Annals of Agrarian Science

Journal homepage: http://journals.org.ge/index.php

# Sustainability Performance Assessment of the Participatory Guarantee Systems: A case study in Beijing Farmers Market

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Received 27 July 2022, Accepted: 01 August 2022

## ABSTRACT

Among the range of incentives that might motivate farmers to adopt more sustainable practices, focus is given on the role that institutional innovations such as Participatory Guarantee Systems (PGS) could play in the transition to sustainable agriculture. PGS are established by producers, consumers, local authorities and other interested stakeholders, and ensure that agreed sustainable agricultural practices are adopted. Despite the growing popularity, there is no an experimental assessment of sustainability performance of PGS in order to better understand the role of PGS in sustainable agriculture. The objective of this study is to (a) assess the sustainability performance of PGS comprehensively, (b) to perform a systematic assessment of synergies and trade-offs between sustainability dimensions and themes and (c) to quantify the real influence of the selected sustainability themes on the least evolved theme. The Sustainability Assessments of Food and Agriculture Systems (SAFA) Guidelines published by the Food and Agriculture Organization (FAO) provide a transparent and aggregated framework to encompass all aspects of sustainability, as well as to understand how strength, weakness and progress could be tackled in the farming systems. This study used the indicator-based SAFA consistent SAFA Tool to assess sustainability performance of Beijing Farmers Market (BFM) PGS in China. Based on the respective sustainability scores, the synergies and trade-offs between sustainability dimensions and themes were analyzed using the non-parametric Spearman correlation test, and a linear regression analysis was applied to identify the influence that selected sustainability themes have on a poorly rated theme. The results displayed trade-offs between "Economic Resilience" dimension and other three sustainability dimensions, due to "Vulnerability" theme which was a most challenging and poorly-rated theme. At the same time, the "Holistic Management", "Biodiversity" and "Water" themes had a significant effect ($P<0.05$) with the capacity to decrease vulnerability level by 43.4%, 41.4% and 37.3%, respectively. Through its positive influence, "Social Well-Being" dimension enhanced the achievement of sustainability goals on other dimensions. The study further argues that with a committed and supportive consumer base PGS could become a reservoir of social capital to build a fair and sustainable community. This study presents a new perspective leading to a guideline for other PGS initiatives those early in the sustainability journey.

***Key words***: PGS, SAFA, sustainability performance assessment, synergies, trade-offs

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## Introduction

Institutional innovations are considered as new regulations and ways of re-organizing the relationships between producers and organizations (actors) in the food system [1] by pushing the boundaries of the traditional roles of market and institutional intermediaries [2]. One of the examples of the institutional innovations is the PGS, which are defined as locally focused quality assurance systems. They certify producers based on active participation of stakeholders and are built on a foundation of trust, social networks and knowledge exchange [3].

PGS offer producers a wide range of benefits

such as market access, farmer empowerment, improved social bonds, regular sales, cost-saving practices, a better management of natural resources and enhanced food security. Hence, PGS play a vital in to reduce food insecurity and poverty problems among rural farmers, thereby fostering more sustainable livelihood [4]. Moreover, PGS can be used as a tool to improve organic agriculture and alternative certification system [5]; intensify knowledge sharing and disseminate good agricultural practices among farmers [6]; facilitate peer-to-peer process, enhance food sovereignty for local markets [7]. PGS have the potential to enable transformation towards sustainability [8], but convincing evidence is needed on how PGS promote the transition to more sustainable food system [9]. Although previous studies scientifically covered individual components of PGS [10-12], a deep analysis that covers key aspects of sustainability and quantitative analysis of interactions between sustainability objectives is still absent.

Many different frameworks have been developed [13-15], but most of them are unclear in agreeing on how to asses sustainability [16,17]. This, perhaps, is partly due to lack of an agreed-upon definition of sustainability [18] and incompatible approaches to performance analysis in the field of sustainable development [19]. For instance, Life Cycle Assessment (LCA) tools quantitatively evaluate environmental impact of a product considering the use of resources and emission of pollutants [20], but ignore the economic and social dimensions [21]. Furthermore, the Framework for Assessing the Sustainability of Natural Resource Management Systems (MESMIS, for its acronym in Spanish) has been applied to more than 20 case studies across Europe and Latin America in order to evaluate agricultural sustainability [22-24]. The operative structure of MESMIS framework is based on a six-step evaluation. The first three steps are related to a system characterization, the identification of key aspects and the selection of indicators with respect to the three sustainability dimensions (environmental, economic and social). The last three steps are assessed through mixed (qualitative and quantitative) techniques and multi-criteria analysis based on the information obtained from the indicators [25]. However, MESMIS framework excludes key indicators (e.g., stakeholder participation) from being included in the assessment [26]. The system-oriented sustainability assessment approaches such as Response-Inducing Sustainability Evaluation (RISE) [27,28] evaluate sustainability of farm management with respect to the three sustainability dimensions like MESMIS, but with limited number of indicators. The precision and scope of more than 30 different approaches identified in literature were comprehensively compared, and it was concluded that none of them captures all aspects of sustainability assessment [29]. The divergence between the proposed sustainability assessment tools and their components to measure "what matters to whom and how" reinforces the point that assessment frameworks remain fragmented. This means that they need to be holistically approached and harmonized, and all essential components of sustainability should be integrated, establishing a "common language" for sustainability assessment that is relevant to governments, policy-makers and agricultural holdings whether they are big companies or small-scale producers. To close this gap, Food and Agriculture Organization of the United Nations (FAO) developed the Sustainability Assessments of Food and Agriculture Systems (SAFA) Guidelines, providing a globally applicable aggregated framework for sustainability assessment [30]. SAFA Guidelines are comprised of 4 dimensions, 21 themes and 58 sub-themes with specific sustainability objectives (Table S1). Based on SAFA Guidelines, FAO created SAFA Tool, which is an indicator-based tool used to conduct sustainability assessment by supporting trade-off and synergy analysis.

