INTEGRAL SWOT-AHP-TOWS MODEL FOR STRATEGIC AGRICULTURAL DEVELOPMENT IN THE CONTEXT OF DROUGHT: A CASE STUDY IN NINH THUAN, VIETNAM

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ABSTRACT

The study combined a qualitative analysis model and quantitative analysis to rank strategies in agricultural production in Ninh Thuan province, Vietnam. A strength, weakness, opportunity, and threat (SWOT) analysis is used to evaluate the characteristics of internal and external factors through the TOWS matrix. The research used the Analytical Hierarchy Process (AHP) to compare and rank the influence of the criteria on agricultural production. The AHP method quantified the weights of the factors in the TOWS matrix based on a pairwise comparison of the elements. The research results show that the AHP technique can help make the decisions of policymakers easier rather than making decisions based on qualitative uncertainty. The SWOT-AHP-TOWS model provides a new approach to drought in Vietnam using a quantitative tool based on multi-criteria analysis.

Keywords: SWOT; AHP analysis; MCDM; TOWS matrix, drought agriculture, Vietnam

1. Introduction

Selecting a strategy for a development plan is an important task to assist managers in achieving their goals. The choice of criteria for developing a process is essential, and it is even more critical to assess the value of each factor. Multiple-criteria decision-making (MCDM) is a group technique that assists policy planners in making decisions by reviewing all criteria and goals (Büyüközkan et al., 2019; Kumar et al., 2017). MCDM techniques are well suited to solve complex problems and situations by analyzing various criteria based on expert selection (Khan & Ali, 2020). MCDM is both a quantitative and a qualitative tool (Khan & Ali, 2020); therefore, MCDM can be implemented with many different algorithms (Dehghanimohammadabadi & Kabadayi, 2020; Khan & Ali, 2020; Lohan et al., 2020).

Currently, the application of the MCDM model is very diverse, being implemented in many different fields from the economy to society and the environment. Many different

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algorithms have been used with the MCDM technique, including the Analytic Hierarchy Process (AHP) (Bellahcene et al., 2020; Dixon-Ogbechi & Adebayo, 2020; Garg & Ganesh, 2020), the Analytic Network Process (ANP) (Arsic et al., 2017; Azizi & Mansouri, 2021, 2021; Kabak et al., 2016; Živkovi & Mihajlovi, 2015), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Arabzad et al., 2015; Ozkaya & Erdin, 2020; Solangi et al., 2019a), Vlse Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR) (Büyüközkan et al., 2019; Opricovic & Tzeng, 2004), Stochastic Multicriteria Acceptability Analysis (SMAA) (Kajanus et al., 2012; Kangas et al., 2003), weighted product model (WPM) (Goepel, 2018), Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) (Gul et al., 2018), Simple Multi-Attribute Rating Technique (SMART) (Lavik et al., 2020), and many other methods that can be reviewed in the studies of Genç et al. (2018) and Kumar et al. (2017).

This study will provide an AHP analysis to select the most optimal agricultural activities under drought conditions in Ninh Thuan province. The AHP is a popular MCDM methodology (Dehghanimohammadabadi & Kabadayi, 2020; Haque et al., 2020), a technique used to prioritize attributes that influence decision-making to select an alternative based on the relative importance of the attributes (Lohan et al., 2020; Saaty, 1980). In addition to preparing the AHP analysis data, the study was combined with the SWOT analysis using the TOWS matrix. SWOT is a popular technique for strategic planning (Helms & Nixon, 2010; Osuna & Aranda, 2007). This analysis is responsible for evaluating internal and external factors through a relationship analysis of factors (Houben et al., 1999). However, the SWOT analysis provides only the decision-making information environment without ranking the strategy or elements of the SWOT analysis (Genç et al., 2018). Consequently, the research will use MCDM to support decisions through SWOT and AHP analyses. This combination aims to strengthen and improve the information basis of the decision-making and strategies (Kajanus et al., 2012).

2. Research method

2.1. SWOT analysis

The SWOT analysis is used to strategically analyze activities based on their Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T). The SWOT study began in the United States between 1960-70 as part of a research project conducted by Albert Humphrey and a research team at Stanford University. The team developed a tool to analyze strategies and understand the causes of business failure, and initially, this method was called SOFT (Sidharth Thakur, 2010). SOFT analysis was studied with 500 companies and 1,100 organizations, and ended with the efforts of 5,000 executives between 1960-1969 (Humphrey, 2005).

At a long-range planning workshop in Zurich, Switzerland in 1964, economists Urick and Orr proposed replacing the F with W (Sidharth Thakur, 2010). This version was used until 1966 and improved and blended in 1973 at J.W. French Ltd. Until 2004, several tweaks were made until the SWOT analysis was perfected and used in many parts of the world (Humphrey, 2005). SWOT analysis is an analytical method that helps plan the development strategy of decision-making (Görener et al., 2012). The construction of the elements in a SWOT analysis is based on identifying the internal and external aspects of the strategy to be implemented (Kangas et al., 2003; Yuksel & Dagdeviren, 2007; Živkovi & Mihajlovi, 2015). Using a SWOT analysis helps leaders set goals in their field and achieve the desired performance while in environmental transformation (Houben et al., 1999). Furthermore, the results of SWOT selection are the starting platform for identifying and selecting feasible strategies that help stimulate and expand the activity (Dyson, 2004).

The SWOT analysis has been widely used in economics, society, and environmental research. For example, it has been used in research on tourist marketing in Sri Lanka (Wickramasinghe & Takano, 2010), a management strategy for the Turkish dyeing industry (Yuksel & Dagdeviren, 2007), strategic development of agricultural products (Elyaspour & Bahmani, 2016), plans to expand the aviation industry (Sevkli et al., 2012), analysis of the hospitality industry (Hung, 2013), and analysis of the global competitiveness of machine tools (Shinno et al., 2006). In the environmental field, research into the development of industrial parks in India (Patnaik & Poyyamoli, 2015), an application for the management of Greek coastal groundwater (Kallioras et al., 2010), hydrology research (Nathan, 2007), and a sustainable energy sector development strategy (Markovska et al., 2009) are some examples of its application.

