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SMART AGRICULTURE, SUSTAINABLE TOURISM, AND URBAN RESILIENCE: AN INTEGRATED APPROACH TO SUSTAINABLE DEVELOPMENT IN VIETNAM

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Abstract. This review article explores the critical intersection of smart agriculture, sustainable tourism, and urban resilience as a comprehensive framework for sustainable development in Vietnam. It analyzes the economic, social, and environmental benefits of smart agriculture and sustainable tourism while highlighting the severe threat of land subsidence in major urban centers, such as Ho Chi Minh City and Hanoi, drawing on the seminal research of Dinh Ho Tong Minh. The paper argues that an integrated policy approach, which includes the development of agritourism and addresses the root causes of subsidence, is essential for ensuring long-term economic prosperity, environmental protection, and social equity. Finally, it proposes a set of integrated policy recommendations for Vietnamese policymakers to navigate the complexities of modern development, ensuring that economic growth does not compromise the environmental and social foundations upon which it is built.

Keywords: smart agriculture, sustainable tourism, land subsidence, sustainable development, urban resilience, Vietnam

1. Introduction

Vietnam has emerged as one of Southeast Asia's most dynamic economies, characterized by rapid growth and a profound societal transformation. This development, however, has placed immense pressure on the nation's natural resources and urban infrastructure, making the pursuit of sustainable development not merely an option but an urgent necessity. The imperative to balance economic expansion with environmental integrity and social equity has led to the exploration of innovative growth models. Among these, smart agriculture and sustainable tourism are increasingly recognized as twin pillars that can drive a green, inclusive, and resilient economy. Smart agriculture, leveraging technologies like the Internet of Things (IoT) and Artificial Intelligence (AI), promises to enhance agricultural productivity while minimizing its ecological footprint [1]. Simultaneously, sustainable tourism offers a pathway to

harness the country's rich cultural and natural heritage for economic benefit while ensuring its preservation for future generations and promoting equitable development [2].

However, this promising trajectory is threatened by a critical yet often overlooked challenge: severe land subsidence in Vietnam's major urban and economic centers. Rapid urbanization, particularly in Ho Chi Minh City and Hanoi, has led to the excessive extraction of groundwater, resulting in the ground sinking at an alarming rate. Pioneering research by Dinh Ho Tong Minh and his collaborators has brought this issue to the forefront, revealing that subsidence rates in some areas are so severe that their impact significantly outweighs that of global sea-level rise [3]. This phenomenon poses a direct threat to urban infrastructure, increases flood risk, and jeopardizes the long-term viability of economic activities, including the very tourism and agricultural systems Vietnam is striving to develop sustainably.

This paper argues that a holistic and integrated approach is paramount for Vietnam's sustainable future. A siloed strategy, where agricultural policy, tourism development, and urban planning operate in isolation, is insufficient to address the interconnected challenges the nation faces. True sustainability can only be achieved by weaving together the threads of smart agriculture, sustainable tourism, and urban resilience. By exploring the synergies between these domains—such as the development of innovative agritourism models—and confronting the foundational threat of land subsidence, Vietnam can construct a more durable and prosperous development path. This review synthesizes the current state of knowledge on these topics, highlights the critical implications of land subsidence based on empirical evidence, and proposes an integrated framework to guide policy and practice toward a genuinely sustainable future for Vietnam.

This article is a review. The methodology involved a comprehensive search of academic databases, including Scopus, Web of Science, and Google Scholar, as well as policy documents from Vietnamese government agencies and international organizations. The literature was selected for its relevance to the key themes of smart agriculture, sustainable tourism, urban resilience, and land subsidence in Vietnam. The analysis and synthesis of the selected literature were conducted to identify the key challenges, opportunities, and interconnections between these themes, leading to the development of the integrated framework and policy recommendations presented in this paper.

2. The promise of smart agriculture

Smart agriculture represents a paradigm shift in the agricultural sector, moving from traditional, labor-intensive methods to a more data-driven, technology-enabled approach. It encompasses a suite of technologies, including precision agriculture, the Internet of Things (IoT), Artificial Intelligence (AI), and unmanned aerial vehicles (drones), all aimed at optimizing resource use, enhancing productivity, and improving sustainability [4]. In the context of Vietnam, a nation with a strong agricultural backbone and a growing appetite for technological innovation, smart agriculture holds immense promise. The Vietnamese government has recognized this potential, with policies such as Resolution 19/NQ-TW/2022 actively promoting the development of a high-tech, sustainable agricultural sector [5].