The aim of this study is to apply SAFA-consistent SAFA Tool to assess sustainability performance of BFM PGS to address the question of whether and to what extent PGS are able to provide a transition towards sustainable agriculture which has governance, environmental integrity, economic and social dimensions. Specifically, sustainability performance scores will be used to analyze the synergies and trade-offs between sustainability dimensions and themes, as well as to quantify the real influence of the selected themes on the least evolved theme.

The sustainability performance assessment of BFM PGS and identifying interactions between sustainability goals provide a roadmap, leading to an evidence-based and action-oriented cyclic process conducive to the sustainable development of other PGS initiatives worldwide.

## 2. Materials and Methods

*2.1 SAFA Tool Approach*

SAFA Tool approach is engaged with the provision of a standardized metrics to guide assessments, which is detailed in terms of what "sustainability" means in a practical context [31]. SAFA Tool assesses the sustainability performance of the agricultural holdings with respect to 21 themes and 58 sub-themes identified in SAFA Guidelines (Figure 1).

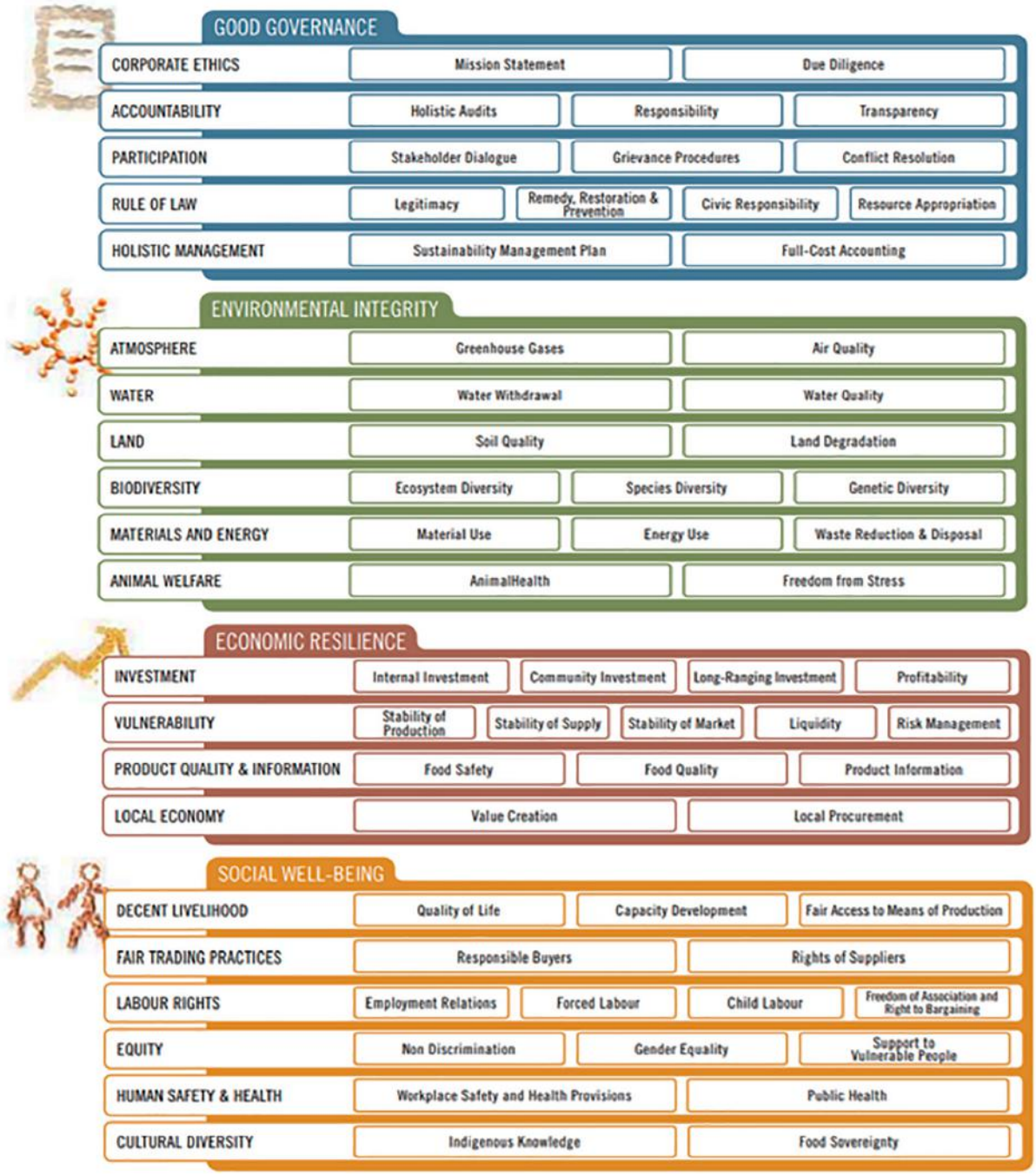


**Figure 1.** Overview of SAFA dimensions and constituent components (themes and sub-themes) *Source: Food and Agriculture Organization of the United Nations (FAO, 2014a).*

For each theme and sub-theme, SAFA Guidelines outline goals and objectives that are globally comparable at all contexts. For instance, for the theme "Land" the goal is "No land is lost due to surface sealing or mismanagement of arable lands and pastures, and soil fertility is preserved and enhanced". Whereas for the sub-theme "Generic Diversity" the objective is "The diversity of

populations of wild species, as well as the diversity of varieties, cultivars and breeds of domesticated species, is conserved and improved". Each sub-theme contains a number of indicators that express sustainability performance on a scale from 0 to 100%. 0% represents an unacceptable state that does not meet the sustainability objectives, whereas 100% represents a situation where all implemented farming activities are related to the "best" achievable objective.