On the other hand, the SWOT analysis also presents specific gaps in the factor measurement and assessment process. The main limitation of a SWOT analysis is the non-quantification of the importance of each factor in the decision-making process, and also its failure to evaluate the effect of each SWOT factor on individual strategies (Arsić, 2017; Hill & Westbrook, 1997). However, the advent of MCDM has made the SWOT analysis more objective in improving SWOT, and this method is used in many social fields (Görener, 2012; Markovska et al., 2009; Partani et al., 2013). Currently, many studies have highlighted the application of SWOT analysis to MDCM, such as SWOT-AHP, SWOT-FAHP, SWOT-ANP, SWOT-FANP, and SWOT-TOPSIS (Aghasafari et al., 2020; Arsic et al., 2017; Karimi et al., 2019; Solangi et al., 2019b).

2.2. TOWS matrix

This strategy is constructed by interacting with internal and external factors (Weihrich, 1982). This analysis has been widely applied in identifying strategies (Asadpourian et al., 2020; Gottfried et al., 2018). Using the TOWS matrix leverages the SWOT analysis of the strengths, weaknesses, opportunities, and threats within and outside the system (Chanthawong & Dhakal, 2016). The advantage of this strategy is the influence of internal and external factors, which are prioritized for elements included in alternative methods (Wickramasinghe & Takano, 2010). Table 1 presents the TOWS matrix subdivided into internal (S, O) and external (O, T) factors. The strategy is constructed through internal and external factors (Haque et al., 2020; Wickramasinghe & Takano, 2010) and on a database from a SWOT analysis (Gottfried et al., 2018). The TOWS matrix study comprises four pairs: SO, ST, WO, and WT (Asadpourian et al., 2020). Inside, SO is the directional strategy for development based on forces to take advantage of external opportunities, and ST is a strategy to mitigate the impacts of external risks through internal forces. The WO strategy uses internal weaknesses to harness external opportunities, and WT is a defensive strategy to reduce the disadvantages of the critical sides to limit external dangers. The TOWS matrix will be used for agriculture production in the context of drought in Ninh Thuan (Table 1).

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Table 1
TOWS matrix analysis

External factors	Internal factors	
	Strengths (S) S1 S2 Sn	**Weaknesses (W)** W1 W2 Wn
Opportunities (O) O1 O2 On	**Strategic: SO** Use internal forces to exploit external opportunities.	**Strategic: WO** Use the weaknesses of the interior to exploit the opportunities of the exterior.
Threats (T) T1 T2 Tn	**Strategic: ST** Apply internal forces to reduce external risks.	**Strategic: WT** Develop strategies to reduce internal weaknesses to minimize external risks.

With the TOWS matrix, it is possible to see the preference for prioritization of future elements (T;O) over those of the past (S;W) (Arsic et al., 2017; Weihrich, 1982). Therefore, during strategic analysis with the TOWS matrix, the evaluator needs to consider the choice of time; it is possible to start TOWS from the past, then move to the present, and then analyze them in the future (Figure 1). It is also necessary to focus on different periods to evaluate the matrix. Usually, the external environment is dynamic, and any change can lead to other factors (Arsic et al., 2017; Weihrich, 1982). Therefore, it is necessary to prepare a TOWS matrix and evaluate its performance for future periods.

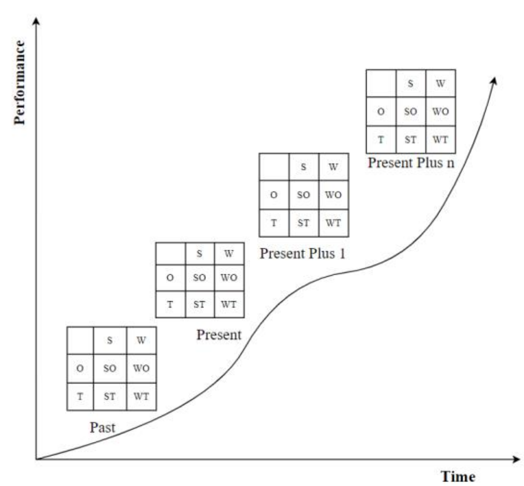

Figure 1 Performance and time of TOWS analysis
Source: (Arsic et al., 2017; Weihrich, 1982)

2.3. AHP analysis

The AHP analysis is a MCDM technique (Al-Rahbi et al., 2020; Dehghanimohammadabadi & Kabadayi, 2020; Garg & Ganesh, 2020; Kopytov et al., 2011; Kou et al., 2013). It was developed by Thomas Saaty to make complex decisions (Mantogiannis & Katsigiannis, 2020; T. L. Saaty, 1980, 1996, 2005). The AHP compares

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pairs of factors to prioritize them using separate calculations for each element (Görener et al., 2012). The AHP method approximates the criteria to prioritize them using the eigenvalue computation. There are several outstanding advantages to the method, such as its ability to assess the importance of the requirements through comparing standards, the fact that the process is easy to understand, and that it is a qualitative and quantitative analysis. The AHP method can be easily combined with other methods to quantify the factors in scoring the criteria and can check the consistency of the decision maker's assessment.

This approach helps decision-makers choose strategies that match the objective of choice. The hybrid approach's application aims to enhance the quantitative aspect of strategic planning. The AHP analysis model is based on T. L. Saaty & Vargas (2012) and Kou et al. (2013) as shown in Figure 2.