The economic and environmental benefits of adopting smart agricultural practices are well-documented. By precisely monitoring and responding to crop and soil needs, farmers can significantly increase yields while reducing input costs. For instance, precision agriculture techniques have been shown to reduce herbicide use by 9% and fossil fuel consumption by 6%, directly contributing to both profitability and environmental protection [6]. Furthermore, studies have indicated that these practices can lead to a reduction in greenhouse gas emissions, with CO_2 emissions potentially decreasing by up to 13% [7]. Research into Digital Agricultural Technologies (DATs) further corroborates these findings, highlighting substantial economic and environmental gains in crop production through their adoption [8]. As the global market for AI in agriculture is projected to grow from $1.7 billion in 2023 to $4.7 billion by 2028, the economic incentive for adoption is increasingly compelling [9].

Smart agriculture offers significant social benefits for Vietnam, particularly for smallholder farmers by increasing income and reducing labor demands. It can enhance food security through a stable supply chain and improve product quality for international markets. Initiatives like traceable carbon footprints, seen in recent UNDP projects, promote sustainable and profitable production [10]. However, adoption faces challenges such as high initial investment, skill development, and infrastructure support. Overcoming these barriers is essential for realizing the full potential of smart agriculture in Vietnam's sustainable development.

3. Sustainable tourism: a pathway to inclusive growth

Sustainable tourism, as defined by the World Tourism Organization (UNWTO), is "tourism that takes full account of its current and future economic, social, and environmental impacts, addressing the needs of visitors, the industry, the environment, and host communities" [2]. This approach is not merely about being "green"; it is a holistic framework that seeks to maximize the positive contributions of tourism while minimizing its negative consequences. For Vietnam, a country that has witnessed a meteoric rise in its tourism sector, embracing sustainability is essential for ensuring the long-term viability of the industry and its contribution to inclusive national development. The principles of sustainable tourism are deeply embedded in the United Nations' Sustainable Development Goals (SDGs), particularly in targets that call for the creation of jobs, promotion of local culture and products, and the conservation of marine and terrestrial ecosystems [11].

The economic significance of tourism to Vietnam is undeniable. The sector has become a powerful engine of growth, contributing significantly to the national GDP and creating millions of jobs. According to the World Travel & Tourism Council (WTTC), the sector's contribution to Vietnam's GDP increased by nearly 30% year-over-year during the post-pandemic recovery, with projections indicating a record-breaking performance in 2024 [12]. This economic boom, however, has brought with it a host of challenges that threaten the very assets upon which the industry is built. Research on sustainable tourism in Vietnam, as seen in the work by Nguyen Xuan Khanh (2024), highlights the pressing issues of environmental degradation, overcrowding in popular destinations, and significant infrastructure limitations, particularly in rural areas [13]. These problems are often compounded by policy and governance gaps, which can lead to the inequitable distribution of tourism's economic benefits and a failure to protect natural and cultural heritage.

Addressing these challenges requires a strategic shift away from a model of mass tourism towards one that prioritizes quality over quantity. This involves fostering community-based tourism initiatives that empower local populations and ensure they receive a fair share of the economic benefits. It also means promoting ecotourism and cultural tourism, which can provide visitors with unique, high-value experiences while simultaneously contributing to the conservation of Vietnam's rich biodiversity and cultural heritage. The development of such sustainable models not only mitigates the negative impacts of tourism but also enhances the overall visitor experience, creating a more resilient and competitive tourism product. As Vietnam continues to position itself as a leading global destination, the integration of

sustainability into all aspects of tourism planning and development will be the defining factor in its long-term success.

4. The sinking foundation: land subsidence in urban Vietnam

While smart agriculture and sustainable tourism present promising avenues for Vietnam's future, the very foundation of its major urban centers is under threat from a severe and accelerating environmental crisis: land subsidence. This phenomenon, characterized by the gradual sinking of the ground, is a direct consequence of rapid, and often unregulated, urbanization. The pioneering and extensive research conducted by Dinh Ho Tong Minh and his colleagues has been instrumental in quantifying the scale of this problem in Vietnam's largest cities, Ho Chi Minh City and Hanoi, and in highlighting its profound implications for sustainable development [3, 14]. Their work provides a critical, data-driven understanding of a hazard that, if left unaddressed, could undermine decades of economic progress.

