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Assessment Of The Impact Of Surface Water Resource Changes On Urban Agriculture In Da Lat

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ABSTRACT
The variability of surface water resources has become one of the major challenges for urban agriculture development in highland cities, particularly in Da Lat, Vietnam, where water plays a crucial role in commercial agricultural production. This study aims to assess the impacts of surface water resource changes on urban agriculture in Da Lat in recent years, through streamflow calculations and surveys of 300 farming households. Results indicate that surface water in Da Lat during 1993–2024 exhibits strong seasonal fluctuations, with 75–80% of streamflow occurring in the rainy season and only 20–25% in the dry season. Dry-season flow shows a declining trend, with record lows in 2011, 2015, and 2019. Household surveys reveal increasing exploitation pressures, mainly due to urbanization (mean score >4.0), irrigation demand, and intensive farming practices (scores 3.7–3.9). Dry-season droughts (56% of households reporting increases) and declining water quality (34.7%) emerge as key challenges. The most significant impact is increased production costs (47.7%), while crop yields largely remain stable (75%) due to seasonal adjustments and technical investments. These findings indicate that surface water variability is heightening the risk of shortages and increasing costs, threatening the sustainability of urban agriculture.
Keywords: *Surface water, urbanization, drought, urban agriculture, Da Lat*

1. INTRODUCTION

Climate change is causing significant alterations to water resources, particularly surface water, which plays a critical role in maintaining ecosystems and food security [1]. Rising temperatures, changing precipitation patterns, and increasing frequency of extreme weather events have heightened the risk of water scarcity, directly impacting agricultural production, especially in rapidly urbanizing areas [2]. Globally, urban agriculture is considered an important strategy to enhance climate adaptation and secure livelihoods for communities [3].

In Vietnam, numerous studies indicate that climate change has already affected agricultural production through changes in crop yields, growing seasons, and irrigation demands [4]. Da Lat – the country's high-tech agricultural hub, renowned for its vegetables and flowers – relies heavily on lakes, streams, and small rivers to meet irrigation needs. In recent years, local surface water resources have exhibited strong fluctuations: depletion during the dry season, unusually high levels during the rainy season, and increasing exploitation pressure due to the expansion of greenhouse areas.

Some domestic studies have focused on evaluating land suitability and agricultural land-use efficiency in Da Lat [5], while others analyzed farmers' adaptation strategies to climate change in production [6]. However, these works primarily approach the issue from the perspectives of land or adaptive practices, without deeply analyzing the relationship between surface water resource changes and urban agricultural production. In contrast, international research has highlighted the critical role of urban agriculture in linking water resource management with urban resilience [1][2].

This research gap underscores the urgent need for systematic analysis of the impacts of surface water resource changes on urban agriculture in Da Lat. Accordingly, this study aims to: (i) clarify the variations in surface water systems in recent decades; and (ii) assess specific impacts on urban agricultural production, particularly from the perspective of farming households – the group both directly affected and actively adjusting production activities. The findings are expected to provide a scientific basis for policymaking in water resource management and sustainable urban agriculture development in Da Lat and, more broadly, in Vietnam's highland cities.

2. RESEARCH METHODOLOGY

2.1. Data Collection Methods

2.1.1. Secondary Data Collection

Secondary data were collected from meteorological and hydrological sources, including monthly and annual precipitation, temperature, and streamflow data from 1993 to 2024. These data were obtained from the Lam Dong Meteorological and Hydrological Station and the Central Highlands Regional Meteorological and Hydrological Station, Vietnam.

2.1.2. Primary Data Collection

The sample size for this study was determined based on the requirements of exploratory factor analysis (EFA) and multiple regression analysis. Specifically, according to Hair et al. (1998), the minimum sample size for EFA should be at least five times the number of observed variables ($n = 5m$) [7]. For multiple regression analysis, Green (1991) recommends the formula $n \geq 50 + 8m$, where m represents the number of independent variables [8]. Accordingly, a survey was conducted with 300 farming households engaged in agricultural production in Da Lat. The survey assessed the impacts of surface water resource changes on urban agricultural production using the DPSIR (Driver–Pressure–State–Impact–Response) analytical framework.