SAFA tool can also be used to cover the farming activities for one year, which provides a benchmark, pointing out critical areas for further improvement. This is especially important for establishing threshold values for the future sustainability assessment. Science-based in nature, SAFA Tool can also be applied to case studies. However, it is not a tool of rating, which is appropriate for a product-specific sustainability, such as LCS approach, and is focused on farms rather than the lifecycle of a product.

*2.1.1 Determining the Sustainability Performance*

SAFA Tool approach starts with the mapping of the assessed entity and review of relevant sub-themes and indicators based on sustainability objectives and context, followed by the determination of a performance score for each indicator and finally, the visual representation of the sustainability report based on the performance scores.

SAFA Tool (Version 2.2.40) contains a total of 116 performance indicators that facilitate measuring progress towards sustainability across the 21 themes and 58 sub-themes (Appendix 1, Table A1). In this study, indicators used for the sustainability performance assessment have been selected according to the following criteria [32,33]:

Parsimony: selection of minimal but manageable set of indicators,

Consistency: the indicators are complementarity for an appropriate interpretation,

Sufficiency: the indicators are comprehensive to integrate all sustainability goals.

For each sub-theme, all indicators in the governance, economic and social dimensions are integrated into the calculation with the weight 1, and the weight is distributed evenly among indicators within each sub-theme (Table 1, A side). No need for weighting if there is only one indicator in the sub-theme (e.g., Community Investment), and if the sub-theme (e.g., Quality of Life, Stakeholder Dialogue) contains more than one indicator, the mean is taken out of the respective number of scores. If the mean is not possible, the lower score is given to the respective sub-theme.

**Table 1.** *Overview of the different weights for the indicators in the governance, economic, social and environmental dimensions* Source: *(FAO, 2014a).*

| The number of indicators per sub-theme is: | Indicator weight in the governance, economic and social dimension |
|---|---|
| 1 | 100 percent |
| 2 | 50 percent |
| 3 | 33 percent |
| 4 | 25 percent |
| Combination of indicator types in the environmental dimension | Maximum potential indicator points in the environmental dimension |
| T - R – P | 1+2+3= 6 points |
| T- R - P – P | 1+2+3+3 = 9 points |
| R - P - P – P | 2+3+3+3 = 11 points |
| R - P - P - P – P | 2+3+3+3+3 = 14 points |
| T - R - P - P – P | 1+2+3+3+3 = 12 points |

On the other hand, three types of indicators are differentiated in the environmental dimension, and the following weighting applies to the indicators in the environmental dimension:

Target (T) indicators = 1 point

Practice (P) indicators = 2 points

Performance (P) indicators = 3 points

The combination of indicators in the environmental sub-themes is presented in Table 1 (B side). Performance indicators (e.g., "Soil Quality") or those that are considered to be direct measurement from an operation itself receive the most weight. Practice indicators (e.g., "Soil-Improvement Practices") or those that are measured by reference to a certain level of good performance are given the second most weight. Target indicators (e.g., "Water Conservation Target") are related to the existence of plan, monitoring, documentation and strategy with a particular sustainability target and are given the lowest amount of weight. Examples of these three types of indicators are given in the Table 2.

**Table 2.** *Examples of different types of environmental indicators for assessing sustainability performance.*

| Indicator type | Indicator example | Potential responses |
|---|---|---|
| Performance indicator | Does the enterprise's operation save seeds, or engage with breeding work to conserve traditional and/or rare breeds on farm? | Yes/no/partial<br>Percentage |
| Practice indicator | What activities and practices have been implemented that have effectively increased the quality and fertility of soils? | Yes/no/partial<br>List of practices |
| Target indicator | Has the enterprise set a target for reducing water consumption or water withdrawals? | Yes/no/partial |

All indicators in SAFA Tool have a 5-scale rating (Table 3), and the rating increases gradually as the performance score goes up from unacceptable to best (Table 4).

**Table 3.** *Rating scales for the SAFA indicators* Source: *(FAO, 2014a).*

| Rating scale | Description: The indicator is rated… |
|---|---|
| Best / 80 – 100% | …at the top level of sustainability performance |
| Good / 60 – 80 % | …at the good level of sustainability performance |
| Moderate / 40 – 60 % | …at the moderate level of sustainability performance |
| Limited / 20 – 40 % | …at the limited level of sustainability performance |
| Unacceptable / 0 – 20 % | …at the unacceptable level of sustainability performance |

Indicators which are considered irrelevant during the contextualization process can be omitted. For instance, indicator with the same name in the sub-theme "Employment Relations" may be irrelevant for small-scale organic producers since they mostly rely on the family work. But the omission of this indicator does not receive "unacceptable" score or 0 percent, rather a potential maximum score of this indicator is subtracted from the total maximum potential score of the sub-theme to determine the overall rating for that sub-theme.

On the other hand, if the indicator is deemed irrelevant without a justification, the final rating for the omitted indicator is 0 percent or "unacceptable".

This score then is averaged with other indicator scores to calculate the sub-theme rating. Thus, if a sub-theme (e.g., "Internal Investment") contains only one indicator, and it is omitted without justification, the sub-theme rating is 0 percent, or "unacceptable". If a sub-theme (e.g., "Product Information") contains more than one indicator, and one of them is omitted without justification, 0 percent or "unacceptable" score is averaged with the other indicator ratings to determine the overall sub-theme rating. To obtain a performance score at the theme level, an arithmetic mean of the sub-theme scores is calculated, if not available, the lowest score is given to the respective theme.

**Table 4.** *Different rating scales for the indicators in the governance, economic, social dimensions (A), and environmental dimension (B, by type)* Source: (FAO, 2014a).

| | Ratings (A) | Ratings (B) | | |
|---|---|---|---|---|
| Rating scale | Indicator points | Target indicator points | Practice indicator points | Performance indicator points |
| Best / 80 – 100% | 5 | 1 | 2 | 3 |
| Good / 60 – 80 percent | 4 | 0.75 | 1.5 | 2.25 |
| Moderate / 40 – 60 percent | 3 | 0.5 | 1 | 1.5 |
| Limited / 20 – 40 percent | 2 | 0.25 | 0.5 | 0.75 |
| Unacceptable / 0 – 20 percent | 1 | 0 | 0 | 0 |

Finally, all data set are integrated into a sustainability performance report, and this process is called data visualization. Data Visualization is a way of depicting the information in a polygonal form allowing to see the concepts and relationships.