The primary driver of land subsidence in these urban areas is the excessive extraction of groundwater. As cities expand, the demand for water for domestic, commercial, and industrial use skyrockets, leading to a heavy reliance on underground aquifers. When water is pumped out faster than it can be naturally replenished, the underlying geological formations compact, causing the land surface to subside. Using advanced radar interferometry techniques (InSAR), Dinh Ho Tong Minh's 2015 and 2025 studies on Ho Chi Minh City provided unprecedented insight into the severity of this issue [3, 18]. The research revealed an average subsidence rate of -8.0 mm per year, with some areas, particularly along the Sai Gon River and in the city's southwest, sinking at up to -70 mm per year (see Figure 1). Subsequent research on Hanoi has revealed similar patterns, linking rapid urban development since the 1990s to significant subsidence, posing a destructive hazard to the capital city [14, 15]. In response to severe subsidence caused by groundwater extraction in Hanoi, the Da River Water Plant Project was initiated in 2003, and by 2009, the Da River–Hanoi clean water pipeline was officially put into operation. This strategic shift to reservoir water has slowed the decline of groundwater levels and brought the risk of land surface subsidence under control, demonstrating a successful, albeit costly, mitigation measure.

In addition, it is important to recognize that other factors contribute to this complex issue. These include geological fluctuations, neotectonic movements, tidal effects causing sand erosion, sediment loss due to upstream dam construction, increased construction loads from rapid urbanization, and the lowering of groundwater levels caused by the development of

underground structures. These factors, in combination with groundwater over-extraction, create a perfect storm for land subsidence.

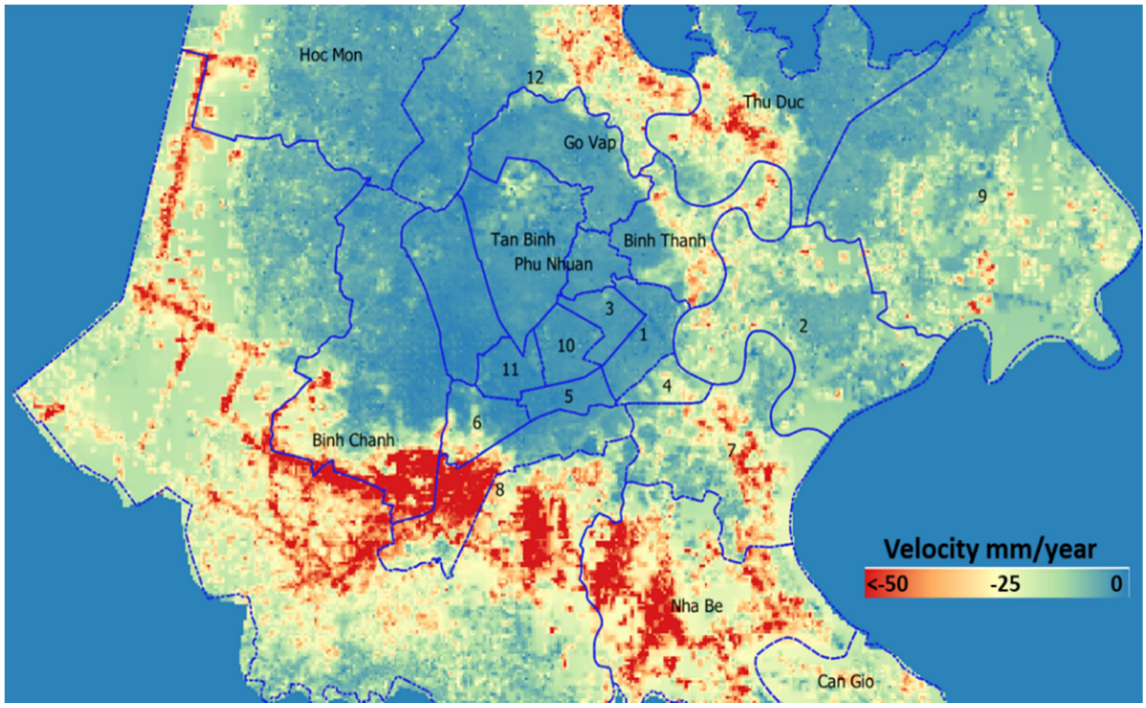

Figure 1. The sinking Ho Chi Minh Megacity by radar interferometry

Source: Ho Tong Minh et al., 2025 [18].

