Sustainability of traditional vermicelli production in Minh Hong village, Ba Vi district, Hanoi, Vietnam

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Abstract: This study was conducted to propose proper indicators and to assess the sustainability of traditional vermicelli production in Minh Hong village. Sustainability of traditional vermicelli production in Minh Hong village was assessed based on 40 indicators belonging to 5 dimensions (production, product management and consumption, economy, society, and environment). All indicators were quantified on a scale of 0-1, in which 0 presenting low sustainability and 1 indicating high sustainability. The results showed high sustainability of economic dimension ranging from 0.87 to 1.00, implying economic efficiency of vermicelli production. However, social and environmental dimensions demonstrated medium sustainability. Some factors affecting on the sustainability of vermicelli production were the unsustainable connection between production and market, stability of input materials, consumption markets, limited training and labor safety, capital for production and business, and management of local authority. Solutions for ensuring the sustainability of traditional vermicelli production were also proposed and discussed.

1. Introduction
Handicraft villages play an important role in the development of socio-economic, livelihood, and culture maintenance in rural areas. In 2014, there were 5096 handicraft villages in operation, of which, 1748 traditional craft villages were certificated [1]. Traditional crafts have been formed and developed for a long time with unique products [2]. A variety of studies have been conducted to assess the socio-economic development of traditional craft villages [3-5]. Development policies, product consumption strategies, preserving and developing cultures of craft villages were also evaluated [6-9]. The unsustainable development of craft villages has also resulted in environmental pollution and severe influence on the public health [10]. Serious water pollution was reported in craft villages with food and foodstuff processing, livestock and cattle slaughter villages, paper recycling, textile dyeing, and metal recycling [10-13]. Environmental pollution in craft villages has induced increasing diseases for local people [10, 14].

Challenges for development of traditional production (e.g., small-scale production, backward technologies, inadequate infrastructure, limited capital and skilled labor resources, inadequate environmental management, and insufficient product commercialization) may pose negative impacts on the sustainability of craft villages [10, 16]. The concept of sustainability was firstly introduced in the report "Our Common Future" [17] which emphasized the development of the global economy together with maintaining core ecosystems and supporting long-term ecological balance. Sustainability indicators
are recognized as an important tool of sustainability assessment by providing view of system sustainability and fundamental information for policy makers and all other stakeholders [18, 19]. An indicator is a variable, which describes one characteristic of the state of a system on the basis of observed or estimated data [19]. An index is a quantitative aggregation of many indicators and can provide a simplified, coherent, multidimensional view of a system [19].

Sustainability has been evaluated worldwide such as in Japan [20], China [21], France [22], Spain [23], and Mexico [24]. Various sustainability indices and indicators were proposed [18, 25]. Indicators or indexes for sustainability assessment of traditional production have been reported [26-29]. Durham and Litterll [26] proposed indicators to assess sustainability of traditional production and craft village; however, social and environmental issues were not mentioned. Patricia et al. [27] introduced comprehensive indicators for sustainability assessment, which covered different aspects of traditional production; however, trend of development and factors affecting on sustainability were not evaluated. Santitaweeroek [28] proposed indicators reflecting the assessment of economic, social, environmental, and production components; nevertheless, production process and management were not mentioned. Considering the specific cultural and social characteristics of traditional production in Vietnam, comprehensive indicators for sustainability assessment are of great concern.

This study was conducted to propose and apply indicators for sustainability assessment of traditional vermicelli production in Minh Hong village, Minh Quang commune, Ba Vi district, Hanoi. These indicators can be adjusted in accordance with characteristics of different production and craft villages to assess the sustainability of traditional production.

2. Study site
Minh Hong village covers an area of 152.25 ha, in which the percentage of production, garden, and residential land is 44.7, 39.7, and 21.2%, respectively [30]. The total population in the village in 2016 was 1378 people with 356 households [30]. The residents of this area are mainly Kinh ethnic group and a small part of residents are Muong and Dao ethnic minorities. The vermicelli production has started since 1969 with 2-3 households, which currently reaching 289 households, accounting for 81% of the total households in the village. The entire production process was firstly handmade without any machine and supporting devices with low productivity. However, at the present, the whole village has 162 starch processing and 9 vermicelli making machines. Minh Hong vermicelli has granted the "Minh Hong" for vermicelli products (Code SHTT/01-2014-2) by Hanoi Department of Science and Technology since 2015.