*2.2 Description of Beijing Farmers Market (BFM) PGS*

This study was carried out in BFM PGS that is established in 2010. BFM PGS was chosen using the following criteria:

It is operational at local context for at least five years;

BFM PGS initiative is achieved local recognition thanks to its four founding principles – health, ecology, fairness and care which is endorsed by IFOAM;

BFM PGS are self-financed and linked to markets;

BFM PGS consists of 66 small-scale organic farms, and its dedicated team of 25 employees (including volunteers) runs a weekly market and two community stores that offer their customers a wide range of organic products throughout the year. Most of the farms are located around the city of Beijing, and a few of them are in Hebei Province. Only 46 out of 66 small-scale member farms were selected just because they were actively-involved in sales fairs which were regularly held at the center of Beijing and field visits to farms which continuously apply PGS standards. The rest 20 farms were not selected as a target group, since they had just started to apply PGS standards at the probation period. In addition to 46 member farms, interviews were also conducted with relevant 78 more stakeholders (management body of BFM, researchers, food bloggers, consumers and volunteers working at the community markets) who had a leading role in the decision-making process.

Interviewed farmers were from Shunyi, Changping, Haidian, Fangshan, Huairou, Daxing districts of Beijing and Tangshan and Zhangjiakou districts of Hebei province (Figure 2). Selected farmers were mainly organic vegetable and fruit growers. Interviews and field observations were the primary source of information, and data collection process was carried out using two farm questionnaires.

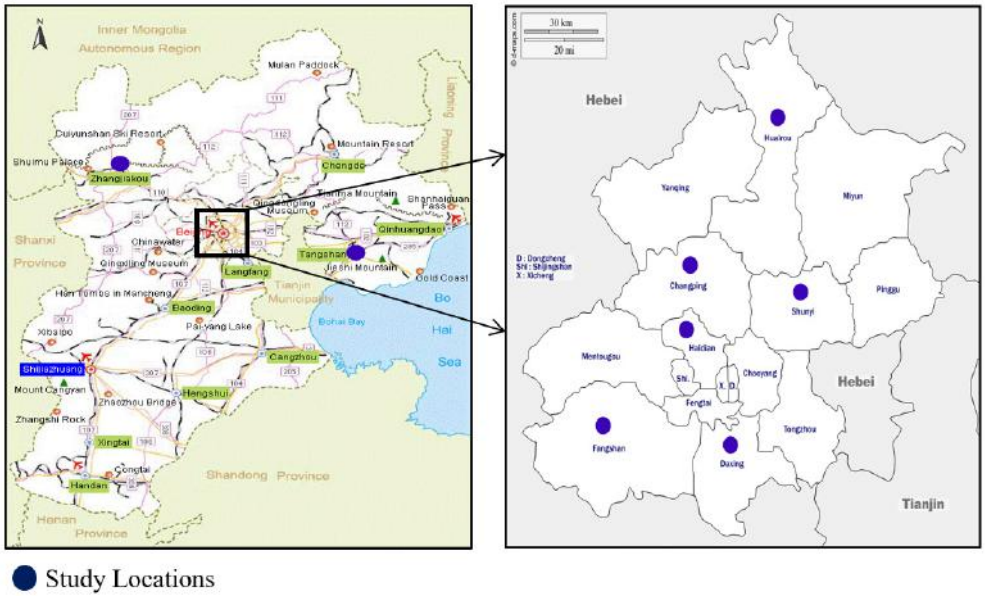


**Figure 2**. *Map of the study locations*

*2.3 Data Collection and Analysis*

Data collection was done between August 2020 and February 2021. Assessment process is illustrated in five steps (Figure 3). Step 1 started with literature and SAFA methodology reviews and preparation of the farm questionnaires. The preparation process was supplemented with the member farmers and key informants from the management body of BFM PGS in order to understand the operating context of BFM PGS. SAFA Tool indicator set was contextualized to find relevant indicators for the study area. From a set of 116 indicators, 80 indicators (47 out of 58 sub-themes) were applied (Appendix 2) to assess sustainability performance of BFM PGS based on the "contextualization" described above.

Step 2 included an interview with the farmers and management body of BFM PGS at the marketplace using farm questionnaires. Interview process started with a question-and-answer session on the target indicators, followed by a farm visit especially for collecting the farm specific information on the practice-based and performance indicators.