The consequences of this subsidence are dire and far-reaching. The most immediate and visible impact is a dramatic increase in the frequency and spatial extent of flooding. As the land sinks, it becomes more vulnerable to tidal inundation, river flooding, and heavy rainfall, affecting millions of inhabitants and causing significant damage to property and infrastructure. This directly impacts the viability of both urban and peri-urban agriculture and threatens the infrastructure that supports the tourism industry. Critically, Dinh Ho Tong Minh's research emphasizes a startling conclusion: for these low-lying coastal cities, the effects of land subsidence are appreciably greater than those resulting from global sea-level rise [3]. This finding highlights the importance of addressing subsidence as a key component of any climate change adaptation strategy. The relentless decline of Vietnam's economic heartlands is not merely an environmental issue; it is a fundamental barrier to sustainable development, posing a threat to public safety, economic stability, and the nation's long-term resilience.

5. Synthesis: an integrated framework for sustainable development

The challenges and opportunities presented by smart agriculture, sustainable tourism, and urban land subsidence are not isolated issues; they are deeply interconnected facets of Vietnam's development landscape. A resilient and prosperous future requires a framework that transcends siloed policies and adopts an integrated approach. This synthesis proposes a model where urban resilience forms the bedrock upon which the pillars of smart agriculture and sustainable tourism can be securely built, with agritourism acting as a strategic bridge between them. This requires not only policy integration but also operational integration through shared governance mechanisms and spatial planning tools. For example, a joint committee for sustainable development could be established with representatives from the ministries of agriculture, tourism, and construction, tasked with creating a unified land-use plan that zones areas for smart agriculture, tourism, and urban development while also identifying and protecting critical zones for groundwater recharge.

Agritourism, the integration of agricultural activities with tourism experiences, offers a powerful mechanism for synergy. It provides a diversified income stream for farmers, helps preserve rural landscapes and cultural traditions, and gives tourists authentic, educational, and engaging experiences [16]. The development of agritourism can directly link urban consumers and tourists with rural producers, creating a virtuous cycle of economic benefits. Recent research has shown that integrating agriculture and tourism can significantly foster agricultural green development, even exhibiting positive spatial spillover effects, where growth in one region benefits its neighbors [17]. This model is particularly relevant for Vietnam, where there is a growing demand for authentic travel experiences and a need to create new economic opportunities in rural areas.

The potential of agritourism is magnified when combined with smart agriculture. Imagine tourists visiting a smart farm in the Mekong Delta where they can use their smartphones to scan a QR code on a piece of fruit and see its entire journey from seed to harvest, including data on water usage and carbon footprint. Consider urban vertical farms, powered by IoT and AI, that double as educational centers and tourist attractions in cities like Ho Chi Minh City. These are not futuristic fantasies; they are tangible applications of how smart agriculture can create innovative, high-value tourism products. By the same token, the principles of sustainable tourism—emphasizing community involvement, cultural respect, and low environmental impact—must guide the development of agritourism to prevent it from becoming another form of extractive mass tourism.

However, this entire integrated model rests on a stable foundation. The viability of both sustainable urban tourism and productive peri-urban agriculture is fundamentally compromised if the land itself is sinking. A city plagued by constant flooding cannot sustain its tourism infrastructure—airports, hotels, heritage sites, and transportation networks are all at risk. Likewise, the agricultural hinterlands surrounding these cities, which are prime locations for agritourism development, are also threatened by subsidence and the associated intrusion of saltwater. Therefore, addressing land subsidence is not just an urban planning issue; it is a prerequisite for the success of both sustainable agriculture and tourism. The critical research on subsidence in Vietnam [3, 14] makes it clear that without a robust strategy for sustainable groundwater management and urban resilience, any investments in the tourism and agriculture sectors are built on literally unstable ground. A truly integrated framework for sustainable development in Vietnam must, therefore, begin with stabilizing its foundation, creating a resilient urban environment from which smart agriculture and sustainable tourism can flourish and intertwine.

6. Policy recommendations

Based on the interconnected challenges of agricultural modernization, tourism development, and urban subsidence, a cohesive and multi-pronged policy response is essential. The following recommendations propose an integrated governance framework to steer Vietnam towards a more sustainable and resilient development trajectory.

6.1. Establish integrated governance and planning mechanisms (short- to medium-term, government-led)

The siloed nature of government ministries often hinders the effective implementation of policies. Vietnam should establish a national council for sustainable development and urban resilience, chaired at the level of deputy prime minister. This council would be tasked with coordinating policies across the Ministry of Agriculture and Environment, the Ministry of Culture, Sports, and Tourism, and the Ministry of Construction. Its primary mandate would be to ensure that urban planning, agricultural modernization, and tourism strategies are mutually reinforcing and aligned with national sustainability goals. This body would be responsible for developing a national integrated land use plan that explicitly accounts for subsidence risk, agricultural potential, and tourism development zones.