2.2. Data Analysis Methods

2.2.1. Streamflow Calculation Method

Based on the collected data and the existing network of meteorological and hydrological monitoring stations, this study applied the similar watershed method, which has been widely used in hydrological studies in Vietnam [9][10], to estimate the streamflow in Da Lat.

General Formula:

$$Q^{tt} = \frac{F_{tt}}{F_{tv}} \times \frac{X_{0tt}}{X_{0tv}} \times Q^{tv}$$

Notes:

Q^{tt}: Mean annual streamflow of the target catchment.
Q^{tv}: Mean annual streamflow at the reference hydrological station.
F_{tv}: Area of the reference hydrological station catchment.
F_{tt}: Area of the target catchment.
X_{0tt}: Mean annual rainfall at the reference hydrological station catchment.
X_{0tv}: Mean annual rainfall over the target catchment.

2.2.2. DPSIR Framework Analysis Method

This study selected assessment factors based on the DPSIR framework [11] to clarify the causal relationship between surface water resource fluctuations and urban agricultural production in Da Lat.

Table 1. Assessment Factors Based on the DPSIR System Analysis Framework

No.	Main component	Evaluation factors
1	Driver (D)	• Variability of surface water resources
2	Pressures (P)	• Urbanization process • Increasing irrigation demand • Expansion of urban agriculture
3	States (S)	• Dry-season drought and water scarcity • Irrigation water quality • Use of fertilizers and pesticides
4	Impacts (I)	• Cropping calendar or crop structure • Production costs • Crop yields

The selected factors are designed to fully reflect the cause–effect–response chain within the DPSIR system, thereby providing a scientific basis for assessing and proposing water resource management policies to support sustainable urban agriculture development in Da Lat.

2.2.3. Likert Scale Method

To quantify farmers' perceptions of the factors within the DPSIR framework, this study applied a 5-point Likert scale [12]. The combination of the DPSIR framework and this scale ensures a systematic analysis while transforming qualitative perceptions into quantitative data. This approach allows for comparison of the relative influence of different factors and supports the formulation of scientifically grounded and feasible water resource management strategies for urban agriculture.

Table 2. Survey Scale for Assessing the Impact Level of DPSIR Factors

Scale	Meaning
1 = Strongly Decreased	Factor significantly decreased; highly positive impact compared to before
2 = Decreased	Factor moderately decreased; noticeable reduction
3 = No Change	Factor remained almost unchanged; stable condition
4 = Increased	Factor moderately increased; negative impacts started to appear
5 = Strongly Increased	Factor significantly increased; strong negative impacts observed

2.2.4. Data Compilation, Statistical Analysis, and Processing Method

The collected data were first checked for completeness, consistency, and outliers. Subsequently, multiple regression analysis was applied to assess the impacts of surface water resource changes on the factors within the DPSIR framework. All statistical analyses were conducted using Excel and SPSS 26.0.

3. RESULTS AND DISCUSSION

3.1. Assessment of Factor Impacts

a. Dominant Factors

The results of the total streamflow calculations for the watersheds in Da Lat City, Lâm Đồng Province, Vietnam, are presented in the following table:

Table 3. Total Surface Water Flow in Da Lat City over the Years

Years	Flow (10^6 m^3)								
	Cam Ly River Basin		Da Tam River Basin		Da Nhim River Basin		Da Hiong Stream Basin		Total
	Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season	
1993	36,7	83,4	27,1	58,9	17,5	38,0	14,2	30,8	306,6
1994	39,7	93,3	25,3	70,6	16,3	45,6	13,3	37,0	341,1
1995	29,5	90,1	19,4	66,0	12,5	42,6	10,1	34,6	304,7
1996	50,3	97,3	36,3	68,8	23,4	44,3	19,0	36,0	375,4
1997	52,2	114,3	30,2	88,9	19,5	57,3	15,8	46,6	424,9
1998	58,4	97,2	50,0	60,6	32,3	39,1	26,2	31,7	395,4
1999	83,6	129,3	42,1	112,3	27,1	72,4	22,0	58,8	547,5
2000	58,5	126,5	45,4	86,7	29,3	55,9	23,7	45,4	471,4
2001	41,2	64,0	32,0	46,3	20,6	29,9	16,7	24,2	275,0
2002	33,9	93,0	29,9	60,2	19,3	38,8	15,7	31,5	322,3
2003	41,2	115,6	33,5	78,6	21,6	50,7	17,5	41,2	399,9
2004	39,2	77,3	25,4	58,9	16,4	38,0	13,3	30,8	299,2
2005	31,8	89,9	22,2	64,2	14,3	41,4	11,6	33,6	309,1
2006	34,7	106,1	23,6	76,9	15,2	49,6	12,4	40,3	358,7
2007	51,7	167,3	31,4	123,2	20,3	79,5	16,4	64,5	554,2
2008	47,0	82,6	34,6	59,5	22,3	38,4	18,1	31,1	333,7
2009	61,6	122,2	34,2	97,6	22,1	62,9	17,9	51,1	469,7
2010	47,1	103,6	45,5	63,0	29,4	40,6	23,8	32,9	385,9
2011	43,2	103,6	30,1	75,9	19,4	49,0	15,7	39,7	376,6
2012	53,2	93,5	33,6	71,9	21,7	46,4	17,6	37,6	375,4
2013	53,2	137,7	35,9	99,8	23,2	64,4	18,8	52,3	485,3
2014	61,8	159,2	36,9	120,4	23,7	77,6	19,3	63,0	561,8

2015	42,2	97,8	27,7	73,5	17,9	47,4	14,5	38,5	359,4
2016	45,7	108,2	35,6	74,6	22,9	48,1	18,6	39,1	392,9
2017	84,8	159,6	48,0	127,5	31,0	82,2	25,1	66,7	624,9
2018	48,9	105,2	39,9	73,4	25,7	47,3	20,9	38,4	399,8
2019	51,7	91,9	35,0	69,2	22,5	44,7	18,3	36,2	369,5
2020	45,6	142,6	34,9	98,6	22,5	63,6	18,3	51,6	477,7
2021	53,0	125,6	39,1	89,2	25,2	57,5	20,5	46,7	457,0
2022	70,6	112,0	39,8	92,5	25,7	59,6	20,9	48,4	469,4
2023	56,9	138,4	33,8	107,2	21,9	69,1	17,7	56,1	501,2
2024	52,5	131,3	40,2	91,6	25,9	59,0	21,1	47,9	469,6
Average	**50,1**	**111,2**	**34,3**	**81,5**	**22,1**	**52,5**	**18,0**	**42,6**	**412,4**