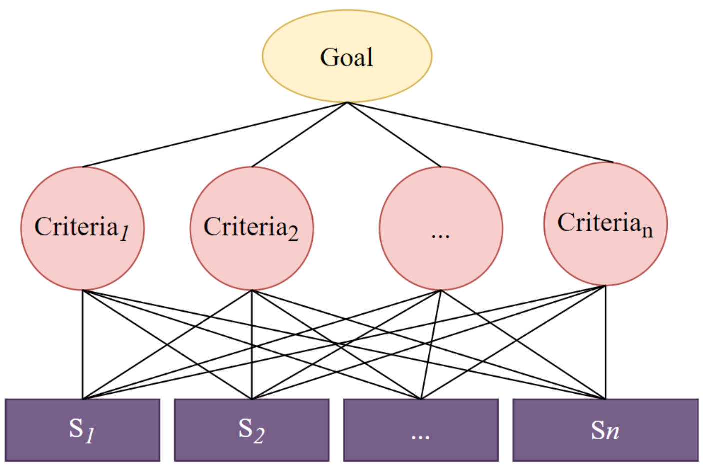

Figure 2 Three-hierarchical structure model of AHP analysis

The AHP analysis is generally based on five basic steps as follows (Kou et al., 2013): (1) Analyze and problem-solve; (2) Construct a set of pairwise comparison matrices; (3) Calculate eigenvalues and eigenvectors; (4) Check the consistency of all comparison matrices; (5) Summarize the absolute priorities of alternatives to make the decision. In the above steps, attention should be paid to calculating the values and checking the consistency ratio (CR).

According to Saaty, a 9-point scale (Table 2) quantifies intangible attributes or criteria into measurable numbers by arranging the pairs to be compared in a matrix (Kou et al., 2013; R.W. Saaty, 1987; T.L. Saaty, 1978; T.L. Saaty & Vargas, 2012).

Table 2
Saaty's rating scale

Rating scale	Definition	Explanation
1	Equally important	These two values contribute equally to the objective.
3	Weak importance	Experience and judgment are somewhat more susceptible to one activity than to another.
5	More important	Experience and judgment are more in place in one activity than in others.
7	Very important	Intense activity and influence have been shown in practice.
9	Extremely important	The evidence for one activity over another is as strong as possible.
2, 4, 6, 8	Intermediate between two adjoining judgments.	Compromise needed between comments.
If activity *a* has one of the above nonzero numbers assigned to it compared to activity *b*, *b* has the inverse value compared to *a*		

Equations 1 and 2 are used to calculate the consistency ratio (CR) and to capture uncertainty in the judgment (Dehghanimohammadabadi & Kabadayi, 2020; Kou et al., 2013).

$$CR=\frac{CI}{RI} \quad (1)$$

And

$$CI=\frac{\lambda_{max} - n}{n-1} \quad (2)$$

Where λ_{max} is the highest eigenvalue in the matrix, n is the number of groups, CI is the consistency index, and RI is the random index.

Table 3
Mean Random Consistency Index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

Source: (T.L. Saaty & Vargas, 2012)

The RI value is displayed in Table 3. The value of CR below or equal to 0.1 or 10% is acceptable, and if the CR is greater than 10% we must consider the matched comparisons (Hussey, 2014; Nguyen & Liu, 2019; T. L. Saaty & Vargas, 2012; Wilford et al., 2020; Yavuz & Baycan, 2014).

2.4. Hybrid SWOT-AHP-TOWS

Although SWOT analysis identifies and describes the internal factors, it has shortcomings in the measurement and evaluation of the weight of each inner element of the SWOT group (Yuksel & Dagdeviren, 2007). In addition, the SWOT analysis results are only qualitative, incompletely express value in terms of internal and external factors, and lead to a failure to comprehensively evaluate the strategy (Hill & Westbrook, 1997; Kangas et al., 2003; Shinno et al., 2006; Yuksel & Dagdeviren, 2007). Therefore, more tools need to be considered and selected to assess the significance of each internal and external value of the SWOT analysis. The SWOT-AHP model is a quantitative strategy that analyzes SWOT analysis factors (Gao & Peng, 2011; Haque et al., 2020; Yavuz & Baycan, 2014). The functionality of this method is a paired comparison of internal and external SWOT factors (Shinno et al., 2006).

The application of the SWOT-AHP model is widely used in the multi-criteria analysis, such as the study for improving service at service stations (Gonzalez & Pradenas, 2019), integrated watershed management (Yavuz & Baycan, 2014), research on the development of healthcare services (Osuna & Aranda, 2007), policy planning for the education sector (Malik, 2013), sustainability of waste management (Felice et al., 2013), agricultural development (Nasab & Azizi, 2014b, 2014a), manufacturing business development strategy (Görener, 2012), support policies for transportation in Europe (D'Adamo et al., 2020), a strategy to develop the Korean satellite and space industry (J. Lee et al., 2021), resolution of internal conflicts in wetland conservation (Pournabi et al., 2021), conversion of biomass refineries in the pulp and paper industry in Europe (Brunnhofer et al., 2020), studies on transboundary trade in Bangladesh (Haque et al., 2020), and the energy planning strategy for Pakistan (Solangi et al., 2019b). In Vietnam, the SWOT-AHP model has been studied in several fields, including research on business strategies for the shipping industry (Thành, 2020), desertification and drought in agriculture production (Hương, 2015), research into sustainable development for lobster farming (Ton Nu Hai & Speelman, 2020), and a study on the competitiveness of the logistics industry (Linh, 2018).

This study aims to combine the SWOT-AHP model with the TOWS matrix to create a SWOT-AHP-TOWS model for selecting a priority strategy. The integrated model is a strategic tool for the bottom-up approach and is widely used for policy formulation (Chanthawong & Dhakal, 2016; Haque et al., 2020). The SWOT-AHP-TOWS model is easy to apply (Gottfried et al., 2018) and can be easily combined with quantitative and qualitative analysis (Chanthawong & Dhakal, 2016). It is used for research in many fields, such as the power trade in Bangladesh (Haque et al., 2020), strategic management of natural resources (Cajanus et al., 2012), policy development on biodiesel and bioethanol in Thailand (Chanthawong & Dhakal, 2016), study on strategic options for private investment in the biogas sector in China (Gottfried et al., 2018), sustainable ecotourism development in Iran (Asadpourian et al., 2020), and the sustainability of ecotourism in Djercdap National Park in Serbia (Arsic et al., 2017).