3. Indicators for assessing sustainability of traditional production
Indicators for sustainability assessment of traditional production in Minh Hong village were proposed mainly based on the indicators reported by Patricia et al. [27], and partly based on Santitaweeroek [28] (Table 1). In total, 40 indicators belonging to 5 dimensions were introduced including production process (S1), product management and consumption (S2), economy (S3), society (S4), and environment (S5) (Table 1).

| Dimensions (S1) | Code | Indicator |
|----------------|------|-----------|
| 1. Production scale* | S1-1 | Production scale |
| 2. Production method* | S1-2 | Production technology |
| 3. Machine and equipment * | S1-3 | Production procedure |
| 4. Time involved in production | S1-4 | Machine and equipment for production |
| 5. | S1-5 | Time involved in production |

Table 1. Indicators for sustainability assessment of traditional production in Minh Hong village
| Dimensions | Group | Code | Indicator |
|------------|-------|------|-----------|
| Product management and consumption (S2) | 5. Business* | S2-1 | Plan to expand production scale |
| | | S2-2 | Contract to supply input materials |
| | | S2-3 | Proportion of products produced and sold |
| | | S2-4 | Support of local authorities in product consumption |
| | | S2-5 | Ability to borrow capital for production |
| | 6. Customer* | S2-6 | Potential of marketing for products |
| | | S2-7 | Contract with the consuming units |
| | 7. Product availability* | S2-8 | Production output |
| | | S2-9 | Change in production output |
| | | S2-10 | The number of months supplying sufficient production materials in the year |
| | 8. Quality control and product classification | S2-11 | Quality control and product classification |
| Economic (S3) | 9. Profit* | S3-1 | Average income of households |
| | | S3-2 | Change in household income |
| Society (S4) | 10. Honesty and commitment to the community* | S4-1 | Awareness of responsibility for environmental protection |
| | | S4-2 | The number of training courses on environmental protection that households participate in |
| | 11. Business ethics* | S4-3 | Awareness of local people on environmental impacts of production activities |
| | 12. Community relations** | S4-4 | Assessment of households on the relationship between producers |
| | | S4-5 | Assessment of households on the relationship between producers and non-producers |
| | | S4-6 | Assessment of households on the relationship between the community and local authorities |
| | | S4-7 | Assessment of households on the impact of production to traditional craft villages |
| Environment (S5) | 13. Use of materials in the production* | S5-1 | Environmental impact of materials used in production |
| | 14. Water supply and use* | S5-2 | Use of water in the production |
| | | S5-3 | Effectiveness of water use in the production |
| | | S5-4 | Regular water supply |
| | | S5-5 | Water availability |
| | 15. Energy consumption* | S5-6 | Environmental impact of energy consumed in production |
| | 16. Environmental pollution * | S5-7 | Quality of wastewater |
| | | | Quality of surface water |
| | | | Assessment of household on soil quality change during 10 years |
| | | | Assessment of household on surface water quality change during 10 years |
Dimensions | Group | Indicators |
|-----------|--------|-----------|
|           |        | Code | Indicator |
|           |        | S5-8 | The number of applied measures for solid waste treatment |
|           |        | S5-9 | The percentage of trained workers (%) |
|           |        | S5-10 | Safety of labor protection and instruments |
|           |        | S5-11 | The proportion of workers participating in insurance |
|           |        | S5-12 | The proportion of workers participating in training courses on first aid and occupational safety |
|           |        | S5-13 | The proportion of workers participating in training courses on industrial hygiene |
|           |        | S5-14 | The proportion of workers participating in training courses on hazardous waste treatment |
|           |        | S5-15 | The proportion of households receiving vocational training support from local authorities |

Note: * Patricia et al. [27]; **Satitaweeroek [28]