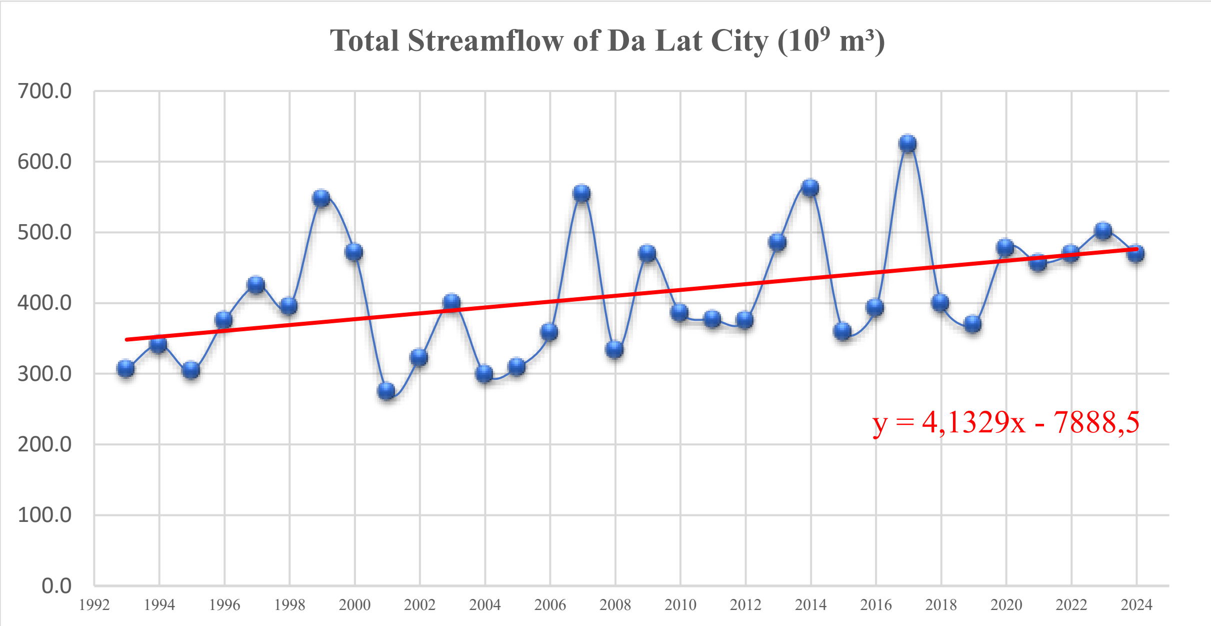

Figure 1. Temporal Variation of Surface Water Flow in Da Lat over the Years

Analyzing the time series of total surface water flow from 1993 to 2024, surface water resources in Da Lat exhibited significant spatial and temporal variability. Analysis of the four main watersheds – Cam Ly River, Da Tam River, tributaries of the Da Nhim River, and the upper Da Hiong Stream – revealed a pronounced seasonal contrast: the rainy season typically contributes 75–80% of the annual total flow, while the dry season accounts for only 20–25%. Average flows during the rainy season were recorded at 111.2 million m³ for Cam Ly, 81.5 million m³ for Da Tam, 52.5 million m³ for Da Nhim, and 42.6 million m³ for Da Hiong, whereas during the dry season, flows reached only 50.1, 34.3, 22.1, and 18.0 million m³, respectively.

Notably, dry-season flows show a gradual declining trend over time, accompanied by increasing variability. The years 2011, 2015, and 2019 represent record lows, with total flows falling below historical averages, reflecting the combined effects of irregular dry-season rainfall, rising temperatures, and altered hydrological regimes under climate change. In addition, occasional abnormal flow increases were observed in some years (1999, 2017), but these were short-term events and do not represent long-term trends.

Thus, the dynamics of surface water resources in Da Lat demonstrate high instability: strong seasonal differentiation coupled with irregular annual fluctuations. Meanwhile, water demand for agriculture, tourism, and domestic use has been rising rapidly, particularly during the dry season, increasing the risk of water scarcity. This situation highlights that surface water variability is not merely a natural phenomenon but also a consequence of the interaction between climate change and increasing exploitation pressure. It underscores the urgent need for flexible, balanced, and long-term adaptive strategies for surface water management, extraction, and utilization.

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b. Pressure Factors

The survey on pressure factors of surface water variability on urban agriculture in Da Lat indicates differentiated levels of influence across factors.

For urban agricultural development, nearly half of respondents (48.3%) perceived the level of pressure as increasing, while 32.7% assessed it as strongly increasing. In contrast, only 14.0% reported no change and 4.6% observed a decrease. This suggests that the expansion and intensification of urban agr icultural practices are placing growing pressure on the exploitation and utilization of surface water resources.

