922	0.05882	0.15686	0.03922	0.03922	0.03922	0.13725	0.03922	0.05882	0.05882	0.07843	0.07843	0.07843
S6	0.14583	0.06250	0.06250	0.04167	0.04167	0.08333	0.04167	0.06250	0.04167	0.04167	0.04167	0.08333	0.08333	0.08333	0.08333
S7	0.13208	0.05660	0.03774	0.07547	0.03774	0.07547	0.03774	0.05660	0.03774	0.03774	0.13208	0.05660	0.07547	0.07547	0.07547
W1	0.04762	0.03175	0.04762	0.04762	0.03175	0.12698	0.12698	0.12698	0.03175	0.03175	0.11111	0.04762	0.06349	0.06349	0.06349
W2	0.05882	0.02941	0.04412	0.04412	0.02941	0.05882	0.05882	0.10294	0.04412	0.02941	0.11765	0.04412	0.10294	0.11765	0.11765
W3	0.03125	0.03125	0.03125	0.10938	0.04688	0.03125	0.04688	0.12500	0.03125	0.03125	0.10938	0.04688	0.10938	0.10938	0.10938
W4	0.03077	0.03077	0.04615	0.10769	0.06154	0.04615	0.04615	0.12308	0.03077	0.03077	0.06154	0.04615	0.12308	0.10769	0.10769
W5	0.04545	0.04545	0.04545	0.09091	0.06818	0.04545	0.06818	0.06818	0.09091	0.04545	0.06818	0.04545	0.09091	0.09091	0.09091
W6	0.04348	0.04348	0.04348	0.04348	0.04348	0.08696	0.15217	0.04348	0.04348	0.04348	0.04348	0.04348	0.15217	0.08696	0.08696
W7	0.05405	0.05405	0.05405	0.05405	0.08108	0.05405	0.05405	0.05405	0.05405	0.05405	0.05405	0.05405	0.10811	0.10811	0.10811
W8	0.06383	0.04255	0.08511	0.08511	0.06383	0.04255	0.08511	0.06383	0.04255	0.04255	0.08511	0.04255	0.08511	0.08511	0.08511
W9	0.03774	0.03774	0.13208	0.03774	0.05660	0.05660	0.03774	0.03774	0.03774	0.03774	0.03774	0.15094	0.15094	0.07547	0.07547
O1	0.05660	0.05660	0.05660	0.13208	0.03774	0.03774	0.03774	0.13208	0.07547	0.03774	0.05660	0.05660	0.07547	0.07547	0.07547
O2	0.04878	0.04878	0.09756	0.07317	0.07317	0.04878	0.04878	0.07317	0.04878	0.04878	0.04878	0.04878	0.09756	0.09756	0.09756
O3	0.06383	0.17021	0.04255	0.06383	0.04255	0.04255	0.06383	0.06383	0.06383	0.04255	0.04255	0.04255	0.08511	0.08511	0.08511
O4	0.06667	0.08889	0.17778	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.04444	0.08889	0.08889	0.08889
O5	0.06250	0.06250	0.16667	0.04167	0.06250	0.06250	0.06250	0.04167	0.04167	0.04167	0.04167	0.06250	0.08333	0.08333	0.08333
O6	0.06122	0.06122	0.16327	0.04082	0.04082	0.06122	0.08163	0.04082	0.04082	0.04082	0.04082	0.04082	0.16327	0.06122	0.06122
T1	0.05357	0.03571	0.07143	0.12500	0.07143	0.05357	0.07143	0.07143	0.03571	0.03571	0.05357	0.03571	0.14286	0.07143	0.07143
T2	0.05556	0.03704	0.07407	0.07407	0.03704	0.07407	0.03704	0.12963	0.03704	0.03704	0.07407	0.03704	0.14815	0.07407	0.07407
T3	0.05882	0.03922	0.03922	0.05882	0.03922	0.03922	0.03922	0.07843	0.03922	0.03922	0.05882	0.03922	0.15686	0.13725	0.13725
T4	0.05128	0.05128	0.05128	0.05128	0.05128	0.07692	0.07692	0.07692	0.05128	0.05128	0.05128	0.05128	0.10256	0.10256	0.10256
T5	0.06977	0.06977	0.09302	0.04651	0.04651	0.06977	0.09302	0.04651	0.04651	0.04651	0.04651	0.04651	0.09302	0.09302	0.09302
T6	0.07317	0.07317	0.07317	0.04878	0.04878	0.07317	0.07317	0.04878	0.04878	0.04878	0.04878	0.04878	0.09756	0.09756	0.09756