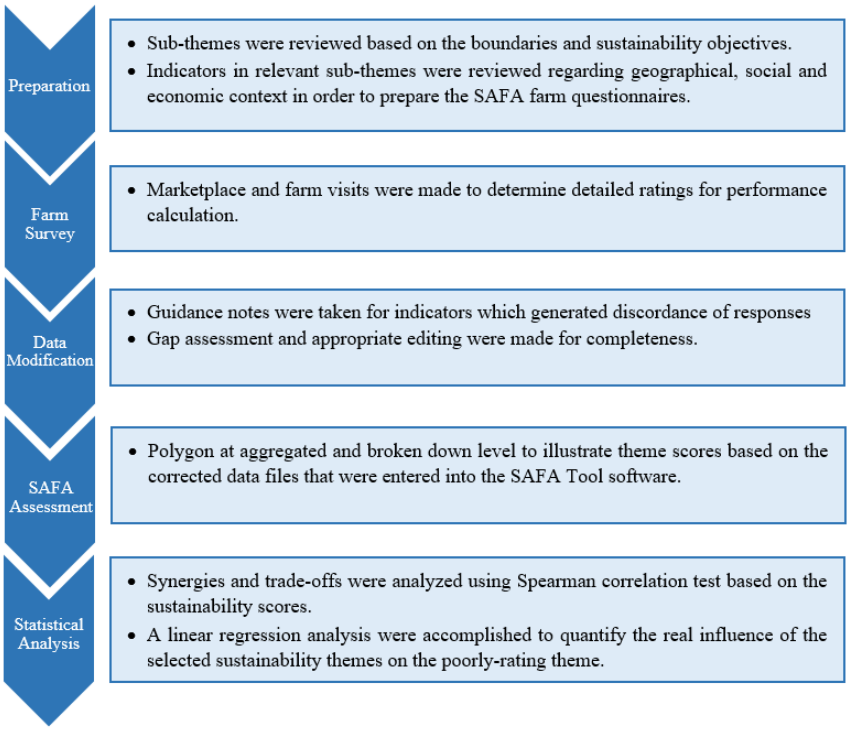


**Figure 3**. *Illustration of data collection and analysis process*

In order to ensure that all of the relevant indicators were answered correctly, each of the farm questionnaires was checked with the farmers and management body of BFM PGS for completeness in Step 3. Guidance notes were taken, and identified gaps were communicated back BFM PGS staff and the respective farm for appropriate editing. In the next step, the completed data sets were integrated into SAFA Tool software to compute the sustainability performance scores for each theme.

In the final step, based on the sustainability performance scores obtained in step 4, the synergies and trade-offs were analyzed using the non-parametric Spearman's rank-correlation test [34]. The coefficients ranged between $0 < rs \leq +1$ represented synergies or positive correlations, while the coefficients ranged between $0 > rs \geq -1$ represented trade-offs or negative correlations. Additionally, a linear regression analysis was conducted to identify mathematical dependences between selected sustainability themes. All statistical analyses were made using IBM SPSS Statistics version 21 [35].

It must be noted that some performance indicators related to "Water Quality" and "Soil Quality" sub-themes in the environmental dimension were unavailable at the farm level since most of the small-scale farms were less able to test their soil and water quality due to high analysis costs. However, considering that these two themes were vital in terms of evaluating the environmental sustainability and also in order for this study to provide high quality assessment, water and soil samples were taken from the fields and analyzed.

The soil fertility status of organic vegetable fields was surveyed after the harvest of cool-season vegetables in November. The soil samples were taken at a depth of 0-20 cm using soil sampling probe. Furthermore, in order to test concentrations of water pollutants tube wells were pumped to remove stagnant water before fresh water samples were collected. A total of 30 (15 water and 15 soil) samples were analyzed for the water pH, electrical conductivity (EC), ammonium-nitrogen ($NH4^{+}$-N) and nitrate ($NO_3^{-}$-N) levels, soil pH, soil organic matter (SOM), nitrogen (N) phosphorus (P) and potassium (K) contents at the Chinese Academy of Agricultural Sciences (CAAS) laboratory in the city of Beijing. The threshold values [36-43], for the selected indicators were presented in Appendix 1, Table A2.

## 3. Results and Discussion

*3.1 Sustainability Performance Assessment of BFM PGS*

Using SAFA Tool, this study helped BFM PGS to benchmark their farming activities against the sustainability objectives defined in SAFA Guidelines.

The sustainability performance of BFM PGS regarding the respective dimensions are presented below (Figure 4):

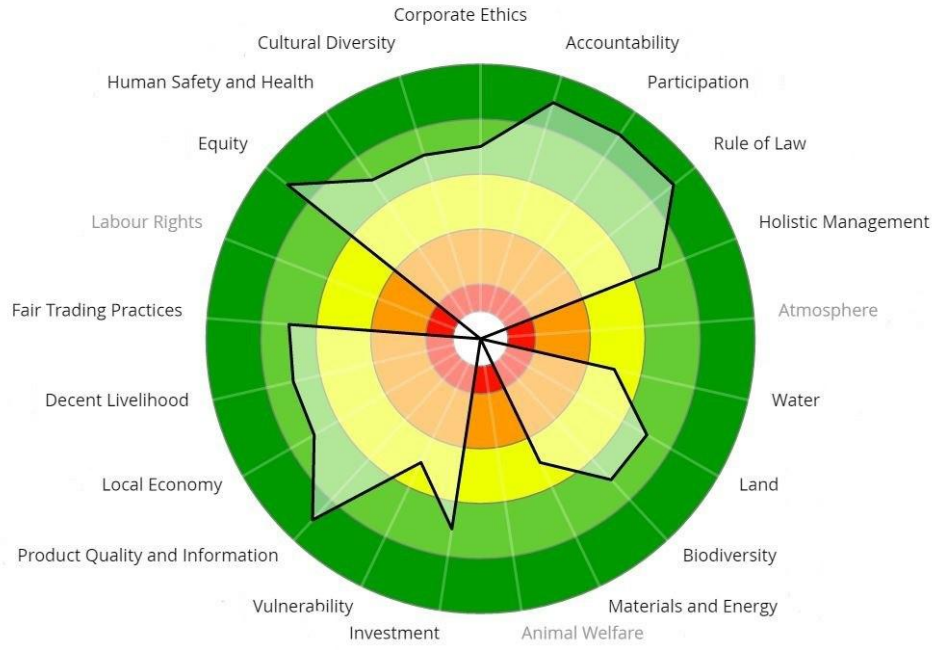


**Figure 4.** *Sustainability Performance report of BFM with respect to SAFA themes.*

"Good Governance" dimension: the result showed that all farms performed well with respect to "Corporate Ethics", "Accountability", "Participation", "Rule of Law" and "Holistic Management" themes. The main reason of this performance score was that BFM PGS particularly emphasized collective action, transparency, democratic structure and independent governance in order to embrace social justice and community welfare which in turn positively impacted its performance in the governance context.