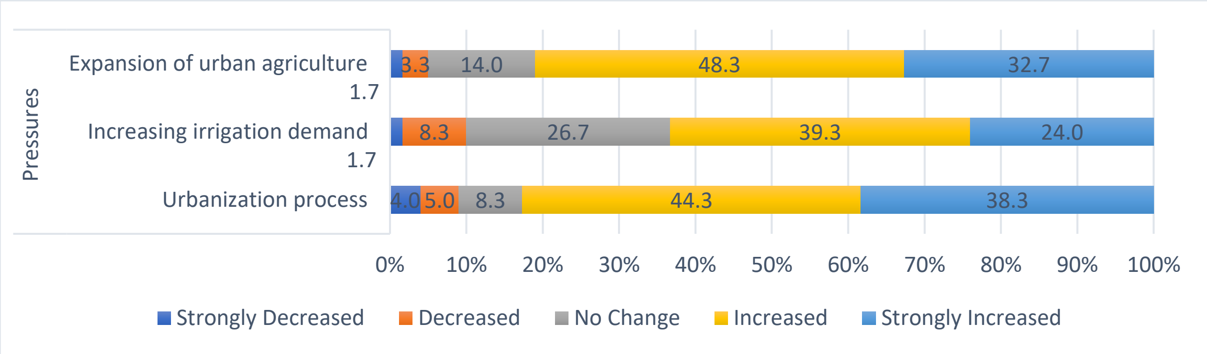

Figure 2. Survey results on pressure factors

With regard to irrigation demand, 39.3% of households reported increasing pressure, and 24.0% identified a strong increase. Meanwhile, 26.7% considered the situation unchanged, and only 10.0% indicated decreasing or strongly decreasing pressure. These findings highlight the escalating irrigation requirements associated with the expansion of vegetable, flower, and other urban crop cultivation in Da Lat, which further intensify stress on surface water resources already showing signs of decline in volume, quality, and spatial–temporal distribution.

For urbanization, the pressure is particularly pronounced, with 44.3% of respondents indicating an increase and 38.3% a strong increase. By comparison, only 8.3% reported no change, while 9.0% perceived decreasing or strongly decreasing impacts. This reflects how rapid urbanization in Da Lat in recent years has not only reshaped land-use structures but also intensified competition for water resources among domestic, tourism, and agricultural demands.

Overall, the survey results clearly demonstrate that urbanization, urban agricultural expansion, and rising irrigation demand are all widely perceived as increasingly significant pressures. This underscores urgent concerns regarding the sustainability of surface water resources in Da Lat, calling for rational and integrated water management strategies that balance urban development with agricultural production.

c. State Factors

The survey results on state factors of surface water variability affecting urban agriculture in Da Lat reveal several critical issues.