The above studies are often in regional contexts and are very general (Haque et al., 2020). They are not directly related to the problem being studied in Vietnam. The strength of this model can be seen in the quantification of each criterion in the SWOT analysis. This model transfers qualitative variables to quantitative variables and helps the decision-maker see the order of the criteria.

In contrast, if only the SWOT analysis is used, the results are qualitative and very subjective regarding strategic options. Therefore, this combination model is more appropriate and has more objective decision-making than other qualitative methods. The model is shown in Figure 3.

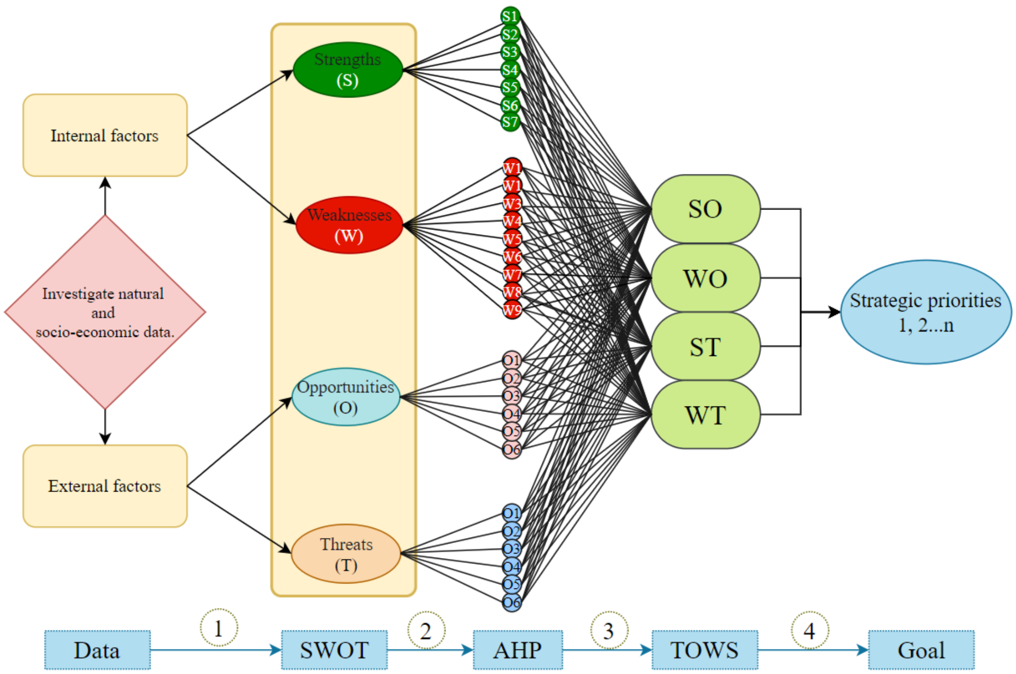

Figure 3 Analysis diagram of SWOT-AHP-TOWS model

Figure 3 shows that the SWOT-AHP-TOWS model is implemented by the following steps: (1) Building the SWOT analysis information through internal factors (strengths and weaknesses) and external factors (opportunities and threats); (2) Comparing each pair to compute the weight of each group in the SWOT analysis; (3) Using AHP analysis to prioritize each factor in the analysis groups; (4) Prioritizing and selecting strategies.

3. Case study of Ninh Thuan, Vietnam

3.1. Ninh Thuan province

Ninh Thuan is a province located in South Central Vietnam (Figure 4) that has a humid and semi-arid climate (Vinh et al., 2013). According to research by scientists, Ninh Thuan is considered an extreme drought region and at risk of desertification (Thao et al., 2018; Truong, 2008; Tuan & An, 2016). The region has seen severe droughts in 1988, 1993, 1998, 2001, 2002, 2004, and 2005, causing significant damage to the agricultural sector and socio-economic activities (Tuan & Canh, 2021). In 2015-2016, Ninh Thuan experienced its worst period of drought, which was the first time the local government declared a drought emergency in the whole province (Thao et al., 2018). According to research, drought has reduced agricultural land area by 83.2%, reduced crop yield by 84.6%, and reduced the quality of agricultural products by 80.3%. (Nam & Trang, 2019). According to Pham Quang Vinh (2013), drought profoundly impacts socio-economic

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activities, and agriculture is the most affected (Vinh, 2015). Therefore, Ninh Thuan needs to have strategic solutions for agricultural development in the context of drought.

