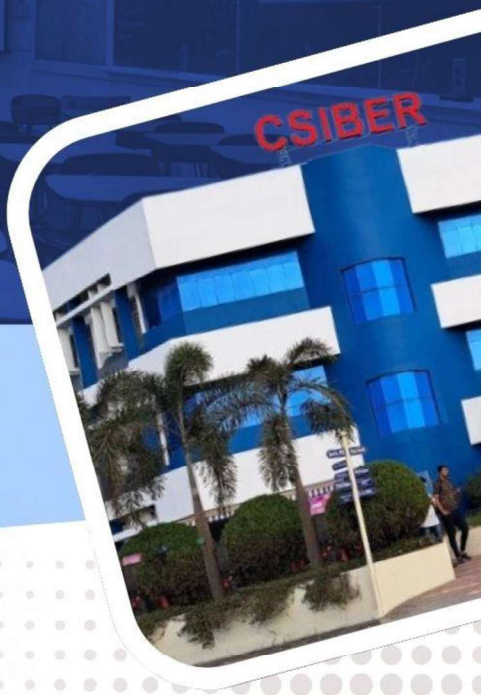
ISSN 0974-763X

SOUTH ASIAN JOURNAL OF MANAGEMENT RESEARCH (SAJMR)



Volume 16, Issue No. 1 January, 2026

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Chhatrapati Shahu Institute of Business Education and Research (CSIBER)

South Asian Journal of Management Research (SAJMR)

Volume 16, Issue No. 1, January 2026

Editor: Dr. Pooja M. Patil

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University Road Kolhapur, Maharashtra - 416004, India.

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South Asian Journal of Management Research
(SAJMR)

Volume 16, Issue No. 1 **January, 2026**

C O N T E N T S

Exploring the Issues and Challenges Faced by Home-Based Hydroponic Farming Practitioners in Western Maharashtra

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Abstract

Hydroponics, is a method of cultivating plants in nutrient-rich water without soil that promises efficient use of natural resources such as land and water, it also gives higher yields and year-round production. Along with commercial hydroponic farming, the popularity of home-based hydroponic farming is also growing in urban cities. In Western Maharashtra, an area characterized by rapid urbanization and shifting climatic patterns, hydroponic systems offer individuals an opportunity to produce fresh produce within confined spaces. **Though,** home based hydroponic farming has the potential to reshape urban and peri-urban agriculture, there are certain limitations as well. The practitioners of home based hydroponic farming face a number of such unique issues and challenges that limit adoption rates, productivity, and economic viability. The research paper employs a systematic framework to consider the key issues and challenges confronting home-based hydroponic farming practitioners in western Maharashtra. The study offers an in-depth examination of the current panorama regarding the status of home based hydroponic farming. The study employs a mixed method approach, combining primary data with secondary data. Primary data was collected by conducting online survey of 52 respondents in western Maharashtra who are engaged in home based hydroponic farming for minimum five years as well as structured interviews of respondents who had given their consent for the same. Insights of local subject experts as well as manufacturers and vendors of hydroponic systems were also considered for this study. Notable issues and challenges identified by the study consist of economic factors such as high upfront capital commitment for equipment, market access for sale of hydroponic produce; lack of technical know-how among practitioners regarding dosage of nutrients, maintenance of ideal pH levels, selection of plants/ crops, suitable hydroponic system, etc. The paper concludes with recommendations for policy, practice, and further research to enable the broader adoption and success of home-based hydroponic farming in the region.

Keywords: Hydroponics, Home-based farming, Western Maharashtra, Urban Agriculture, Sustainability, Challenges

Instroduction

The urban population globally is expected to grow by 72 percent by the year 2050 and the majority of this growth is expected to be in urban areas across the sphere. While urbanization is considered to be reflection of modernization, economic growth and development, there is a growing concern about the consequence of rapid urbanization on demographic trends like employment, food security, water supply, shelter, etc. The conversion of agricultural land and use of water resources for residential /commercial purpose has negative impacts on food security, water supply and health of people in urban and peri-urban areas.