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Table 13c
Values of the $\widetilde{W}_{4_{top}}$ of the alternative solution $\widetilde{W}_{alternatives}$

$\widetilde{W}_4$ _top	Solutions														
	SO1	SO2	SO3	WO1	WO2	WO3	WO4	ST1	ST2	ST3	WT1	WT2	WT3	WT4	WT5
S1	0.10000	0.05000	0.05000	0.05000	0.05000	0.05000	0.10000	0.10000	0.05000	0.05000	0.05000	0.05000	0.05000	0.10000	0.10000
S2	0.08511	0.04255	0.06383	0.17021	0.04255	0.04255	0.08511	0.08511	0.04255	0.04255	0.04255	0.04255	0.04255	0.08511	0.08511
S3	0.16071	0.03571	0.03571	0.14286	0.03571	0.03571	0.03571	0.14286	0.03571	0.03571	0.08929	0.03571	0.03571	0.07143	0.07143
S4	0.07692	0.05128	0.07692	0.07692	0.05128	0.05128	0.07692	0.05128	0.05128	0.05128	0.07692	0.05128	0.05128	0.10256	0.10256
S5	0.05882	0.03922	0.03922	0.05882	0.17647	0.03922	0.03922	0.03922	0.15686	0.03922	0.05882	0.03922	0.05882	0.07843	0.07843
S6	0.16667	0.06250	0.06250	0.04167	0.04167	0.08333	0.04167	0.06250	0.04167	0.04167	0.04167	0.06250	0.08333	0.08333	0.08333
S7	0.15094	0.05660	0.03774	0.07547	0.03774	0.07547	0.03774	0.05660	0.03774	0.03774	0.15094	0.03774	0.05660	0.07547	0.07547
W1	0.04615	0.03077	0.04615	0.04615	0.03077	0.13846	0.13846	0.13846	0.03077	0.03077	0.12308	0.03077	0.04615	0.06154	0.06154
W2	0.05556	0.02778	0.04167	0.04167	0.02778	0.05556	0.05556	0.11111	0.04167	0.02778	0.12500	0.11111	0.04167	0.11111	0.12500
W3	0.02857	0.02857	0.02857	0.11429	0.04286	0.02857	0.04286	0.12857	0.02857	0.02857	0.11429	0.11429	0.04286	0.11429	0.11429
W4	0.02857	0.02857	0.04286	0.11429	0.05714	0.04286	0.04286	0.12857	0.02857	0.02857	0.05714	0.11429	0.04286	0.12857	0.11429
W5	0.04762	0.04762	0.04762	0.09524	0.07143	0.04762	0.07143	0.07143	0.09524	0.04762	0.07143	0.04762	0.04762	0.09524	0.09524
W6	0.04545	0.04545	0.04545	0.04545	0.04545	0.09091	0.13636	0.04545	0.04545	0.04545	0.04545	0.04545	0.04545	0.18182	0.09091
W7	0.05556	0.05556	0.05556	0.05556	0.08333	0.05556	0.05556	0.05556	0.05556	0.05556	0.05556	0.08333	0.05556	0.11111	0.11111
W8	0.08511	0.04255	0.08511	0.08511	0.06383	0.04255	0.08511	0.06383	0.04255	0.04255	0.08511	0.06383	0.04255	0.08511	0.08511
W9	0.03704	0.03704	0.14815	0.03704	0.05556	0.05556	0.03704	0.03704	0.03704	0.03704	0.03704	0.03704	0.16667	0.16667	0.07407
O1	0.05556	0.05556	0.05556	0.14815	0.03704	0.03704	0.03704	0.14815	0.07407	0.03704	0.05556	0.05556	0.05556	0.07407	0.07407
O2	0.05128	0.05128	0.10256	0.07692	0.07692	0.05128	0.05128	0.07692	0.05128	0.05128	0.05128	0.05128	0.05128	0.10256	0.10256
O3	0.06250	0.18750	0.04167	0.06250	0.04167	0.04167	0.06250	0.06250	0.06250	0.04167	0.04167	0.08333	0.04167	0.08333	0.08333
O4	0.06818	0.09091	0.20455	0.04545	0.04545	0.04545	0.04545	0.04545	0.04545	0.04545	0.04545	0.04545	0.04545	0.09091	0.09091
O5	0.06383	0.06383	0.19149	0.04255	0.06383	0.06383	0.06383	0.04255	0.04255	0.04255	0.04255	0.04255	0.06383	0.08511	0.08511
O6	0.06000	0.06000	0.18000	0.04000	0.04000	0.06000	0.08000	0.04000	0.04000	0.04000	0.04000	0.04000	0.04000	0.18000	0.06000
T1	0.05263	0.03509	0.07018	0.14035	0.07018	0.05263	0.07018	0.07018	0.03509	0.03509	0.05263	0.05263	0.03509	0.15789	0.07018
T2	0.05556	0.03704	0.07407	0.07407	0.03704	0.07407	0.03704	0.14815	0.03704	0.03704	0.07407	0.03704	0.03704	0.16667	0.07407
T3	0.06522	0.04348	0.04348	0.06522	0.04348	0.04348	0.04348	0.08696	0.04348	0.04348	0.06522	0.04348	0.04348	0.19565	0.13043
T4	0.05405	0.05405	0.05405	0.05405	0.05405	0.08108	0.08108	0.08108	0.05405	0.05405	0.05405	0.05405	0.05405	0.10811	0.10811
T5	0.07317	0.07317	0.09756	0.04878	0.04878	0.07317	0.09756	0.04878	0.04878	0.04878	0.04878	0.04878	0.04878	0.09756	0.09756
T6	0.06522	0.06522	0.06522	0.04348	0.04348	0.06522	0.06522	0.04348	0.04348	0.04348	0.04348	0.19565	0.04348	0.08696	0.08696