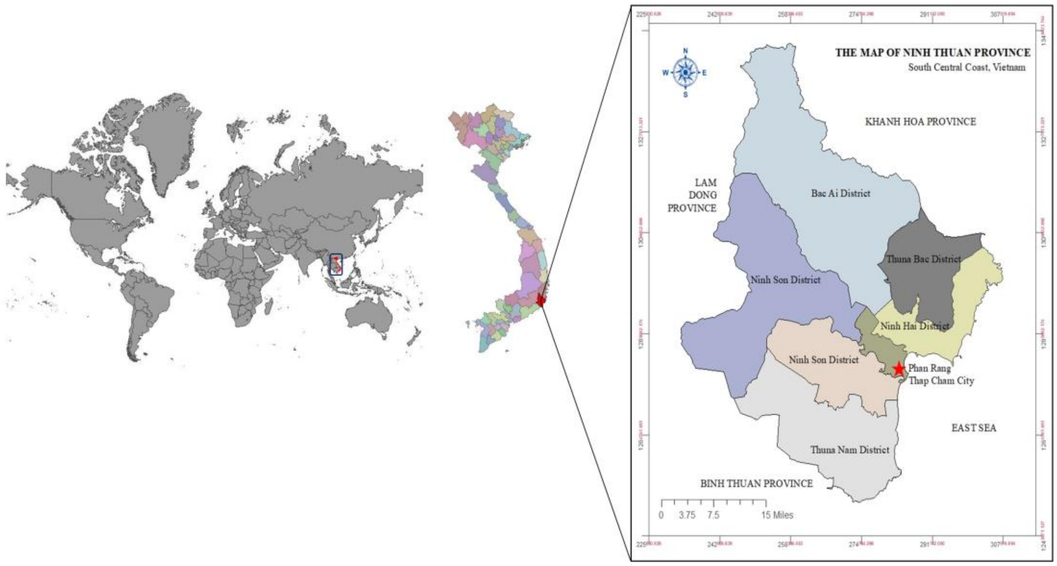

Figure 4 Location map of the research area

3.2. Research data

The study uses research data from experts in drought and agriculture in Vietnam. Drought data and data about drought’s effect on agricultural production are used. The drought data includes research using documents about climate change trends and future climate forecasts for Ninh Thuan province (Tuan & Canh, 2021), rainfall trends in Ninh Thuan in the context of climate change by non-parametric methods (Tuan & Canh, 2020), drought and climate change in Ninh Thuan province (Vinh, 2015), research on climate characteristics of Ninh Thuan province (Nam et al., 2018), and investigation, evaluation and proposals for integrated management measures to limit land degradation due to drought and desertification in Ninh Thuan (Gai et al., 2018). Data on the impact of drought on agricultural production has been collected including research on planting techniques of some indigenous tree species with economic value in arid areas of Ninh Thuan and Binh Thuan provinces (Dung et al., 2012), assessing the effects of agro-climatic conditions on short-term crops in Ninh Thuan and Binh Thuan (Vinh et al., 2013), and studying desertification and degradation land conversion to agricultural production in Ninh Thuan province (Truong, 2015).

3.3. Results and discussion

Phase 1: SWOT model in agriculture in Ninh Thuan province

The SWOT analysis is based on a detailed analysis of Ninh Thuan province's natural and socio-economic characteristics. The research focuses on terrain, climate, rivers, soil, organisms, temperature, precipitation, and climate change with natural elements. In addition to the socio-economic characteristics, the study focuses on assessing growth rate, socio-economic planning policies for agriculture, and policies to attract scientific research, demographics, markets, and labor qualification. In relation to external factors, the study focuses on the agricultural planning policy of the state, the development policy of neighboring regions, the scientific research and its application in the country, and the climate change situation in Vietnam. The internal and external factors and selected factors were identified through a survey with experts asking their opinions on the elements of the SWOT group. The experts participating in the assessment of the SWOT analysis framework include local and non-local experts who have studied drought in the Ninh Thuan area. Fourteen experts were selected for the research including ten from research institutes and universities and four from Ninh Thuan province (Table 4).

Table 4
Experts participating in the survey/scoring

Expert	Academic Titles	Fields of research/department
Expert 1	Prof., PhD	Water Resources and Drought Management
Expert 2	Assoc. Prof., Dr	Earth Sciences and Climate Change
Expert 3	Assoc. Prof., PhD	Socio-Economic Geography
Expert 4	Assoc. Prof., PhD	Environmental Science, Engineering and Management
Expert 5	Assoc. Prof., PhD	Geographic Information Systems, remote sensing, and drought management
Expert 6	Assoc. Prof., PhD	Drought management
Expert 7	PhD	Human Geography
Expert 8	PhD	Regional Sustainable Development
Expert 9	PhD	Human Geography
Expert 10	PhD	Earth Sciences
Expert 11	Master	Department of Natural Resources and Environment of Ninh Thuan Province
Expert 12	Master	Department of Science and Technology of Ninh Thuan Province
Expert 13	Master	Department of Agriculture and Rural Development of Ninh Thuan Province
Expert 14	Master	Center of Hydro-Meteorological Forecasting of Ninh Thuan Province

A TOWS matrix was created through a four-step process of building a SWOT analysis as follows:
Step 1: Synthesize relevant documents mentioned in Section 3.1 of the research data.
Step 2: Deploy the survey and consult experts on the contents of the SWOT analysis through scoring.
Step 3: Re-check the elements in the additional SWOT analysis and remove the non-conforming factors based on expert judgments.
Step 4: Select the factors in the SWOT analysis with an average score of 5.0 or higher.

These steps helped select the internal factors (strengths, weaknesses) and external factors (opportunities, threats). The elements in the SWOT analysis are shown through the TOWS matrix (Table 5).

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Table 5
TOWS matrix for agricultural production strategy of Ninh Thuan province

External factor	**Internal factor**	
	Strengths (S)	**Weakness (W)**
	(S1). Diverse terrain and soils (S2). The number of days and sunny hours is favorable for annual planting (S3). The irrigation system is gradually upgraded and invested in (S4). People have extensive experience in production in drought conditions. (S5). There is a policy to attract and apply science and technology to the agricultural sector (S6). High-tech agricultural cluster planning policy (S7). There are many critical crops of high economic value	(W1). Water sources in reservoirs and groundwater are increasingly depleted. (W2). The dry season is prolonged, and there is a high potential for evaporation. (W3). Average annual precipitation is low and very unevenly distributed. (W4). Drought usually occurs in the dry season, and soil degradation is ongoing. (W5). Agricultural production greatly depends on nature (W6). People's ability to proactively prevent and mitigate natural disasters is low. (W7). Agricultural land is on a downward trend due to industrialization and urbanization. (W8). Disaster forecasting and warning work are limited and not close to reality (W9). Human resources with expertise in disaster management are lacking.
Opportunity (O)	**Strategy: SO**	**Strategy: WO**
(O1). Policies support national crop conversion and agricultural production policies in drought-affected areas. (O2). The trend of applying science and high technology to sustainable agricultural production adapting to drought	(SO1). Focus on investing in the production of critical crops of high economic value. (SO2). Expand the market for vital agricultural products.	(WO1). Develop policies and transform farming in drought-affected areas (WO2). Call for scientific research projects in the field of agriculture