In India too, rapid urbanization along with increase in population has adversely affected land resources and food supply chains. Regions of western Maharashtra in India is considered as a hub of modernization that has emerged as the most urbanized area in the country due to large scale industrialization and ongoing infrastructural projects. Along with urbanization, there is also decline in traditional farming in this region due to fragmentation of land, erosion of soil caused by constant use of chemical fertilizers, water scarcity, and erratic climatic conditions.

Hydroponics, a method of growing plants in aqueous solvent with mineral nutrient solutions without soil, has been widely recognized as a viable alternative to conventional agriculture and as a sustainable approach for agriculture throughout the world (Ozenturk et al 2023). Hydroponic farming is particularly useful for areas where arable land is limited or water is scarce, and urbanization and biodiversity loss is rapid. In India, and especially in Western Maharashtra areas, these constraints are compounded and hence, hydroponic systems are seen as a promising option. Urban sprawl is reducing the size of landholdings and is also converting agricultural land to non-agricultural uses for building residential, commercial complexes, industries, etc. Variable rainfall and increasing temperature are making water crisis more pronounced. At the same time, the growth in consumer awareness regarding food quality, pesticide residues, and increasing herbicide resistance has stimulated consumer

interest in controlled-environment agriculture, as hydroponics has the potential for increased produce yield, lower input costs, and year-round production potential it is gaining popularity. Home based hydroponic farming is also gaining popularity in this region not only due to above factors but because of its potential of providing additional source of income for the urban dwellers. Home based hydroponic farming is thus an emergent complementary approach for the alleviation of urban poverty and food insecurity, and improvements to urban environmental management.

However, despite the advantages of hydroponic farming, it too has some unique issues and challenges. The issues and challenges of commercial hydroponic farming and home based hydroponic farming are different, as home based users tend to lack the technical expertise, money and regulatory support that are generally available in commercial hydroponic farms. Further, a major concern lies in the fact that many individuals, driven by the allure of earning additional revenue from higher profits and efficient farming, blindly adopt hydroponics without a solid understanding of the complexities involved. There are many other factors that make it difficult for home-based hydroponic farming practitioners and, despite the opportunities, many issues need to be considered by urban dwellers.

This research paper seeks to systematically investigate the multifaceted challenges faced by home-based hydroponic farming practitioners in Western Maharashtra. Through a comprehensive literature review, primary data collection, and rigorous analysis, the study aims to provide actionable insights that can inform policy, practice, and future research in the domain of urban and peri-urban agriculture.

Literature Review:

S H Shahrajabian and M K Chavoshi (2020) highlight the challenges faced in hydroponic farming including high initial investment, energy consumption and water management.

A A Al-Hammadi et.al, (2018) discuss about the challenges and opportunities in hydroponics, including the need for specialized knowledge and skills, and the potential for increased crop yields and water consumtion.

P K Singh et.al., (2019) highlights the challenges and limitations of hydroponic systems, including high energy costs, limited crop selection and the need for precise nutrient management.

R K Srivastava et.al. (2020) discusses the sustainability challenges in hydroponic farming including energy consumption, water usage and waste management.

S Kumar et. al., (2018) highlights the technical challenges in hydroponic systems, including nutrient management, pH control and pest management.

Nuru Seid Tehulie, Agegnehu Mekonnen and Ahmed Hassen examined the roles and challenges of hydroponics, aeroponics and aquaponics in improving vegetable production. They discussed the importance of nutrient management, pH control and water conservation strategies.

Roberto S Velazquez- Gonzalez, Adrian L Garcia-Garcia and Elsa Ventura-Zapata, highlighted the challenges faced by hydroponic systems including initial investment costs, technical complexities and issues related to pest management and nutrient management,

Subhash Verma, Ashutosh Kumar and Manju Kumari while reviewing the innovations and challenges in hydroponics and vertical farming for vegetable cultivation, noted that along with its benefits, there are notable challenges such as high investment, energy intensive operations and the need for specialized technical expertise.