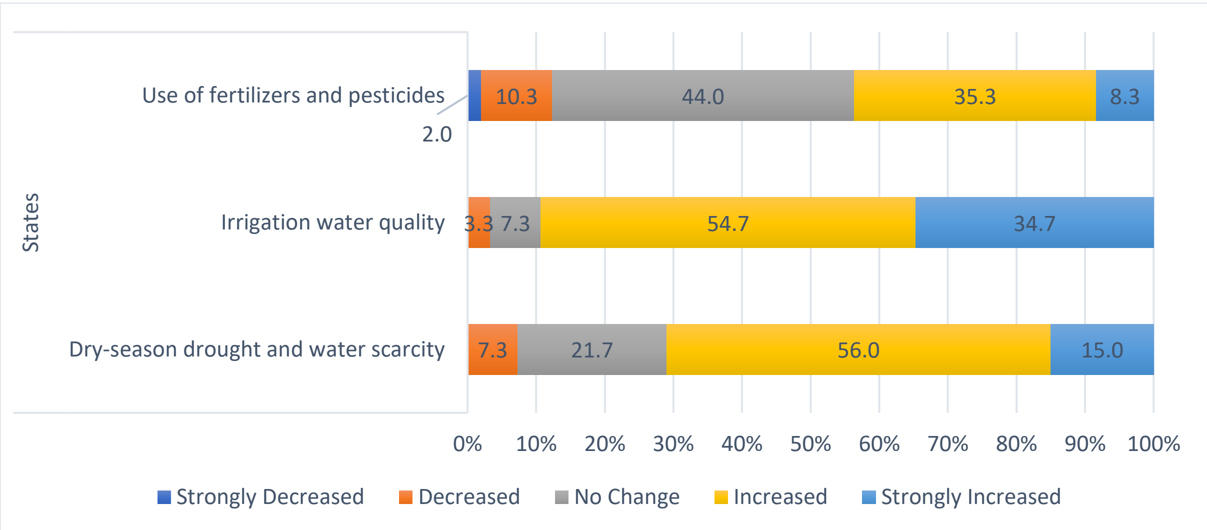

Figure 3. Survey results on state factors

Regarding the use of fer tilizers and pesticides, 44.0% of households reported no change, while 35.3% perceive d an increase and 8.3% a strong increase. Only 12.3% indicated a decrease or strong decrease. This suggests that the trend of rising agricultural input use persists, closely tied to the need to sustain crop yields and manage pests under increasingly unstable environmental conditions.

Concerning the quality of irrigation water, the majority of farmers (54.7%) perceived no change. However, 34.7% reported a marked decline and 7.3% noted a slight decline, while only 3.3% observed improvement. These findings highlight widespread concerns about deteriorating surface water quality, potentially linked to pollution from urbanization, intensive farming practices, and domestic activities.

Notably, drought and water scarcity during the dry season were perceived as increasing significantly: 56.0% of respondents indicated an increase and 15.0% a strong increase. Only 21.7% reported no change, while decreases were negligible. This stands out as the most critical factor, reflecting how climate change and urbanization pressures are intensifying dry-season water shortages, thereby posing direct threats to the sustainability of urban agriculture.

In summary, the survey highlights two particularly pressing issues: the decline in irrigation water quality and the worsening drought and water scarcity during the dry season, alongside the continued rise in fertilizer and pesticide use. These findings underscore the urgent need for effective water resource management, pollution control, and the promotion of sustainable agricultural practices to enhance climate change adaptation in Da Lat.

d. Impact Factors

The survey results on the impacts of surface water variability on urban agricultural production in Da Lat indicate marked differences across factors.

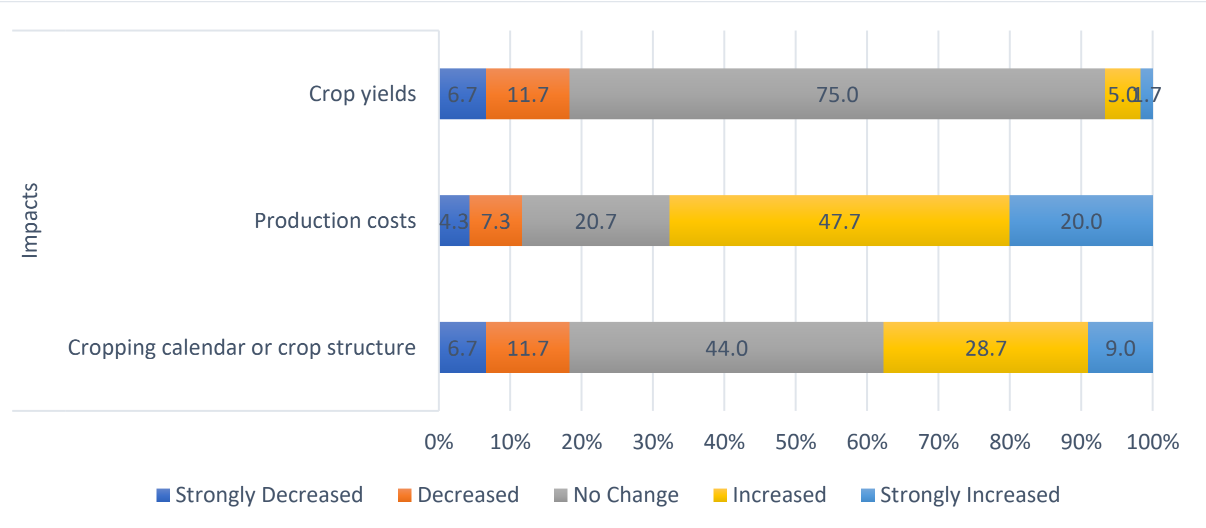

Figure 4. Survey results on impact factors

For crop yields, t he majority of households (75.0%) reported no change compared with previous years; however, 11.7% perceived a decline and 6.7% a strong decline. Conversely, only 6.7% observed an increase or strong increase. This suggests that fluctuations in water resources have not led to notable yield improvements, but rather pose potential risks of decline.