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(O3). The policy of restructuring the agricultural sector and forming regional link chains for critical products (O4). Near the market of large agricultural products in the country. (O5). Domestic and international cooperation, scientific research projects. (O6). NGOs' concerns about natural disasters caused by drought and climate change		
Threats (T) (T1). The hard-to-assess activity of climate change (T2). Dry season flows tend to decrease (T3). Drought and desertification are on the rise (T4). The irrigation development policy of neighboring areas (T5). The trend of the labor movement in agriculture (T6). No insurance policy for agriculture	**Strategy: ST** (ST1). Increase investment, expansion, and upgrading of irrigation systems. (ST2). Support enterprises to invest in the application of science and technology to agricultural production	**Strategy: WT** (WT1). Adjust the time of planting (WT2). Develop of insurance policies in agricultural production (WT3) Train human resources, increase investment in disaster warning and monitoring systems

Based on evaluation of the factors in the TOWS matrix, the research has combined pairs of SO, WO, ST, and WT (Table 5). The results of the proposed solutions for the couples are as follows. Research on the SO pair suggests the following two solutions: focus on investing in the production of critical crops of high economic value (SO1) and expand the market for vital agricultural products (SO2). The study proposes two solutions for the WO pair as follows: develop policies and transform farming in drought-affected areas (WO1) and call for scientific research projects in agriculture (WO2). The ST solutions include increasing investment, expansion, and upgrading irrigation systems (ST1) and supporting enterprises to apply science and technology to agricultural production (ST2). The WT pair solutions include strategies such as adjusting the time of planting (WT1), developing insurance policies in agricultural production (WT2), training human resources, and increasing investment in disaster warning and monitoring systems (WT3).

It has been demonstrated that the SO strategy maximizes internal resources by making the most of external opportunities. The WO strategy shows that it is necessary to minimize weaknesses and maximize opportunities from external factors. The minimal ST strategy involves defining a production strategy based on internal resources while minimizing impacts from external threats; WT is the ultimate strategy for identifying solutions in agriculture to reduce weaknesses and avoid external challenges (Arsic et al., 2017; Weihrich, 1982).

Phase 2: Calculating the weights of factors in the TOWS matrix by AHP analysis

Since the decision-making process is often not easy, objective judgment and subjective evaluation must be considered when making decisions (Arsić, 2017). In addition, to establishing criteria, it is necessary to reconcile and accept ambiguous assessments, and different levels of expert interest (Yu et al., 2005). A comparison of the weights of the S, W, O, and T factors based on expert selection and scoring are shown in Table 6.

The comparison matrix of the factor pairs of the analysis, SWOT, shows that the CR of this comparison is satisfactory and acceptable, with CR = 0.0631 (CR≤0.1). The results of comparing S pairs with weighted WOT is 0.416 (rank 1); W with weighted SOT gives 0.198 (rank 2); O with weighted SWT gives 0.236 (rank 2); and T with a weighted SWO yields 0.150 (rank 4). This comparison shows the importance of strengths (S) and opportunities (O) which rank 1 and 2, respectively.

Table 6
Pairwise comparison of the SWOT factors

SWOT	S	W	O	T	Weight	Ranking
S	1	2	2	3	0.416	1
W	1/2	1	1/2	2	0.198	3
O	1/2	2	1	1	0.236	2
T	1/3	½	1	1	0.150	4
CR=0.0631						

The process was combined with an AHP analysis where experts calculated the weight of the SWOT group. The evaluation findings were demonstrated by the internal comparison of factors with the CR of satisfactory SWOT components with CR < 0.1 (Tables 7, 8, 9, and 10). In the group of strengths, local weights of strengths that have factors directly or indirectly related to agriculture in Ninh Thuan province were calculated. The results show that S3 ranks first, S1 ranks second, and S2 ranks third with weights of 0.263, 0.206, 0.141, respectively (Table 7). Next, the weighting of the weaknesses group shows that the human resource factor is considered the most important among the weaknesses, ranking first with a weight of 0.226 (W9); next, the problem of forecasting and warning of natural disasters (W8) had a weight of 0.192 (Table 8). The weighting results also reflected some of the weaknesses of Ninh Thuan province. In recent years, human resources with expertise in drought have been greatly reduced, and are therefore unable to handle the changes in drought patterns and the problem of forecasting and warning of natural disasters.

Table 7
Pairwise comparison matrix of the strengths

S	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**Weight**	**Ranking**
S1	1	½	1/2	1/2	3	2	2	0.141	3
S2	2	1	1/2	2	2	3	3	0.206	2
S3	2	2	1	3	3	2	3	**0.263**	**1**
S4	2	½	1/3	1	1/2	1/2	2	0.109	5
S5	1/3	½	1/3	2	1	1/2	1	0.083	6
S6	1/2	1/3	1/2	2	2	1	2	0.122	4
S7	1/2	1/3	1/3	1/2	2	1/2	1	0.077	7
CR=0.0840									

Table 8
Pairwise comparison matrix of the weaknesses

W	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**Weight**	**Ranking**
W1	1	2	2	4	3	2	½	1/3	1/2	0.123	4
W2	1	1	2	4	4	2	1/3	1/3	1/3	0.096	5
W3	1/2	1/2	1	1/2	1/2	2	1/3	¼	1/3	0.051	7
W4	1/2	1/2	2	1	3	2	1/3	½	1/2	0.081	6
W5	1/4	1/4	2	1/3	1	2	½	½	1/3	0.061	8
W6	1/2	1/2	1/2	1/2	1/2	1	½	½	1/5	0.042	9
W7	2	2	3	3	2	2	1	1/3	1/3	0.128	3
W8	3	3	4	2	2	3	3	1	1/2	0.192	2
W9	3	3	3	2	3	5	3	2	1	**0.226**	**1**
CR=0.0833											

The results of the opportunities group showed that O1 ranked first with the direct support of the national crop conversion support policy for drought-producing regions (0.326), and O3 ranked second with policy restructuring and the formation of chain links for critical products. In addition, the guidelines for attracting scientific research and collaborating with NGOs were ranked at 5 and 6, with local weights of 0.077 and 0.051 (Table 9). The evaluation matrix of threat factors shows the priority order from T6 > T5 > T1-T2 > T3 >

T4. Among the threats, T6 (0.329) is considered a top challenge for Ninh Thuan and the country. T1 and T2 have equal assessments of the difficult-to-assess activities of climate change, and the volume of dry season flows tends to decrease (Table 10).