4. Materials and methods

4.1. Sampling
Field survey was conducted in 2017 in Minh Hong village, Minh Quang commune, Ba Vi district for assessing current status of vermicelli production, related economic, social, and environmental dimensions. A total of 12 water samples were collected including wastewater, surface water, and groundwater. The wastewater samples were taken in large, medium, and small scale producers. The surface water samples were taken at the location before flowing into the village, scattered around the village, and at the end of the general collection system in the village. Wastewater, lake water, rivers and streams, and groundwater analyses were performed following guidelines TCVN 5999: 1995 [31], TCVN 5994-1995 [32], TCVN 6663-6-2008 [33], TCVN 6663-11: 2011 [34], respectively. Samples preservation was conducted in accordance with TCVN 6663 - 3: 2016 guideline [35]. All samples were collected in duplicate.

4.2. Social survey
The social survey using questionnaire was conducted in 2017 following the proposed indicators for sustainability assessment of traditional vermicelli production in Minh Hong village. The survey households were randomly selected based on the even distribution in 4 hamlets in Minh Hong village. A total of 41 households were selected, ensuring 90% confidence level and 12% margin of error following the equation (Eq.1) [36].

\[
n = \frac{z^2 \times p(1-p)}{e^2} \div \left(1 + \left(\frac{z^2 \times p(1-p)}{e^2 \times N}\right)\right) \quad \text{(Eq.1)}
\]

Where \( n \) is sample size or interviewed households, \( N \) is the number of households in the study area, \( p \) is confidence level, \( z \) is value corresponding to desired confidence level, and \( e \) is margin of error.


4.3. Analytical methods
Biochemical Oxygen Demand (BOD₅) and Chemical Oxygen Demand (COD) values in water samples were determined following the TCVN 6001-2008 [37] and TCVN 6491:1999 [38], respectively. Sample analysis was performed at VNU University of Science, Vietnam National University, Hanoi. The results of duplicated samples showed the low variation of BOD₅ (5.5%) and COD (3.5%).

4.4. Data analysis
Data from current reports of the study area, social survey, and sample analysis was used for sustainability assessment of traditional vermicelli production in Minh Hong village. Qualitative data was coded properly. The data was transformed to a range from 0 to 1 for quantitative assessment, of which, value 0 indicates the unsustainability and value 1 represents high sustainability. Equations (Eq. 2 or Eq. 3) were used for transforming data [39, 40] when the indicators were positively or negatively correlated with sustainability, respectively:

\[ x_{ij} = \frac{X_{ij} - \text{Min}X_{ij}}{\text{Max}X_{ij} - \text{Min}X_{ij}} \]  
\[ x_{ij} = \frac{\text{Max}X_{ij} - X_{ij}}{\text{Max}X_{ij} - \text{Min}X_{ij}} \]  

where \( x_{ij} \) is transformed value of indicator \( i \) of household \( j \), \( X_{ij} \) is the real value of indicator \( i \) of household \( j \), \( \text{Max} \) and \( \text{Min} \) values are the maximum and minimum values of the households of each indicator.

Sustainability of each dimension and total sustainability was calculated by average values of corresponding indicators. The scale for sustainability assessment of Minh Hong vermicelli production was proposed (Table 2).

| No | Level                        | Score         |
|----|------------------------------|---------------|
| 1  | High sustainability         | 0.81 – 1.00   |
| 2  | Relatively high sustainability | 0.61 – 0.80   |
| 3  | Medium sustainability       | 0.41 – 0.60   |
| 4  | Low sustainability          | 0.21 – 0.40   |
| 5  | Unsustainability            | 0.00 – 0.20   |

5. Results and discussion

5.1. Assessment of sustainability of traditional vermicelli production in Minh Hong village

5.1.1. Vermicelli production in Minh Hong village (S1). The result of social survey showed a majority of small vermicelli production in the study area, of which 97% of producers were producing at household scale. 85% of households were semi-manual and 10% of households used modern machine in production. The production procedure includes the following steps: (1) Harvesting arrowroot, (2) Processing into powder, (3) Processing into vermicelli, and (4) Products. Large volume of wastewater has released due to the high fiber content of arrowroot and processing technology. Most of households used electromechanical machines (93%) for production. A majority (98%) of households participated in the vermicelli production for more than 10 years, implying the stabilization of production in the study area.