Dr. R S Tomar and Vikas Sharma reviewed the current status and future prospects of hydroponics in India. They highlighted the benefits of hydroponics including increased crop yield and water conservation and discussed the challenges and limitations of adopting hydroponics systems in India

P K Singh and S K Singh evaluated the economic feasibility of hydroponic farming in India, They discovered that hydroponics can be a profitable venture and note the high initial investment and energy costs associated with hydroponics systems

Resh, 2012 observed that hydroponic farming requires specialized knowledge and skills, including nutrient management, pH control and pest management

Sutton et al., 2017 believe that developing integrated pest management strategies for hydroponic systems is crucial for reducing the use of chemical pesticides and maintaining crop health

Jones, 2014 stresses that farmers may need training and education to acquire the necessary technical knowledge and skills to manage their hydroponic systems effectively.

Albright et al., 2018 felt that hydroponic systems require a significant initial investment in infrastructure, equipment and nutrients. They also commented that maintaining optimal pH and temperature levels is crucial for plant growth, but the same can be challenging in hydroponic systems.

Jensen, 2018 believes that high initial investment can be a barrier to entry for small scale farmers, making it challenging for them to achieve economic viability.

Tropea et.al., 2018 remarked that hydroponic farmers may face challenges in accessing markets and selling their produce, particularly if there is limited demand for hydroponically grown crops

Gunning, 2019 felt that farmers may need to develop effective marketing strategies to promote their produce and attract customers.

Research Gap

The reviewed academic literature has not yet examined and reviewed the challenges faced in adaptation of hydroponic technology into the specific socio-economic and climatic situation of Western Maharashtra. This research paper attempts to fill this gap by exploring the complex realities faced by home-based hydroponic practitioners in Western Maharashtra.

Research Question

"What are the primary issues and challenges faced by home based hydroponic farming practitioners in western Maharashtra?"

Statement of Problem:

To understand the issues and challenges faced by home based hydroponic farming practitioners while doing hydroponic farming at home.

Objectives of the Study

The Study aims to achieve the following objectives:

- To identify and categorize key issues and challenges faced by home based hydroponic farming practitioners in western Maharashtra
- To identify specific technical issues and challenges faced by home based hydroponic farming practitioners in western Maharashtra
- To identify specific economic issues and challenges faced by home based hydroponic farming practitioners in western Maharashtra

Formulation of Hypothesis

- **H1:** Lack of technical knowledge is a significant barrier to the adoption of home-based hydroponic systems in Western Maharashtra
- **H2:** High initial setup costs negatively impact the willingness of urban households to invest in hydroponic farming.
- **H3:** Identification and Selection of plant/ crop (which plant/ crop to grow) has impact on revenue and the overall profitability of the project
- **H4:** Selection of Right Type of Hydroponic system (Aeroponics, Deep Water Culture (DWC), Nutrient Film Technique (NFT), Ebb and Flow, etc.) poses significant influence on the sustainability of home-based hydroponic practices.
- **H5:** Access to reliable markets for sale of produce correlates with perceived success in hydroponic farming.

Methodological Framework

This research differentiates between insight and deployment objectives in alignment with the framework for challenge design outlined by Mendrik and Aylward (2021). In the first phase a qualitative, insight-oriented approach to uncover the breadth of issues and challenges, employing purposive sampling and in-depth interviews with hydroponic practitioners, experts, and potential adopters was utilized. The second phase uses a quantitative, deployment-oriented approach, surveying a representative sample of urban dwellers engaged in hydroponic farming. This research thus will use a deployment-oriented approach to help ensure findings are generalizable and relevant for policy and practice. The structured questionnaire was designed according to quantitative research principles for collection of quality data that can be analyzed and the formulated hypothesis can be tested.

Research Methodology

This study adopts a Realistic Research design to systematically investigate the issues and challenges faced by home based hydroponic farming practitioners in western Maharashtra. With a view to provide a detailed and accurate account of the experiences and perceptions of the targeted respondents involved in home based hydroponic farming, the descriptive research design is chosen.

Data Collection

Primary Data
Qualitative and quantitative methods were used for the collection of primary data by conducting online survey of 52 respondents in the Western Maharashtra who are engaged in home based hydroponic farming for minimum five years. The data collection was based on open and closed end structured questionnaire related to issues and challenges faced by practitioners of hydroponic farming at home. Further, as a part of the online survey, consent of online participants was also taken for telephonic as well as personal interviews as well. A structured questionnaire was prepared for conducting telephonic interview of those participants who agreed for phone interview. The purpose of telephonic and personal interview was to get better clarity and deeper understanding of their online responses.