The matrix of $\widetilde{W}_{alternatives}$ is defined as:

$$\widetilde{W}_{alternatives} = \begin{bmatrix} SO1 \\ SO2 \\ SO3 \\ WO1 \\ WO2 \\ WO3 \\ WO4 \\ ST1 \\ ST2 \\ ST3 \\ WT1 \\ WT2 \\ WT3 \\ WT4 \\ WT5 \end{bmatrix} = \widetilde{W}_4 \ x \ \widetilde{W}_{sub\_factor(global)} \begin{bmatrix} 0.06883 & 0.07448 & 0.07779 \\ 0.06254 & 0.05785 & 0.05913 \\ 0.06880 & 0.06978 & 0.07412 \\ 0.07955 & 0.07713 & 0.08117 \\ 0.06023 & 0.05152 & 0.05279 \\ 0.05898 & 0.06138 & 0.06135 \\ 0.06147 & 0.06138 & 0.06135 \\ 0.07934 & 0.07766 & 0.08135 \\ 0.06023 & 0.05056 & 0.05210 \\ 0.05652 & 0.04166 & 0.04169 \\ 0.06943 & 0.06104 & 0.06372 \\ 0.06943 & 0.05191 & 0.05821 \\ 0.06077 & 0.09690 & 0.05115 \\ 0.08142 & 0.08695 & 0.10211 \\ 0.06543 & 0.08695 & 0.08764 \end{bmatrix}$$

Step 8

Next, the TFN matrix values were converted to the weighted mean values. In the defuzzification step, the average of three fuzzy values for each strategy were calculated. Once the average of each strategy was obtained, the total of the solutions was calculated and then the ratio of each strategy was calculated. The result is shown below:

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$$W_{alternatives} = \begin{bmatrix} SO1 \\ SO2 \\ SO3 \\ WO1 \\ WO2 \\ WO3 \\ WO4 \\ ST1 \\ ST2 \\ ST3 \\ WT1 \\ WT2 \\ WT3 \\ WT4 \\ WT5 \end{bmatrix} = \begin{bmatrix} 0.07370 \\ 0.05984 \\ 0.07090 \\ 0.07928 \\ 0.05485 \\ 0.05614 \\ 0.61640 \\ 0.07961 \\ 0.05430 \\ 0.04662 \\ 0.06374 \\ 0.05985 \\ 0.06961 \\ 0.09016 \\ 0.08001 \end{bmatrix}$$

Step 9

Based on the selected preferred solution according to T-FANP, the final step was to compare the results of calculating $\boldsymbol{W_{alternatives}}$ with the internal relationship of the alternative solutions by constructing a fuzzy matrix $\widetilde{W}_{factor\_alternatives}$. Based on the assessment of the importance of the factors $\widetilde{W}_{factor\_alternatives}$, the results of the triangular matrix are shown below.

$$\widetilde{W}_{factor\_alternatives} = \begin{bmatrix} SO1 \\ SO2 \\ SO3 \\ WO1 \\ WO2 \\ WO3 \\ WO4 \\ ST1 \\ ST2 \\ ST3 \\ WT1 \\ WT2 \\ WT3 \\ WT4 \\ WT5 \end{bmatrix} = \begin{bmatrix} 0.00057 & 0.00064 & 0.23307 \\ 0.00040 & 0.00013 & 0.04223 \\ 0.00030 & 0.00012 & 0.05210 \\ 0.00035 & 0.00018 & 0.07052 \\ 0.00024 & 0.00006 & 0.02904 \\ 0.00145 & 0.00022 & 0.02904 \\ 0.00127 & 0.00022 & 0.03678 \\ 0.00343 & 0.00053 & 0.03963 \\ 0.00042 & 0.00005 & 0.02790 \\ 0.00034 & 0.00005 & 0.02790 \\ 0.00213 & 0.00045 & 0.05668 \\ 0.00418 & 0.00106 & 0.07179 \\ 0.00208 & 0.00048 & 0.06746 \\ 0.42022 & 0.51641 & 0.00078 \\ 0.56262 & 0.47940 & 0.21509 \end{bmatrix}$$

When the evaluation of the relationship between wide tile $\widetilde{W}_{factor\_alternatives}$ and $W_{alternatives}$ the following results were obtained.

$$W'_{alternatives} = W_{alternatives} \times \widetilde{W}_{factor_{alternatives}}$$

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$$\begin{bmatrix} 0.07370 \\ 0.05984 \\ 0.07090 \\ 0.07928 \\ 0.05485 \\ 0.05614 \\ 0.61640 \\ 0.07961 \\ 0.05430 \\ 0.04662 \\ 0.06374 \\ 0.05985 \\ 0.06961 \\ 0.09016 \\ 0.08001 \end{bmatrix} \times \begin{bmatrix} 0.00057 & 0.00064 & 0.23307 \\ 0.00040 & 0.00013 & 0.04223 \\ 0.00030 & 0.00012 & 0.05210 \\ 0.00035 & 0.00018 & 0.07052 \\ 0.00024 & 0.00006 & 0.02904 \\ 0.00145 & 0.00022 & 0.02904 \\ 0.00127 & 0.00022 & 0.03678 \\ 0.00343 & 0.00053 & 0.03963 \\ 0.00042 & 0.00005 & 0.02790 \\ 0.00034 & 0.00005 & 0.02790 \\ 0.00213 & 0.00045 & 0.05668 \\ 0.00418 & 0.00106 & 0.07179 \\ 0.00208 & 0.00048 & 0.06746 \\ 0.42022 & 0.51641 & 0.00078 \\ 0.56262 & 0.47940 & 0.21509 \end{bmatrix} = \begin{bmatrix} SO1 \\ SO2 \\ SO3 \\ WO1 \\ WO2 \\ WO3 \\ WO4 \\ ST1 \\ ST2 \\ ST3 \\ WT1 \\ WT2 \\ WT3 \\ WT4 \\ WT5 \end{bmatrix} = \begin{bmatrix} 0.00587 \\ 0.00084 \\ 0.00122 \\ 0.00186 \\ 0.00052 \\ 0.00056 \\ 0.00077 \\ 0.00113 \\ 0.00050 \\ 0.00043 \\ 0.00124 \\ 0.00152 \\ 0.00161 \\ 0.02819 \\ 0.03363 \end{bmatrix}$$