5.1.2. Product management and consumption (S2). The result of social survey demonstrated that 40% of households had a plan to expand production scale; whereas, only 10% of households wanted to open more production facilities (Figure 1). Although 100% vermicelli products were consumed, most of the
households did not have contracts with suppliers of materials (97%) and product consumption (90%). Most of vermicelli were purchased by agents, then consumed in Hanoi and other provinces (90%) (Figure 2). Only 10% of households had contracts with consumption agents.

The ratio of households having sufficient raw materials for production of < 3 months, < 6 months, and all year was 40, 52, and 8%, respectively. The ratio of households having yield of arrowroot of approximately 50 and 10-50 tons/year was 43 and 57%, respectively. Approximately 38, 56, and 6% households had arrowroot flour of < 10, 10 - 50, and > 50 tons/year, respectively. Whereas, the percentage of households having vermicelli production of < 10, 10 - 50, and > 50 tons/year was 8, 42, and 50%, respectively. The high percentage (56%) of households having an increasing yield of vermicelli, arrowroot flour, or arrowroot was also obtained (Figure 3).

The quality control of production is only based on experience of each household without any related training. A majority of households did not receive any support from the local authority (93%).

![Figure 1. Production expansion plan](image1)

![Figure 2. Consumer market](image2)

![Figure 3. Change of vermicelli yield](image3)

![Figure 4. Household income from vermicelli](image4)

5.1.3. Economic dimension of traditional vermicelli production in Minh Hong village (S3). The result of social survey showed that approximately 27, 46, and 20% of households had income from vermicelli production of 50 - 100, 100 - 200, and ≥ 200 million VND/year, respectively (Figure 4). The average income of local people in the study area is higher than the average income of Vietnamese in 2012 [42], reflecting the economic effectiveness of vermicelli production. High income was observed in
households involving in selling vermicelli products and large-scale production. In addition, high proportion (78%) of households with increasing income was also found.

5.1.4. Social dimension of traditional vermicelli production in Minh Hong village (S4). A majority of production and business households in the craft villages voluntarily paid environmental fees (70% of producers) with a monthly waste collection fee of 5,000 VND/person. However, households along streams still have a habit of littering rubbish directly near their house. In addition, awareness on environmental impacts of producers is not high. Approximately 45% of households assessed that production activities did not affect the surrounding environment.

Local authorities organize annual training or propaganda on environmental protection every year. However, most of the households did not participate or only participated for the first time. Therefore, 83% of the households had decreasing trend of participating frequency in environmental protection training courses, reflecting the low interest of local people in these courses in the study area.

The result of social survey also showed medium percentage of households assessing the better relationship during production among producers (54-66%) and between households and local authority (56%). High proportion (88%) of households evaluated that the production of vermicelli had a positive effect on traditional craft villages, in which, 88% of households felt that the village's tradition was better.

5.1.5. Environmental dimension of traditional vermicelli production in Minh Hong village (S5). The source of raw material is arrowroot, which is grown and processed locally. The processing of raw materials will affect the environment via the following processes: washing, peeling, grinding, soaking, annealing, filtering copper powder, drying products, and transporting raw materials and products. The result of field survey demonstrated that 1 ton of arrowroot and 40-80m³ of water are needed for processing 125kg vermicelli. The percentage of households using water over 1000, 500 - 1000, 300 - 500, 100-300, and 0-50 m³ per month was 29, 32, 27, 5, and 7 %, respectively. All the households use groundwater for production and domestic purposes. In addition, local people also use surface water during the cultivation of arrowroot on the hill.

Electricity-consumption machines (e.g., crushers, kneading, coating and cutting machines, and dryers) are commonly used for vermicelli production which accounts for 67% of households. Some households also use additional coal and firewood (33%).

The result of social survey demonstrated that the proportion of households assessing the worse trend of the quality of soil, surface water, domestic water, and water for production during the last 10 years was 20, 68, 46, and 54%, respectively.