"Environmental Integrity" dimension: Farms showed a good performance score with respect to the "Biodiversity" theme (72%), even though the overall performance score of the environmental dimension (60%) was lower than other dimensions. This low score was attributed to "Water" (52%) and "Material Use" (51%) themes as the majority of the farms found themselves in a region (Beijing Plain) with high groundwater withdrawals due to intensive agricultural irrigation [44]. Moreover, a rapid urbanization and migration to the cities from an area where the farmers live negatively affected their material consumption patterns.

At the same time, water and soil test results (see Appendix 1, Table A3-A4) showed that "Water Quality" was the sub-theme where the all farms managed to perform well. Whereas for "Soil Quality" sub-theme, the highest variability among farms in the performance scores was found as some farms have far exceeded the proposed threshold levels (e.g., soil pH, K and P content) (see Appendix 1, Table A4-A5).

"Economic Resilience" dimension: Farms performed well with respect to "Product Quality & Information", "Investment" and "Local Economy" themes - 85%, 80%, 80%, respectively. On the other hand, no single farm performed better than 58% for "Vulnerability" theme. This indicates that for "Vulnerability" theme sustainability objectives formulated in SAFA Guidelines were relatively difficult to achieve for farms.

"Social Well-Being" dimension: High performance scores were achieved with respect to "Decent Livelihood", "Fair Trade Practices", "Human Safety" and "Health and Cultural Diversity" themes - 79%, 80%, 81%, 79%, respectively. At the same time, 100% of goal achievement was realized for "Equity" theme. Even though farmers had access to information and knowledge through regular farm visits, sharing meetings and discussions with the consumers, scientists and researchers, the level of contact between the agricultural extension services (AES) and the farmers was too weak (see Appendix 1, Table A6). Only 25% of the farmers were visited by the AESs during 2019. The number of farmers visiting the extension services was 33% during the same period. But, a mutual exchange of information with the extension agencies can help some farmers to gain a clearer insight into balanced fertilization to improve their management and production skills which in turn will positively affect their environmental sustainability performance. This is the synergetic effect of the social dimension on the governance and environmental dimension.

The key determinants that may affect sustainability performance of BFM PGS are summarized in Appendix 1, Table A7.

*3.2 Analysis of Interactions within Sustainability Dimensions and Themes*

In the previous sub-section, sustainability performance of BFM PGS in terms of the dimensions and themes was analyzed. While BMF PGS achieved high scores respect to a large number of themes, it did not perform well across all dimensions and themes. This justifies the importance of further assessment of synergies and trade-offs between dimensions and themes [45]. When analyzing the dimensions individually, high performance scores were identified in "Social Well-Being" (84%), "Good Governance" (83%) and "Economic Resilience" dimensions (75%), and low performance score in "Environmental Integrity" (60%) dimension.

Table 7. SAFA Tool sustainability assessment scores for the respective themes

| Sustainability themes | BFM PGS (N = 46) | |
|---|---|---|
| | Mean | Std. Deviation |
| Corporate Ethics | 81.553 | 1.267 |
| Accountability | 92.395 | 2.881 |

| | | |
|---|---|---|
| Participation | 82.395 | 1.685 |
| Rule of Law | 84.526 | 2.826 |
| Holistic Management | 76.921 | 4.456 |
| Water | 52.763 | 2.454 |
| Land | 64.763 | 3.267 |
| Biodiversity | 72.027 | 3.192 |
| Materials and Energy | 51.579 | 4.221 |
| Investment | 80.842 | 1.853 |
| Vulnerability | 57.948 | 3.676 |
| Product Quality & Information | 85.421 | 3.301 |
| Local Economy | 80.711 | 2.205 |
| Decent Livelihood | 79.947 | 2.610 |
| Fair Trading Practices | 80.263 | 2.854 |
| Equity | 100.000 | 0.000 |
| Human Safety & Health | 81.421 | 2.201 |
| Cultural Diversity | 79.895 | 3.178 |

Based on the sustainability performance scores in Table 7, synergies and trade-offs were analyzed between dimensions and themes using Spearman correlation test. Synergies were found between governance and social dimensions (10%). To a lesser extent there were also synergies between environmental and social dimensions (1%) (Table 8).

**Table 8.** *Overview of synergies and trade-offs between sustainability dimensions.*

| Dimensions | Good Governance | Environmental Integrity | Economic Resilience | Social Wellbeing |
|---|---|---|---|---|
| Good Governance | 83% | | | |
| Environmental Integrity | -13% | 60% | | |
| Economic Resilience | -24% | -14% | 75% | |
| Social Wellbeing | 10% | 1% | -8% | 84% |

*Note: Green color and yellow medium color indicate synergies whereas red color indicates trade-offs*

In the theme level (Table 9), in "Good Governance" dimension, the highest degree of synergies was found between "Corporate Ethics" and "Rule of Law", and between "Holistic Management" and "Rule of Law" followed by "Corporate Ethics" and "Participation". While the synergies between "Rule of Law" and "Participation", and between "Holistic Management" and "Participation" were low. In "Environmental Integrity" dimension, synergies between "Biodiversity" and "Water" themes were high. At the same time "Materials Use" theme showed the lowest degree of synergies with the other environmental themes. In addition, environmental themes showed the significant synergies with economic and governance themes. In "Economic Resilience" dimension, synergies between "Investment" and "Local Economy" and between "Investment" and "Product Quality & Information" themes were higher than the synergies between "Local Economy" and "Product Quality & Information" themes, whereas "Vulnerability" showed the lowest degree of synergy with "Product Quality & Information" theme. In "Social Well-Being" dimension, "Fair Trading Practices" had the highest synergies with other social themes, except "Decent Livelihood" theme.