Secondary Data
Secondary data is the research or article which is done on the topic by some other researcher. In this study, the secondary data in form of online journals, online articles, books and research done by other researchers will be considered to corroborate data analysis.

Data Analysis

- **Qualitative Data:** Thematic analysis was conducted to identify recurring themes, challenges, and perceived barriers. Coding was performed inductively, with cross-validation to ensure reliability.
- **Quantitative Data:** Statistical analysis included descriptive statistics, statistical tests for categorical variables, and logistic regression to test the stated hypotheses

Ethical Considerations
All participants provided informed consent. Data was anonymized, and privacy was maintained in accordance with ethical guidelines for social research.

Sampling Design and Sample Size
Purposive sampling technique is employed to select participants who are doing home based hydroponic farming for minimum five years. The list of such persons from western Maharashtra were obtained from manufacturers and suppliers of hydroponic farming systems and these people were contacted for providing their inputs for this study.

Population
The population for this study comprises of persons involved in home based hydroponic farming in western Maharashtra for a period of five years and more.
Sample Size: 52

Limitations of Study

- As home based hydroponic farming is still in an infancy stage. Home based hydroponic farming is being practiced by people for a period of less than a decade, hence population size is very limited. Further, it may also be possible that many of the respondents would be having firsthand experience of doing home based hydroponic farming.
- The study is limited to home based hydroponic farming units in western Maharashtra as well as those who are involved in this activity for a period of five years or more

Analysis and Interpretation of Data

Qualitative Insights: Thematic Analysis

Lack of Technical Knowledge
Majority of the respondents expressed that lack of technical knowledge and skills was one of the most critical challenge faced by them. Several respondents mentioned difficulty in managing proper dosage of nutrients, monitoring the pH and EC levels and the quality of water. The respondents also mentioned that although there were many tutorials available on the internet, no specific tailored content was available to assist and guide them. One of the respondents in his interview quoted that "To learn how to do the basics was easy, but the nuances, e.g., learning how to modify pH and nutrients for local water, required expertise that was missing."

High initial investment costs
Respondents agreed that the cost of hydroponic system and its ancillary were on the higher side which they felt was a challenge as the payback period of almost all respondents was over four years. According to them, the prime

reason for longer period of payback was the initial investment cost that was very difficult to justify when the cost of vegetables that could be procured from the local market were cheaper than growing the same hydroponically.

Crop Selection
Some of the respondents felt that selection of proper crop to grow hydroponically is a challenge as the same depended on factors such as compatibility with hydroponic system being utilized, cultivation period, crop cycle, yield of crop, market demand and market rate. Crop selection has significant impact on the revenue and therefore, the process of selection of crop is crucial as one mistake would result in loss of income. Respondents felt that profitability of the project was directly related to the crops being cultivated in the home based hydroponic system.

Right Hydroponic System
Majority of the respondents were in agreement in considering the selection process of hydroponic system as one of the challenging tasks. Respondents mentioned that careful assessment had to be done for selection of the right kind of hydroponic system from the different types of hydroponic systems available in the market, based on factors such as cost, space, type of crop proposed to be cultivated, ease of operations, etc. According to the respondents any error in selection of hydroponic system may prove fatal for the viability of the entire project.

Market Access
Many of the respondents expressed concern over exploring and identifying market for selling the produce grown hydroponically which could fetch them better rates than the local markets. Since, crops grown hydroponically are free from any chemical residue the demand for the same is expected to better along with higher price. However, the challenging task faced by the respondents was finding access to such markets to market their produce. Respondents felt that access to such markets could generate more revenue and increase their profitability which could ultimately help in reducing the payback period.

Quantitative Findings: Statistical Analysis

Statistical analysis of issues and challenges faced by 52 respondents engaged in home based hydroponic farming rated 5 hypothesized issues and challenges variables on a scale of 1 to 5.