4.5. Discussion of the results of the model

As a result of the T-FNAP model, the research identified priority solutions for agricultural production in the context of climate change in Ninh Thuan (Table 14). The preferred solutions are ranked in the following order: WT5 - WT4 >SO1 - WO1-WT3>WT2-WT1-SO3-ST1-SO2-WO4>WO3-WO2-ST2-ST3. With these 15 solutions, the research was divided into three groups, with the performance phase ranked in Table 14 and Figure 4.

Table 14
Prioritization of finalized solutions for agriculture in the context of climate change

Priority	Weight	Solution	Explanation
1	0.429	WT5	Identify drought risks for each locality and each type of farming
2	0.352	WT4	Assess the impact of drought for each region, each type of farming
3	0.073	SO1	Expand the market for agricultural products
4	0.023	WO1	Develop a policy framework and crop conversion for drought-stricken areas
5	0.020	WT3	Train human resources, increasing investment in disaster warning and monitoring systems
6	0.019	WT2	Develop insurance policies in agricultural production
7	0.016	WT1	Adjust planting time
8	0.015	SO3	Re-plan cultivation areas according to the strengths of each locality
9	0.014	ST1	Increase investment, expand and upgrade irrigation systems
10	0.010	SO2	Focus on investing in crops with high economic value.
11	0.010	WO4	Change the farming model for crops to suit irrigation water conditions.
12	0.007	WO3	Call for investment in irrigation systems according to key areas of cultivation
13	0,007	WO2	Call for scientific research projects in the field of agriculture adapt.
14	0.006	ST2	Support businesses to invest in applying science and technology to hi-tech agricultural production
15	0.005	ST3	Promote the people’s ability and experience of self-adaptation in agricultural production.

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In Phase 1, the solution's scores range from 0.429 (WT5) to 0.352 (WT4), with two solutions focusing on drought assessment and identification. Under the influence of climate change, the drought situation in Ninh Thuan is currently becoming increasingly complicated, so it is necessary to identify the risks of drought occurrence. Identifying drought risks will help localities adjust cropping plans to local conditions. The second solution is to assess the impact of drought for each region, locality, and farming type. Although the drought occurs throughout the province, not all localities are affected equally, and each crop's drought tolerance is different. Therefore, assessing the impact of drought needs to involve an assessment of each crop's minimum level and adaptability. Assessing the impact on a large and general territory is not advisable because this may lead to developing plans suitable for one locality but not another.

In Phase 2, the solutions are SO1 (0.073), WO1 (0.023), and WT3 (0.020). It is necessary to pay attention to the market for agricultural products and crops with high economic value at this stage. Especially for drought-stricken areas, it is necessary to choose crops that are suitable for this type of area. In addition, it is necessary to train local human resources and disaster early warning systems.

In Phase 3, the solution groups are WT2 (0.019), WT1 (0.016), SO3 (0.015), ST1 (0.014), SO2 (0.010), and WO4 (0.010). In this group, insurance in agriculture is the first solution that should be implemented. Ninh Thuan is an agricultural province, but the development of insurance policies in agriculture is almost nonexistent. Therefore, for people to feel secure in production and receive support from agricultural insurance (in case of drought), the strengthening of availability of agricultural insurance for each household operating in the province's agricultural sector is recommended.

The final phase implements solutions WO3 (0.007), WO2 (0.007), ST2 (0.006), and ST3 (0.005). In this phase, farming models are can be adjusted through upgrading irrigation for agricultural areas. In addition, local authorities should call for scientific research in adaptive agriculture and, simultaneously, support enterprises that invest in applying science and technology to high-tech agricultural production.