Table 9
Pairwise comparison matrix of the opportunities

O	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**	**Weight**	**Ranking**
O1	1	2	2	3	4	5	**0.326**	**1**
O2	1/2	1	1/3	2	3	3	0.161	3
O3	1/2	3	1	3	4	3	0.262	2
O4	1/3	½	1/3	1	3	3	0.122	4
O5	1/4	1/3	1/4	1/3	1	3	0.077	5
O6	1/5	1/3	1/3	1/3	1/3	1	0.051	6
CR=0.0747								

Table 10
Pairwise comparison matrix of the threats

T	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**Weight**	**Ranking**
T1	1	½	2	2	1/2	1/2	0.135	3
T2	2	1	2	1/2	1/2	1/3	0.135	3
T3	1/2	½	1	2	1/2	1/2	0.107	4
T4	1/2	2	1/2	1	1/3	1/4	0.093	5
T5	2	2	2	3	1	1/3	0.201	2
T6	2	3	2	4	3	1	0.329	1
CR=0.0982								

Phase 3: Determining the weighting of factors in SWOT

At the end of the AHP analysis, the study determined the weight of each factor in the SWOT group. However, according to experts, it is necessary to calculate the global importance of the individual elements with the group weight of that factor. Therefore, the particular factor's global weight is calculated by the *local weights x group weights* (Lee, 2013; Wickramasinghe & Takano, 2010; Yavuz & Baycan, 2014). The results of the global weight calculation are detailed in Table 11.

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Table 11
Global weight score of SWOT group with AHP analysis

SWOT Group		Group weight	SWOT Factors	Local weight	Global weight
Internal	S	0.416	S1	0.141	0.059
			S2	0.206	0.086
			S3	**0.263**	**0.109**
			S4	0.109	0.045
			S5	0.083	0.035
			S6	0.122	0.051
			S7	0.077	0.032
	W	0.198	W1	0.123	0.024
			W2	0.096	0.019
			W3	0.051	0.010
			W4	0.081	0.016
			W5	0.061	0.012
			W6	0.042	0.008
			W7	0.128	0.025
			W8	0.192	0.038
			W9	**0.226**	**0.045**
External	O	0.236	**O1**	**0.326**	**0.077**
			O2	0.161	0.038
			O3	0.262	0.062
			O4	0.122	0.029
			O5	0.077	0.018
			O6	0.051	0.012
	T	0.150	T1	0.135	0.020
			T2	0.135	0.020
			T3	0.107	0.016
			T4	0.093	0.014
			T5	0.201	0.030
			T6	**0.329**	**0.049**

Phase 4: Ranking and selection of priority strategies

The priority of the strategies depends on the experts' choice on a scale of 0 to 5 (Table 12). The relational weighting of the SWOT factors and strategies was calculated from previous DCMD research (Fabac & Zver, 2011 ; Kandakoglu et al., 2007 ; Malik, 2013; Wickramasinghe & Takano, 2010; Yavuz & Baycan, 2014).

Table 12
Levels of relationship evaluation

Degree of relationship	**Number**
None	0
Very weak	1
Weak	2
Medium	3
Strong	4
Very strong	5

To evaluate the priority selection of the research strategies, Equation 3 was used (Kandakoglu et al., 2007; Wickramasinghe & Takano, 2010).

$$S_i = \sum_{j=1}^{n} G_j R_{ij} \qquad (3)$$

Where S_j is the total weight of the i^{th} strategy, G_j is the global weight of the j^{th} SWOT factor, R_{ij} is the degree of relationship of the i^{th} strategy and j^{th} SWOT factors, and n is the number of SWOT factors.

Next, the standardized value of strategic weights was calculated by Equation 4,

$$N_i = \frac{S_i}{\sum_{i=1}^{m} S_i} \qquad (4)$$

where N_i is the normalized weight of i^{th} strategy and m is the number of strategies.

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Table 13
Priority strategy selection matrix

SWOT Factors	**Strategy with the degree of relationship**								
	SO1	**SO2**	**WO1**	**WO2**	**ST1**	**ST2**	**WT1**	**WT2**	**WT3**
S1	3	0	1	1	3	0	0	0	0
S2	3	0	4	1	0	2	5	0	1
S3	5	3	4	1	5	1	3	0	1
S4	3	1	2	1	0	0	2	1	0
S5	2	0	2	5	0	4	2	1	2
S6	4	3	1	1	2	1	1	2	3
S7	4	3	3	1	2	0	3	2	2
W1	3	0	2	1	5	0	4	1	2
W2	3	0	2	1	4	2	5	4	2
W3	1	0	4	2	5	1	4	4	2
W4	1	0	4	3	5	1	3	5	2
W5	1	1	3	2	2	3	2	1	1
W6	0	0	1	1	0	0	1	0	0
W7	1	0	1	0	0	0	0	2	0
W8	2	0	3	2	2	0	3	2	0
W9	0	0	1	2	1	0	1	0	5
O1	2	2	4	1	4	3	2	2	2
O2	1	0	2	2	2	1	1	0	1
O3	3	5	2	1	2	2	1	3	0
O4	2	3	0	0	0	0	0	0	0
O5	0	0	0	2	0	0	1	0	2
O6	0	0	0	1	1	1	0	1	1
T1	2	1	4	3	3	0	2	2	1
T2	2	0	3	1	4	0	3	0	1
T3	2	1	2	1	3	1	2	1	1
T4	1	0	1	0	2	0	1	0	0
T5	0	1	0	0	0	0	0	0	1
T6	1	1	1	0	0	0	0	5	0
Total weight	2.397	1.299	2.310	1.224	2.099	0.991	1.955	1.260	1.182
Weight of relationship	0.163	0.088	0.157	0.083	0.143	0.067	0.133	0.086	0.080
Ranking	1	5	2	7	3	9	4	6	8

The weighting of the relationship of the SWOT factors with the proposed strategies is described in Table 13. The results of the calculations identified strategies with different weights. For example, in the strategic group of the TOWS matrix, the SO group (0.126) has the highest priority; the second is WO (0.120), the third is ST (0.105), and the last is WT (0.100). However, if we consider the priority of each strategy, there is a division of priority in the specific strategy. For example, Figure 4 shows the order of the strategy from the core going counter-clockwise with the priority strategy SO1 (0.163), the second-priority strategy WO1 (0.157), and the last-priority strategy ST2 (0.067).