Descriptive Statistical Analysis
Descriptive statistical analysis (count, mean, SD, quartiles) for each issue and challenge was done and the results of the same are presented in Table 1 below:

Table 1. Descriptive Statistical Analysis

index	count	mean	std	min	25%	50%	75%	max	variance	skewness	kurtosis
Lack of Technical Knowledge	52.0	1.808	0.687	1.0	1.0	2.0	2.0	4.0	0.472	0.645	0.821
High Investment Cost	52.0	1.923	0.621	1.0	2.0	2.0	2.0	3.0	0.386	0.048	-0.304
Crop Selection	52.0	1.865	0.687	1.0	1.0	2.0	2.0	4.0	0.472	0.557	0.694
Right Hydroponic System	52.0	2.192	0.742	1.0	2.0	2.0	3.0	4.0	0.551	0.271	-0.018
Market Access	52.0	1.788	0.637	1.0	1.0	2.0	2.0	3.0	0.405	0.206	-0.56

Results and Interpretation of Descriptive Statistical Analysis
Lack of Technical Knowledge

- **Mean = 1.81** indicates that the responses lean towards the **lower side** (higher concern).
- **Skewness = 0.65** is an indication of positively skewed data, which means that a majority of respondents rated it as a challenge, but a few gave higher ratings (less concern).
- **Interpretation:** Many farmers feel that they lack adequate technical knowledge and see this as a strong issue and challenge

High Investment Cost
- **Mean = 1.92** indicates slightly higher than technical knowledge, but is still low reflecting the concern of the respondents.
- **Skewness = 0.05** shows an almost symmetric distribution indicating unswerving concern
- **Interpretation:** Investment cost is a **widely shared concern**, which is fairly consistent issue and challenge among all respondents.

Crop Selection

- **Mean = 1.87** indicates strong challenge perception like lack of technical knowledge
- **Skewness = 0.56** shows that it is positively skewed, i.e. it is concentrated on lower scores indicating more concern
- **Interpretation:** Respondents consistently reported uncertainty in selecting crops as a key and major issue and challenge

Right Hydroponic System

- **Mean = 2.19** indicates slightly higher average, which means that respondents are divided in the responses for e.g. some see this as an challenge while others don't feel so.
- **Skewness = 0.27** shows mild skew indicating balanced distribution.
- **Interpretation:** though the respondents perceived this as a significant challenge, they felt that it was less severe as compared to Lack of Knowledge or Crop Selection

Market Access

- **Mean = 1.79** indicates lowest mean among all, which means that respondents perceive it as a strong challenge
- **Skewness = 0.21**shows mild positive skew
- **Interpretation:** respondents felt that market access remains as a critical bottleneck for adoption and profitability and it is certainly a strong issue and challenge

Testing of Hypothesis using Chi –square test

Table 2. Chi – Square Test Results

Issues and Challenges	χ^2	df	p-value	Significant
Lack of Technical Knowledge	36.92	3	<0.001	Yes
High Investment Cost	19.08	2	0.0001	Yes
Crop Selection	37.39	3	<0.001	Yes
Right Hydroponic System	28.62	3	<0.001	Yes
Market Access	15.27	2	0.0005	Yes

Results and Interpretation of Chi-square Test

- The p-values of all the five issues and challenges are well below 0.05 indicating that the distribution of responses significantly deviate from a neutral or uniform pattern.
- The respondents felt that Crop Selection and Lack of Technical knowledge posed a strong challenge as reflected by the strong deviations (largest χ^2 values) for them in the above table
- Issues and challenges in the form of Market Access and High Investment cost have a slightly smaller χ^2, still show strong significance thereby indicating consistent concern among the respondents.
- Right Hydroponic System with a moderate χ^2 value also shows strong significance indicating it to be a real issue and challenge across the respondents
- The results of the Chi-square test implies that the respondents perceive all the five issues and challenges as real, hence all the five hypothesis formulated on these issues and challenges are accepted.

Results and Discussions

The overall results of the study can be summarized from the above descriptive and inferential findings:

Lack of Knowledge:

Lack of technical knowledge regarding the overall procedure of crop cultivation in hydroponic system including nutrient and water management along with proper selection of crop, creates dependency of respondents on accepting trial and error approach or taking help of external consultants that could add up to inefficiencies.