Table 9. Spearman correlation values between sustainability themes

| Dimensions | Good Governance | | | | | Environmental Integrity | | | | Economic Resilience | | | | Social Well-being | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Themes | Corporate Ethics | Accountability | Participation | Rule of Law | Holistic Management | Water | Land | Biodiversity | Material use | Investment | Vulnerability | Product Quality & Information | Local Economy | Decent Livelihood | Fair Trading Practices | Human Safety & Health | Cultural Diversity |
| Corporate Ethics | 1 | | | | | | | | | | | | | | | | |
| Accountability | -0.004 | 1 | | | | | | | | | | | | | | | |
| Participation | 0.224 | -0.12 | 1 | | | | | | | | | | | | | | |
| Rule of Law | 0.32 | -0.032 | 0.134 | 1 | | | | | | | | | | | | | |
| Holistic Management | -0.053 | -0.019 | 0.089 | 0.226 | 1 | | | | | | | | | | | | |
| Water | -0.118 | 0.296 | -0.077 | -0.248 | 0.066 | 1 | | | | | | | | | | | |
| Land | 0.098 | -0.021 | 0.028 | -0.08 | 0.054 | -0.066 | 1 | | | | | | | | | | |
| Biodiversity | -0.041 | .709** | -0.129 | -0.12 | -0.205 | 0.159 | -0.073 | 1 | | | | | | | | | |
| Material use | 0.039 | -0.191 | 0.163 | -0.091 | -0.063 | 0.078 | 0.08 | -0.162 | 1 | | | | | | | | |
| Investment | -0.069 | -0.198 | -0.046 | -0.215 | -0.012 | -0.006 | 0.034 | -0.084 | -0.098 | 1 | | | | | | | |
| Vulnerability | 0.247 | -.362* | 0.127 | 0.057 | -.329* | -.390* | 0.049 | -.356* | -0.129 | -0.029 | 1 | | | | | | |
| Product Quality & Information | 0.257 | 0.281 | -0.095 | -0.014 | -0.272 | 0.217 | -0.31 | .355* | 0.176 | 0.123 | 0.03 | 1 | | | | | |
| Local Economy | -0.086 | 0.29 | 0.106 | -0.074 | 0.274 | .336* | 0.022 | 0.253 | -0.119 | 0.193 | -0.206 | 0.079 | 1 | | | | |
| Decent Livelihood | -0.21 | 0.096 | 0.072 | -0.305 | -0.147 | 0.165 | 0.192 | 0.013 | 0.068 | 0.136 | -0.016 | -0.156 | 0.22 | 1 | | | |
| Fair Trading Practices | -0.04 | -0.015 | 0.12 | -0.001 | .352* | 0.14 | 0.203 | -0.036 | -0.169 | -0.231 | -0.005 | -.336* | 0.154 | 0.075 | 1 | | |
| Human Safety & Health | 0.081 | 0.219 | -0.218 | 0.274 | 0.224 | -0.031 | 0.138 | 0.114 | -0.139 | -0.154 | -0.018 | -0.07 | 0.241 | -0.059 | 0.172 | 1 | |
| Cultural Diversity | -0.162 | -0.095 | -0.002 | 0.004 | -0.033 | -0.202 | 0.064 | -0.125 | -0.101 | 0.11 | 0.226 | -0.148 | -0.142 | -0.091 | 0.19 | 0.107 | 1 |

-0.126 -0.237 +0.102 -0.135 +0.011 -0.075

*Note:* * - Correlation is significant at the 0.05 level (2-tailed); ** - Correlation is significant at the 0.01 level (2-tailed)*

It was also found that "Economic Resilience" dimension had the trade-offs with all sustainability dimensions (Table 9) due to "Vulnerability" theme. There were also trade-offs between "Environmental Integrity" and "Good Governance" dimensions. Furthermore, between theme levels (Table 9), "Vulnerability" theme showed the significant trade-offs ($P<0.05$) with "Accountability" and "Holistic Management" themes in "Good Governance" dimension on the one hand, and with "Water" and "Biodiversity" themes in "Environmental Integrity" dimension on the other hand. In addition, "Vulnerability" theme also had the trade-offs with social themes such as "Local Economy" and "Decent Livelihood". Trade-offs between the theme levels in all dimensions were even higher than the synergies. Whereas the trade-offs within the theme levels in all dimensions were lesser than the synergies.

*3.3 Regression Analysis*

A regression analysis was performed to generate a mathematical equation in order to demonstrate the statistical dependency between selected sustainability themes. The Sustainability Performance Report (Figure 4) provided information regarding each theme individually, and the dependent variable was assigned to "Vulnerability" theme which was a challenging and less evolved theme from BFM PGS point of view. Furthermore, this theme seemed to be poorly correlated with other themes (Table 9).

The equation (1) captures the true relationship with the predictors, where subscript *X* represents the associated themes.

$$Y_{vulnerability} = 160.737 - 0.434X_1 - 0.373X_2 - 0.414X_3 - 0.255X_4 \quad (1)$$

$X_1$ = "Holistic Management" theme,
$X_2$ = "Water" theme,
$X_3$ = "Biodiversity" theme,
$X_4$ = "Material Use" theme,

From Table 10, it can be seen that the predictor variables of "Holistic Management", "Water" and "Biodiversity" are significant. Whereas p-value for "Material Use" theme (0.059) shows that the relationship is not statistically significant. The coefficients indicate that for every additional increase in "Holistic Management", "Water" and "Biodiversity" theme, it can be expected the negative tendency of the "Vulnerability" theme to decrease 43.4%, 37.3% and 41.4% respectively.