With the prioritization of the strategies defined, we needed to prioritize the coordination based on the same time with strategic equal weights. Table 14 shows progress in

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implementing solutions for the agricultural sector in the context of drought. First, the priority strategy was established to select joint or individual strategies. This process shows that the priority strategy must focus on producing crops of high economic value and developing crop conversion policies for drought-stricken areas. Crops of high economic value in Ninh Thuan are mostly those that use water sparingly and are specially adapted to drought conditions. The transformation of the crop structure to drought conditions is the next most important issue because Ninh Thuan is one of the driest regions in Vietnam. To prepare for the development of the agricultural sector, it is necessary to increase investment and expand the irrigation system to adjust the planting time to suit the actual situation. Later stages focus on policies in agriculture, such as raising the market for agricultural products, building insurance policies in agriculture, and calling for investment in science and technology in agriculture.

In addition to implementing strategies, decision-makers need to define a timeline for strategy implementation (Figure 5). Since there will be big or small changes depending on the status quo, it is necessary to adjust the strategy. The PDCA cycle (Plan–Do–Check–Act) can be combined with strategies to check the performance of the implemented strategy and then make adjustments to the subsequent development strategy.

Table 14
Strategic alternatives

Strategy		**Explanation**
1	SO1	Focus on investing in the production of critical crops of high economic value
2	WO1	Develop policies and transform farming in drought-affected areas
3	ST1	Increase investment, expansion, and upgrading of irrigation systems
4	WT1	Adjust the time of planting
5	SO2	Expand the market for vital agricultural products
6	WT2	Develop insurance policies in agricultural production
7	WO2	Call for scientific research projects in the field of agriculture
8	WT3	Train human resources, increase investment in disaster warning and monitoring systems
9	ST2	Support enterprises to invest in the application of science and technology to agricultural production

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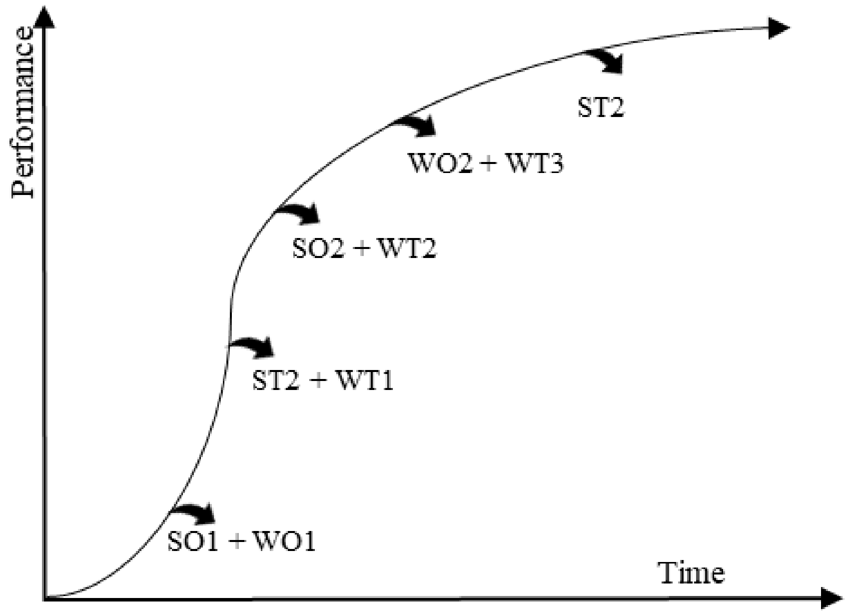

Figure 5 Performance and time of strategies

4. Conclusion

This study has successfully combined the SWOT-AHP-TOWS models to select a priority strategy in agricultural development in Ninh Thuan province in the context of drought. With an accepted CR of 0.0631, the study determined the local weighting of the factors in the SWOT group. The order of the weights is as follows: Strengths (0.416), Weaknesses (0.198), Opportunities (0.236), and Threats (0.150). The TOWS matrix is formed with strategy pairs of SO, WO, ST, and WT. By evaluating the relationship between individual factors within the SWOT group and strategies, the study calculated and selected the priority strategies for SO1, WO1, ST1, WT1, SO2, WT2, WO3, and ST2. The research results show that Ninh Thuan should implement agricultural development plans in drought conditions. The first proposed task is to increase the planting of high economic value crops based on drought adaptation (SO1). In parallel, policies are required to support drought-affected agricultural production areas (WO1).

On the other hand, the research findings also demonstrate the role of experts in the selection and assessment of strategies. Therefore, selecting experts and researchers who understand the research problem and have a strategic vision is important. For further evaluation, experts may be chosen from local researchers and non-local activists. In addition, priority strategies can only be developed quickly and adjusted for internal and external changes.

The research results show that qualitative and quantitative analysis is an effective combination for selecting solutions. These methods have solved the problem of subjectivity in the decision-making of strategic planners, and the application of MCDM in planning is essential. Thus, a strength of the research is the improvement of qualitative decisions through quantitative modeling. In addition, the analysis simplified and explained the calculation steps and strategy selection to the reader. The weakness of the research is that decisions are based on individual factors without considering the network of criteria. Therefore, it is necessary to conduct further research on the network relationship between the requirements to improve and enhance the reliability of future decisions. In the future, the SWOT-AHP-TOWS research model may be applied to agriculture and drought. First, however, it is necessary to combine this model with other MCDM methodologies to increase more effective decision-making accuracy.

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