Financial Constraints:

As compared to traditional farming method, the cost of hydroponic setups is high. The higher initial investment costs along with the recurring operational costs is seen as a prominent challenge which leads to longer payback periods, thus discouraging adoption of the same

Difficulty in System Selection:
The respondents' feedback regarding their struggle with selecting the right type of hydroponic system from the multiple hydroponic systems available in the market indicates it to be a challenging issue. Selection of appropriate hydroponic setup that could suit their budget as well as be compatible for cultivation of crops identified by them along with ease of use is really an uphill task for the respondents.

Market Bottlenecks:
Even if respondents overcome technical and economic challenges, exploring and establishing access to proper market place for selling hydroponically grown produce profitability is equally important. Limited consumer awareness about hydroponically grown produce further aggravates this issue.

Comparison of Findings with Existing Literature

With the purpose to establish relevance and identify patterns and trends as well as validate the findings and results of this study, comparison in broader terms was done with the previous studies that were part of literature review of this research paper. Most of the findings of the study aligned with previous studies in sustainable agriculture and hydroponics:

- **Technical Knowledge:** the need for structured training to impart technical knowledge and awareness in hydroponic farming has been highlighted by many studies, since lack of expertise is considered as primary barrier.
- **Investment Cost:** innovative technology such as hydroponic farming is more expensive than traditional farming. Along with equipment costs, there are other ancillary costs such as shade nets, plumbing systems and automation, UV lighting, climate control devices, etc. that are also need to be installed. All such expenses add to higher initial investment costs which have been identified in multiple contexts as a deterrent for small-scale farmers.
- **Crop Selection:** research papers have highlighted selection of crop as essential pre-requisite in growing crops hydroponically because it impacts production, profitability and suitability of crop for specific environment of the hydroponic system. Important factors mentioned include the crop's life cycle, the market demand, yield of crop, etc.
- **Market Access:** for achieving profitability and sustainability it is important to explore access to markets where hydroponic produce can fetch better returns than local markets. Similar to conventional farming, market integration remains a challenge in hydroponic farming that has been emphasized in many research papers.

All of the above, suggest that the issues and challenges experienced in this study were not isolated incidents but indicative of wider trends in global hydroponic adoption as a more sustainable agricultural method.

Future Research Directions
While this study recognizes the challenges faced by people participating home-based hydroponic farming, it also recognizes there are a number of gaps worth further study. The focus of future studies should shift from challenges to solutions and reflect identified farmer demographics, economic models, technology adoption, market development and sustainability outcomes. Such studies will help ensure that hydroponics can develop as a practical, accessible and sustainable farming alternative to be adopted across a larger demographic area.

Recommendations
For improving the adoptability of home based hydroponic farming, following recommendations are suggested:

- **Conduct Training Programs:** The manufacturers and vendors of hydroponic systems should take the initiative of developing structured training sessions and workshops that can help address the lack of technical knowledge among the people and at the same time promote home based hydroponic systems.
- **Affordable Financing:** The Government should take policy decisions whereby banks and financial institutions should be advised to provide financial assistance at subsidized low-interest rates that can influence more people to invest in home based hydroponic farming.
- **Advisory Services:** Agricultural agencies along with manufacturers and vendors of hydroponic systems should jointly establish expert advisory services and digital tools to help urban dweller who are interested in home based hydroponic farming take appropriate decisions regarding selection of crop as well as right kind of hydroponic system.
- **Awareness of Hydroponic crops:** large scale social media campaigns and initiatives need to be undertaken to promote awareness among the common public regarding the unique qualities of hydroponically grown crops like residue free crops, etc.

- **Market Access Initiatives:** The Government should build cooperative marketing platforms as well as direct-to-consumer channels for facilitating home based hydroponic practitioners sell their high quality residue free produce at better rates.

Conclusion

Home based hydroponic farming has an excellent opportunity for urban dwellers. However, the issues and challenges faced by the present practitioners of home based hydroponic farming that are highlighted in this study need to be addressed. Failure to resolve these issues and challenges may result in hydroponic farming falling short of its potential for sustainable farming and food security. However, if these issues are dealt with using appropriate knowledge, technology, and infrastructure, home based hydroponic farming may revolutionize urban farming in Indian cities.

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