Regarding production costs, the increasing trend was striking: 47.7% of households reported higher costs and 20.0% a strong increase, while only 20.7% noted no change. The proportion reporting reduced costs was limited to 11.6%. These findings reflect that surface water variability compels farmers to invest more in irrigation, fertilizers, pesticides, and technical measures, thereby driving production costs upward.

For cropping calendars and crop structures, 44.0% of households reported no change, but 28.7% observed rising pressures and 9.0% a strong increase, while 18.4% indicated declines. This indicates that water variability has, to some extent, forced farmers to adjust planting schedules and crop choices, especially for vegetables and flowers requiring stable irrigation.

Overall, the results show that the most significant impact of surface water variability lies in rising production costs, while crop yields remain relatively stable but show a tendency to decline among certain households. At the same time, adjustments in cropping calendars and crop structures are evident, underscoring the need for improved water management and technical support to reduce costs, stabilize yields, and sustain urban agricultural development in Da Lat.

3.2. Assessment of the Impact Levels of Factors

The results of the assessment of impact levels for the factors within the DPSIR framework are presented in the following figure:

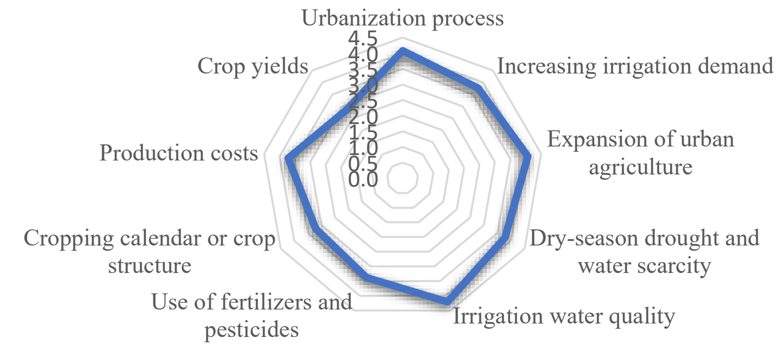

Figure 5. Assessment of Factor Impact Levels – Based on Farmers' Perceptions

The results from the radar chart indicate that changes in surface water resources have strongly impacted urban agricultural production in Da Lat. First, urbanization was assessed as having the greatest influence (average score above 4.0), reflecting that urban expansion has intensified competition for water among domestic, tourism, and agricultural demands.

In addition, increased demand for irrigation water and urban agricultural development were also rated as highly impactful (approximately 3.7–3.9 points). This suggests that agricultural production in Da Lat, which heavily relies on surface water, is under significant pressure due to the intensive cultivation of high-value crops such as vegetables and flowers, which require substantial water resources.

Notably, dry-season droughts and water shortages, together with declining irrigation water quality, were assessed as having considerable impact levels (around 3.5–3.6 points). This situation not only threatens crop yields but also increases production costs, as farmers must seek or treat alternative water sources.

Moreover, factors such as cropping calendar, crop structure, and production costs were impacted at a moderate level. This reflects that changes in water resources force farmers to adjust planting schedules, restructure crops, and invest additional resources to maintain production. However, the impact on crop yields was lower compared to other factors, indicating that farmers are still able to adapt to maintain production efficiency, albeit at the cost of higher input expenses or altered cultivation techniques.

Overall, the radar chart shows that surface water resource variability primarily affects three key areas: (i) competitive pressure and increased water demand due to urbanization and intensive cultivation, (ii) risks of water shortage and declining water quality during the dry season, and (iii) rising production costs alongside changes in crop structure. These factors could directly threaten the sustainability of urban agriculture in Da Lat in the future.