The analytical results showed that BOD₅ values in surface water and wastewater range by 1 - 209 and 342 - 749 mg/l, respectively (Table 3). BOD₅ values at 40% of surface water samples were 6-14 times higher than the regulation [43] and those of wastewater were 6 - 15 times higher than the QCVN40: 2011/BTNMT [44]. COD values were also high in the surface water, wastewater, and groundwater which ranged within 2 - 640, 1480 - 2630, and 4 - 6 mg/l, respectively (Table 3). Higher BOD₅ and COD values near the discharge points of production households were found. BOD₅ and COD values at the stream before flowing into the craft village (MH1) were lower than those after flowing through the craft village (MH5), indicating the impacts of vermicelli production on the environment.

The solutions to reduce pollution have not been implemented well. Wastewater from production and domestic was discharged directly into the sewer system. The result of social survey showed that the percentage of solid waste from vermicelli production being used for livestock, poured into ponds, and poured into the sewer system was 39, 51, and 10%, respectively.

All households are self-training without participating in vocational training courses. In addition, 92% of households did not take part in training on occupational safety for vermicelli production. The ratio of households who did not use any regular protection or used simple labor protection accounted for 25 and 50% respectively. Moreover, up to 87% of households did not participate in industrial hygiene training, and only 5% of them regularly attended these training classes. A majority of households who did not attend the waste treatment training course was found (85%). Most households believed that wastewater from production activities caused negligible pollution and often incubates piles of trees or dumps in a
centralized yard. In addition, a majority of interviewed households (62%) did not receive the training support and skills improvement from the local authorities.

Table 3. BOD\textsubscript{5} and COD (mg/l) in water samples of Minh Hong village

| Sample | Type of sample | BOD\textsubscript{5} | COD | Regulation limits |
|--------|----------------|-----------------------|-----|------------------|
| MH1    | Surface water  | 1                     | 2   |                   |
| MH2    | Surface water  | 209                   | 640 |                   |
| MH3    | Surface water  | 92                    | 160 | 15               | 30               | 43 |
| MH4    | Surface water  | 6.8                   | 17  |                   |
| MH5    | Surface water  | 10                    | 13  |                   |
| MH6    | Wastewater     | 324                   | 2380|                   |
| MH7    | Wastewater     | 749                   | 2630|                   |
| MH8    | Wastewater     | 461                   | 2400| 50               | 150              | 44 |
| MH9    | Wastewater     | 342                   | 2300|                   |
| MH10   | Wastewater     | 400                   | 1480|                   |
| MH11   | Groundwater    | -                     | 4   |                   | 4                | 45 |
| MH12   | Groundwater    | -                     | 6   |                   |

5.1.5. Sustainability assessment of traditional vermicelli production in Minh Hong village. The results of quantitative sustainability assessment of vermicelli production in Minh Hong village demonstrated 9/40 indicators at high sustainability (0.81-1.00) (S1-4, S1-5, S2-3, S2-11, S4-4, S4-7, S5-4, S5-5, and S5-11), 8/40 indicators at relatively high sustainability (0.61-0.80) (S1-3, S2-1, S2-5, S2-9, S3-2, S4-5, S4-6, and S5-6), 10/40 indicators at medium sustainability (0.41-0.60) (S1-2, S2-6, S2-8, S3-1, S4-3, S5-1, S5-3, S5-8, S5-9, and S5-10), 6/40 indicators at low sustainability (0.21-0.40) (S1-1, S2-10, S4-1, S5-2, S5-7, and S5-15), and 7/40 indicators at unsustainability (0-0.20) (S2-2, S2-4, S2-7, S4-2, S5-12, S5-13, and S5-14).

The sustainability of the production process (S1), product management and consumption (S2), economy (S3), society (S4), and environment (S5) of Minh Hong vermicelli production was 0.72, 0.53, 0.73, 0.60, and 0.49, respectively (Figure 5). The total sustainability of vermicelli production in Minh Hong village was 0.61, indicating the relatively high sustainability. The result of this study also indicates that the sustainability of vermicelli is greatly dependent on market for products, capital for production and business, stability of input materials for vermicelli production, unsustainable connection between production and market, trained labors and labor safety, and management effectiveness of local authority.