6.2. Implement a national strategy for sustainable water and land management (short- to medium-term, government-led, with private sector and academic collaboration)

Given the critical threat of land subsidence, a robust national strategy for water and land management is urgently needed. This strategy should be grounded in the empirical evidence provided by researchers like Dinh Ho Tong Minh and should include:

Strict Regulation of Groundwater Extraction: Implement and enforce stringent limits on groundwater pumping in high-risk urban and industrial areas, particularly in Ho Chi Minh City and Hanoi. This should be accompanied by a tiered pricing system that discourages excessive water use.

Investment in Alternative Water Sources: Aggressively invest in developing alternative water sources, including rainwater harvesting, surface water treatment plants, and water recycling facilities, to reduce reliance on groundwater.

Mandatory Use of Subsidence Data: Enact a requirement for all new urban planning, infrastructure projects, and real estate developments in designated subsidence zones to integrate the latest scientific data on ground deformation. Subsidence risk assessments must be a compulsory element of the environmental impact assessment process.

6.3. Foster the growth of smart agritourism (medium- to long-term, private sector-led, with government support)

To capitalize on the synergies between agriculture and tourism, the government should actively promote the development of a smart agritourism sector. Key policy actions should include:

Financial Incentives and Support: Provide a package of financial incentives, including low-interest loans, grants, and tax breaks, for farms and rural enterprises that adopt smart agricultural technologies and develop sustainable agritourism services.

National Standards and Certification: Develop a national certification program for "Sustainable Agritourism" to ensure that developments adhere to high standards of environmental protection, cultural authenticity, and community benefit. This would help build brand reputation and attract high-value tourists.

Investment in Rural and Digital Infrastructure: Prioritize public investment in the rural infrastructure necessary to support agritourism, including transportation links, high-speed

internet access, and digital payment systems, to connect rural producers with urban and international markets.

Enhancing Traditional Craft Villages: A specific policy focus should be placed on promoting the application of smart agriculture in traditional craft villages. This would not only enhance the economic viability of these villages but also create unique, high-value tourism experiences that are rooted in local culture and heritage. This can be achieved through targeted subsidies for technology adoption and the development of dedicated tourism promotion campaigns.

6.4. Invest in human capital and capacity building (continuous, a joint effort of government, academia, and private Sector)

A transition to a more sustainable development model requires a skilled workforce. The government, in partnership with academic institutions and the private sector, should launch comprehensive training and education programs to support the development of a skilled workforce. These programs should target farmers, tourism operators, and local government officials, focusing on sustainable practices in agriculture, hospitality, and resource management. Curricula should be developed in collaboration with research institutions like INRAE and VNU Ha Noi to ensure the latest scientific knowledge, including the principles of smart farming, sustainable tourism management, and the challenges of urban resilience.

7. Conclusion

Vietnam stands at a critical juncture, where the decisions made today will define its developmental trajectory for decades to come. The pursuit of economic growth, while essential, cannot be decoupled from the principles of environmental sustainability and social equity. This review has argued that an integrated strategy, one that cohesively blends the innovations of smart agriculture, the inclusive potential of sustainable tourism, and the urgent necessity of urban resilience, is the most viable path forward. The promise of a high-tech, productive agricultural sector and a vibrant, culturally rich tourism industry can only be fully realized if the very ground beneath Vietnam's economic centers is secure.

The seminal research on land subsidence in Ho Chi Minh City and Hanoi serves as a stark reminder that unchecked urbanization has severe consequences that threaten the nation's long-term prosperity. The research of Dinh Ho Tong Minh et al. makes it unequivocally clear that subsidence is not a peripheral environmental issue but a central development challenge

that requires immediate and decisive action. Ignoring this sinking foundation is not an option. Therefore, building resilience, particularly through sustainable water management, must be the bedrock of Vietnam's national strategy.

By embracing a holistic framework, Vietnam can create a virtuous cycle in which progress in one domain reinforces progress in another. Smart agriculture can give rise to a new generation of sustainable agritourism, creating diversified rural economies and unique visitor experiences. Sustainable tourism, in turn, can generate the revenue and foster the environmental ethic needed to invest in conservation and green technologies. All of this, however, depends on the political will to implement integrated policies and to make decisions based on scientific evidence. By leveraging the expertise of its researchers and fostering collaboration across sectors, Vietnam can navigate the complexities of 21st-century development and build a truly sustainable, prosperous, and resilient future for all its citizens.

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