4. CONCLUSIONS

This study highlighted the multidimensional impacts of surface water resource fluctuations on urban agricultural production in Da Lat using the DPSIR framework combined with impact-level measurement. Results show that surface water resources in Da Lat exhibit strong seasonal differentiation, with 75–80% of flows concentrated in the rainy season and only 20–25% in the dry season; notably, the years 2011, 2015, and 2019 recorded record-low declines. Farmer surveys indicated that urbanization (>4.0 points), irrigation demand, and intensive agriculture (3.7–3.9 points) are the primary pressures, while dry-season droughts (56% of households reporting increase) and declining water quality (34.7%) emerged as major challenges. The most pronounced impact was increased production costs (47.7%), while crop yields were largely maintained through adjustments in cropping seasons and increased technical investments (75% of households reporting stable yields). These findings suggest that surface water variability increases the risk of shortages and higher costs, threatening the sustainability of urban agriculture. Therefore, flexible water resource management, pollution control, rational allocation between urban and agricultural use, promotion of water-saving irrigation technologies, and climate-adaptive farming models are essential.

STUDY LIMITATIONS

While this study clarified the impacts of surface water fluctuations on urban agriculture in Da Lat, several limitations remain. Data were primarily based on farmer surveys, which may be influenced by subjectivity; the temporal scope of analysis was limited; and the methodology relied mainly on linear statistical models, without integrating simulation tools or spatial analysis. Future research should use long-term datasets, mixed-method approaches, and modern modeling tools to enhance reliability and comprehensiveness in assessment.

COPYRIGHT STATEMENT

REFERENCES

[1] Sun, M., & Kato, T. (2022). The effect of urban agriculture on water security: A spatial approach. *Water, 14*(16), 2529. https://doi.org/10.3390/w14162529
[2] Facts Reports. (2020). Urban agriculture as a climate change and disaster risk reduction strategy. *Field Actions Science Reports*, (Special Issue 20). https://journals.openedition.org/factsreports/6101
[3] Thi, Q. V., & Juntti, M. (2024). Urban resilience from agriculture: A case study of Ho Chi Minh City. *Emerald Open Research,* 6(12). https://doi.org/10.35241/emeraldopenres.15092.1
[4] Đỗ, T. H., Nguyễn, Q. T., & colleagues. (2022). Climate change and its impacts on Vietnam agriculture: A macroeconomic perspective. *Climate Risk Management, 36*, 100439. Elsevier. https://doi.org/10.1016/j.crm.2022.100439
[5] Nguyễn, V. B., Thi, Q. P., & Nguyễn, P. K. (2020). Assessment of land suitability for certain types of agricultural land use in Da Lat City. *Hue University Journal of Science: Agriculture and Rural Development, 129*(3A), 43–56. https://doi.org/10.26459/hueuni-jard.v129i3A.5734
[6] Phạm, H. H. (2017). Adaptation to climate change in cultivation of residents in Dalat City. *Dalat University Journal of Science,* 7(3), 45–56. https://doi.org/10.37569/DalatUniversity.7.3.333(2017)
[7] Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis* (5th ed.). Prentice Hall.
[8] Green, S. B. (1991). How many subjects does it take to do a regression analysis? *Multivariate Behavioral Research, 26*(3), 499–510. https://doi.org/10.1207/s15327906mbr2603_7
[9] Nguyễn, V. T., & Nguyễn, Q. K. (2002). *General hydrology* [Thủy văn học đại cương]. Agriculture Publishing House.
[10] Institute of Meteorology, Hydrology and Environment Science (IMHEN). (2006). *Engineering hydrology textbook* [Giáo trình Thủy văn công trình]. Science and Technology Publishing House.
[11] European Environment Agency (EEA). (1999). *Environmental indicators: Typology and overview* (Technical Report No. 25). https://www.eea.europa.eu/publications/TEC25
[12] Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology, 22*(140), 1–55.