5.2. Measures for enhancing sustainability of traditional vermicelli production in Minh Hong village

5.2.1. Policies. Policy of input material area: there is currently no planning for areas to supply input material for vermicelli production in the study area. Therefore, a plan for planting material areas and land for stable production is of high priority. The area size, location for planting materials, and enlarging scale of planting to neighboring communes (e.g., Ba Trai and Tan Linh) based on production expansion should be carefully considered.
Figure 5. The sustainability of Minh Hong vermicelli production

Policies to support infrastructure construction of craft village: Some policies to develop craft villages of Hanoi city have been issued (e.g., [46-49]). However, the implementation of these policies still faces many difficulties (e.g., cost of construction of clean water supply and wastewater drainage infrastructure, and waste treatment areas). Therefore, in addition to support from the Provincial and District People's Committees, the policies to raise participation of local people as well as private financial support (e.g., public–private partnership -PPP) for water treatment plant should also be taken into account.

Policies of investment and credit: These policies should be built and improved to ensure the flexibility and diversification of funds for production. The social survey showed high need of local people to borrow capital for production investment. However, in fact, they face with low amounts of money and complicated procedures to approach capital from bank loans. Therefore, policies to support capital for production development should be performed. In addition, financial support should be integrated with responsibility in environmental protection. For example, households with certificates on environmental protection are given priority to access to bank loans.

Policies of production consumption: The vermicelli products from Minh Hong village are now consumed by local people and neighboring provinces in retail stores and have not yet entered the supermarket system as well as export. Therefore, it is necessary to promote and introduce more extensive products for Minh Hong vermicelli to be widely known by consumers. In order to accomplish this goal, the local authority must be the core, has the strategy and direction to promote products, even find new markets for the products. The local authority needs to find the new market, propaganda and helps people sign contracts with purchasing units to avoid the situation of local people trading without legal binding. In addition, the local authority should assist households to follow standard production procedure required by consumers.

Policies of human resource training: It is necessary to combine and maintain vocational training regularly with the improvement of the workforce qualification, timely training of the next young workers who are able to study quickly and apply effectively the skills in production. Effectiveness of these training courses should also be improved.

5.2.2. Science and technology. Scientific and technical solutions need to be applied to maintain and ensure the sustainability of vermicelli production in Minh Hong village as follows: (1) Enhancing the application of science and technology, improving the design and product quality, (2) Innovating in production equipment gradually toward automation while improving productivity, and product quality for reducing environmental pollution, (3) Investing equipment, technology for wastewater treatment, (4)
Promoting research, transfer, and application of advanced science and technology in production, preservation and processing of vermicelli products and (5) Developing communication system to create conditions for households to access and use the internet, data transmission services.

5.2.3. Planning. Ba Vi District People's Committee is also undertaking a land use planning for Minh Hong village for vermicelli production. The investment in construction and infrastructure development, drainage systems, clean water supply system, and wastewater collection and treatment system should be considered in this planning.

5.2.4. Other measures. Other measures should also be implemented to ensure sustainability of vermicelli production as follows: (1) Propagating and mobilizing production households to sign contracts with raw material supply units and product purchasing units to ensure stable production, (2) Fostering knowledge for workers at production facilities, including skills and awareness related to working as well as regular awareness of environmental protection, (3) Ensuring occupational safety and health, and preventing labor accidents during production, (4) Building the village regulations on environmental protection based on the current environmental protection fund of the village, and (5) Improving the role of Minh Hong cooperative in accordance with its functions and tasks as it was established, helping to link production households, connecting with material suppliers, seeking to expand the market of product consumption.

6. Conclusions
A total of 40 indicators belonging to 5 dimensions (production process, product management and consumption, economy, society, and environment) was proposed and applied for sustainability assessment of traditional vermicelli production in Minh Hong village, Ba Vi district, Hanoi. The traditional vermicelli production in the study area was assessed to be relatively high sustainability (0.61 per 1 scale). On the basis of this study, some solutions should be implemented for ensuring sustainability of vermicelli production in the study area: (1) Building and applying policies related to land use, raw materials, production consumption and credit, (2) Applying science and technology in production improvement and environmental remediation, (3) Building production planning and environmental production, and (4) Propagandizing and raising awareness of local people on labor safety and environmental protection.

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