**Table 10.** *Interactions between the sustainability themes*

| Variables | Coefficients [a] | Std. Error | p-values |
|---|---|---|---|
| *Constant* | 160.737*** | 18.634 | .000 |
| Holistic Management | -0.434*** | -3.361 | .002 |
| Water | -0.373*** | -2.924 | .006 |
| Biodiversity | -0.414*** | -3.068 | .004 |
| Material Use & Energy | -0.255 | -1.956 | .059 |

*Note:* ***- Significant at the 1 percent level; a - Dependent Variable: "Vulnerability"

## 4. Discussion

BFM PGS has high scores in "Good Governance", "Social Well-Being" and "Economic Resilience" dimensions, and low score in "Environmental Integrity" dimension. This is the characteristic of PGS where the effectiveness of the market regulation comes from the mutual supervision between market organizers and participants, and economic gains of the small-scale farmers are high because of getting direct access to consumers. This finding is consistent with other studies, which reported positive impacts of PGS as a mean for empowering small-scale farmers and local communities [46-47], as well as facilitating access to markets and strengthening domestic food systems [48]. This is also true for most PGS in the world – within the community stakeholders, especially producers and consumers act according to their common values and behavioral norms and also have a strong identity and even emotional belonging to each other [4]. These PGS have determined their own principles and ways of running the community in the original way in order to improve livelihoods of rural farmers.

Comparing inter-linkages between sustainability dimensions and themes, more trade-offs were found than synergies. Major trade-offs were seen between "Economic Resilience" dimension and other three dimensions. In addition, significant trade-offs were also observed between economic themes and other themes (especially governance and environmental themes) due to "Vulnerability" theme, emphasizing that specific focus is needed to improve "Vulnerability" theme. It is further clear that the vulnerability level might disrupt the volume of a production, stability of supply, as well as quality standards in the near future. In addition, there could be records of input supply shortages that revel that at least some farmers have unfavorable level of vulnerability to certain inputs which in turn could affect economic sustainability as a whole.

On the contrary, synergies were found between "Social Well-Being" dimension and other sustainability dimensions (except "Economic Resilience" dimension). In addition to the synergies between "Social Well-Being" dimension and the other dimensions, there were also significant synergies founded between social theme "Fair Trading Practices" and governance theme "Holistic Management", which emphasizes the importance of "Social Well-Being" dimension through its positive influence in the other dimensions of sustainability.

After contrasting with a sustainability performance report (Figure 4) and Spearman's correlation coefficients (Table 9), "Vulnerability" theme was counted as the most challenging indicators, so a mathematical dependency equation was obtained. From the Table 10, it is obvious that "Holistic Management" theme was the most effective theme, with the capacity to decrease vulnerability level by 43.4%. The next effective themes in order of importance were "Biodiversity" and "Water" themes. Each of these explained vulnerability level decrease by 41.4% and 37.3% respectively following a doubling of applied units. The results also showed that "Material Use" theme affects vulnerability but not significantly. Possible explanation could be that a decreasing number of local input suppliers, gradual loss of traditional farming varieties and knowledge, popularization of hybrid seed and manure from industrial farms negatively affect farms' material consumption patterns, and further improvement in the material consumption patterns could decrease vulnerability level.

The significant effect of "Biodiversity" and "Water" theme can be explained by the fact that the protection of biodiversity and water resources are necessary to sustain the functioning of ecosys-

tems and human communities [30]. Therefore, the efficient water management practices and the availability of buffers in a form of species and generic diversity can help decrease a tendency of the vulnerability level.

*4.1 Limitations of this study*

Since interviewed farmers were mainly small-scale organic vegetable growers, "Animal Welfare" (including "Animal Health" and "Freedom from Stress" sub-themes) theme were omitted because of out of scope. In the study area, farming activities did not produce potentially polluting gaseous emissions, and operations did not depend on external energy inputs of any kind. In addition, sub-themes such as "Greenhouse Gases" and "Energy Use" can be examined more quantitatively using the life cycle assessment method in order to obtain reasonable and credible results. Therefore, "Atmosphere" theme (including "Greenhouse Gases" and "Air Quality" themes) and "Energy Use" sub-themes were omitted. Besides, "Full-Cost Accounting" sub-theme was also omitted since this is an emerging field, as well as a complex and difficult subject without an international consensus on its standards.

In "Social Well-Being" dimension many sub-themes refer to the handling of employees, and therefore have less relevance for farms in the study area. Member farms of BFM PGS generally rely on family work in order to cope with the varying availability of labor, and participatory approach on a voluntary basis is encouraged as a labor-saving strategy among farmers living in the same area. That's why "Labor Rights" theme (including "Employment Relations", "Forced Labor", "Child Labor" and "Freedom of Association" and "Right to Bargaining" sub-themes) and "Rights of Suppliers" sub-theme were also omitted.

## 5. Conclusions

It is important to look at the factors that positively affect sustainability performance of BFM PGS and the future behavior of inputs and control mechanisms that are conceptually external to the farming system, when setting the right priorities and suggesting changes on farms or for policy implications. This highlights the importance of understanding a set of strategies to construct sustainability pathway.

Looking at the interactions between sustainability themes (Table 9), "Vulnerability" theme was the most challenging to optimize as major trade-offs exist with other themes, and "Holistic Management", "Biodiversity" and "Water" themes exhibited a strong influence on "Vulnerability" theme (Table 10). Therefore, it can be concluded that a holistic view of sustainability with the long-term goal of improving resilience and adaptive capacity to potential shocks positively affects the negative tendency of "Vulnerability" theme since they proved to be interlinked. In addition, given the synergetic effect of "Social Well-Being" dimension, it can also be concluded that a specific attention on "Social Well-Being" dimension will shed light on the performance of the other sustainability dimensions.

This study has some policy implications. BFM PGS has a committed and supportive consumer base which in turn consumers become increasingly receptive to the farmers' products. Consumers who have a deep understanding and recognition of community-supported agriculture constantly appear in the market. They do not often satisfy with the support through purchase and are willing to provide support in the form of voluntary services. This means that with PGS a community could have a dedicated function to make this responsive consumer base become the labor, intelligence and communication medium of this quality assurance system. Without PGS, this format cannot go further, as it advocates the idea of achieving quality assurance through communication and collaboration between producers and consumers. This is an important strength of PGS as a socio-institutional function on building a truly sustainable community.

Consequently, this study encourages the policy-makers, non-government organizations, investors and people to be more receptive and responsible towards PGS and create positive conditions for sustaining PGS.

## Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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