This model evaluated the priority solutions in Ninh Thuan, Vietnam, using the T-FANP model. It is dynamic, and any change in the model depends on the change of factors in the SWOT analysis and the TOWS matrix. Therefore, the proposed solutions may change along with the characteristics of the internal and external environment in the study area. Figure 4 depicts the process of implementing solution groups with different stages. However, it is essential to have a well-defined roadmap for implementing solutions. After completing a set of solutions, it is crucial to assess their effectiveness. Based on the effectiveness or ineffectiveness of the solutions, the analyst can recalculate and readjust

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each element of the SWOT group to adjust the alternative solutions to suit customers' needs.

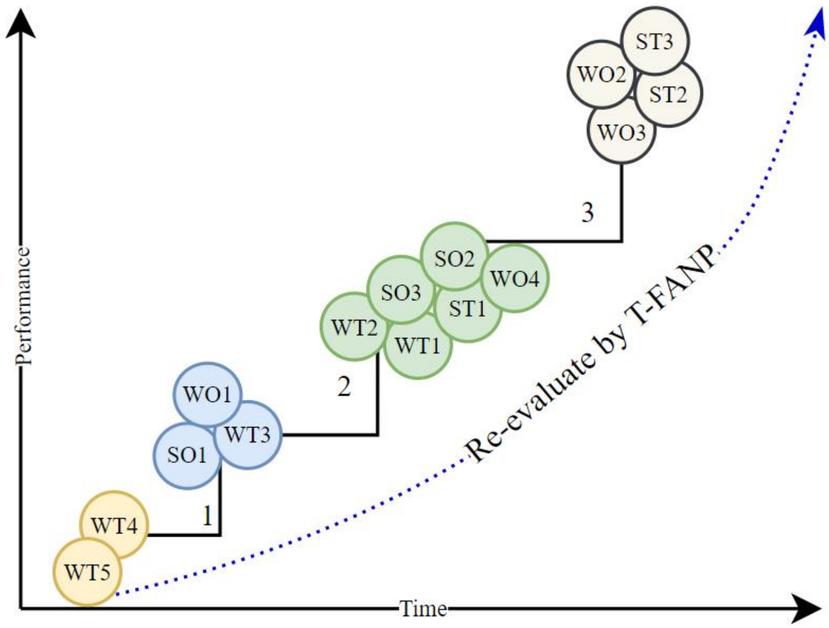

Figure 4 Process of implementing solutions based on priority solutions

5. Conclusion

The study proposed solutions for agricultural production in Ninh Thuan, Vietnam in the context of climate change using T-FANP. The research has also built group solutions with specific tasks proposed through priority solutions. The first group includes WT5 and WT4 solutions; the second group of solutions includes SO1, WO1, and WT3; the third group of solutions is WT2, WT2, SO3, ST1, SO2, and WO4; and the fourth group of solutions includes WO3, WO3, ST2, ST3. The first task is to identify and assess the impact of climate change through drought.

Research findings have further highlighted the efficacy of MCDM both quantitatively and qualitatively, leveraging fuzzy logic. The strength of the research lies in enhancing objectivity and the stakeholders' role. On the other hand, the T-FANP model also seems to have issues that need further discussion, such as expert participation in scoring. None of the previous studies were concerned with the number of experts participating in the assessment. Therefore, subsequent studies may discuss and suggest how many experts are sufficient for a study using MCDM. The FANP method assessed the research objectives by proposing strategies; however, this method also has several limitations related to time and expert evaluation. In terms of time, this method is highly time-consuming as it requires multiple interactions with experts to achieve a relatively objective result. Second, there are challenges due to varying levels of expertise among the experts, leading to changing perspectives after multiple rounds of evaluation. Finally, in future research, to gain a deeper understanding and analysis of the inherent characteristics of natural and socio-economic factors influencing decision-making, studies may apply AHP or ANP individually.

The research serves as a foundation for Ninh Thuan province in the selection of suitable agricultural production strategies amidst drought conditions. Additionally, it provides local analysts with an interdisciplinary approach and the integration of methods in strategic decision-making. Therefore, local authorities must conduct a SWOT analysis for proposed solutions and seek stakeholder input to develop weight sets when utilizing this study. The step-by-step implementation plan for prioritized solutions in Ninh Thuan should have a defined timeframe aligned with regional planning, from 1 to 5 years or 5 to 10 years.

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