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Management Aspects of Food Biodiversity Conservation for Fulfilling School-Based Nutritional Needs and Food Security

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Abstract: This study aimed to identify aspects and relationships between aspects and sub-aspects of Food Biodiversity Conservation (FBC) management to meet the nutritional needs of students in schools. The research findings are new, as there is a lack of literature that can be used to solve current problems regarding the plan to implement free nutritious meals in schools with limited infrastructure, facilities, and budget conditions. The results of this study are expected to help overcome the major problems faced by the Indonesian community and government, and improve student nutrition in Indonesian schools. The results of this study propose a conceptual model of the "triangle and five pillars of food biodiversity conservation management aspects in schools". This study was exploratory and used mixed methods. The research subjects were teachers, principals, non-teaching work teams, and supervisors in schools that have implemented Food Biodiversity Conservation (FBC) to meet students' nutritional needs. The samples were sequentially determined and gradually reduced according to the criteria. Questionnaires, observation sheets, and

workshops were used. Data validation was performed using triangulating methods, namely, surveys, interviews, workshops, and triangulating sources, including teachers, principals, non-teaching FBC working teams, and school supervisors. MAXQDA-2020 was used for the data analysis. The results revealed three aspects of FBC in schools: philosophy, policy, and implementation. The dominant sub-aspects were obtained from three aspects: curriculum, principal, work team, innovation, and collaboration.

Keywords: conservation, biodiversity, food, nutrition, school.

食品生物多样性保护管理方面，以满足学校的营养需求和食品安全

摘要：本研究旨在确定食物生物多样性保护（FBC）管理的各个方面以及各个方面和子方面之间的关系，以满足学校学生的营养需求。研究结果是新的，因为缺乏可用于解决当前在基础设施、设施和预算条件有限的学校实施免费营养餐计划的问题的研究文献。本研究的结果有望帮助克服印度尼西亚社区和政府面临的主要问题，并改善印度尼西亚学校的学生营养。本研究的结果提出了学校食物生物多样性保护管理方面的“三角和五大支柱”概念模型。本研究是探索性的，采用混合方法。研究对象是实施食物生物多样性保护（FBC）以满足学生营养需求的学校的教师、校长、非教学工作团队和主管。样本按顺序确定，并根据标准逐渐减少。使用的工具是问卷、观察表和研讨会。数据验证采用三角测量法，即调查、访谈、研讨会和三角测量来源，包括教师、校长、非教学 FBC 工作团队和学校督导员。MAXQDA-2020 用于数据分析。结果揭示了学校 FBC 的三个方面：理念、政策和实施。从这三个方面，我们得到了主要的子方面：课程、校长、工作团队、创新和协作。

关键词：保护、生物多样性、食物、营养、学校。

1. Introduction

The 2024 Global Hunger Index report identified Indonesia as the third-most hungry country in Southeast Asia. The report states that 7.2% of Indonesia’s population is undernourished, 26.8% is stunted, 10.0% is wasted, and 2.1% of children under five are dying [1].

Hunger is an uncomfortable or painful physical sensation caused by insufficient consumption of dietary energy. It becomes chronic when a person does not consume a sufficient amount of calories (dietary energy) on a regular basis to lead a normal, active, and healthy life. For decades, FAO has used the Prevalence of Undernourishment indicator to estimate the extent of hunger in the world, thus “hunger” may also be referred to as undernourishment, or malnutrition [2]. Hunger and malnutrition in children can cause various health problems. In addition to affecting body growth, it inhibits brain development, leading to reduced intelligence during childhood and adulthood [3].

School-age is a vulnerable age that determines the future of a person and nation [4]. Indonesia has set a development goal for 2045 as a golden age called “Golden Indonesia.” At that time, Indonesia will reach various peaks of developmental success, which will be obtained from the brilliance of thinking of the nation’s children who are educated today.

Schools play a strategic role in the building of human resources. On the other hand, food biodiversity is a world treasure that plays a strategic role in providing germplasm for food, medicine, recreation, and other purposes [5]. Indonesia is the world’s second richest country in biodiversity after Brazil [6]. The problem is that until now, almost all schools in Indonesia have not played an active role in FBC to address the national problem of undernourished or hungry children [7, 8]. As an agricultural country, Indonesia imports large amounts of vegetables to meet its domestic needs.

This is a developmental contradiction between the possession of high biodiversity wealth and the reality of poverty, malnutrition, and hunger [6]. Brazil is the richest country in terms of biodiversity, but its government can implement a good school feeding program. Community members are involved in sourcing healthy food, including biodiversity community groups [9].

Saylan and Blumstein [7] stated that current education has failed to provide students with the opportunity to develop food resources and live in harmony with nature in a sustainable manner. Food biodiversity conservation (hereinafter abbreviated as FBC in this paper) for the sustainable provision of healthy food in schools in many countries, including Indonesia, has not been widely practiced [6, 5]. Conservation activities in schools are mainly focused on learning activities [7].

Given the strategic position and role of schools in overcoming the food and nutrition crisis, strengthening

implementation of FBC management will directly help students, communities, and governments overcome malnutrition and hunger. This can also improve the quality of education [7, 8, 10].

However, no research has specifically examined the aspects of FBC management in Indonesian schools. Existing literature provides information on learning and conservation education techniques in schools [11-13]. Recent research conducted in Berlin, Germany [14] focused on plant-based foods but did not cover biodiversity as a whole, such as fish as a source of protein. Another study conducted in the United Kingdom [15] emphasized student diet as a consideration for policymaking in schools' food systems.

Biodiversity conservation activities require implementation strategies and management appropriate for the location and stakeholders [5, 16, 17]. Conservation management differs from one institution in one location to another [17]. Similarly, FBC in one school differs from that in other schools. However, due to these differences, there may be common management aspects that determine the success of these activities.

It is hoped that this research will provide an important overview of the management aspects of FBC in schools and the relationships between these aspects and the sub-aspects of management to help improve student nutrition and build school-based food security.

2. Theoretical Basis

2.1. School Food Systems and Management

The most recent study on school food systems was conducted by Bryant in the United Kingdom [15]. The research explores and explains in detail the foods that students like and then explores what things are related to the student food system at school. This research examines policymaking regarding food in schools for students.

This study identified 202 factors in the student food system at schools. These factors were grouped into 27 nodes. The factors were analyzed thematically and four main themes were identified: leadership culture, children's preferred foods, home environment, and school food environment. These factors were qualitatively analyzed for their relationships. The results revealed that the related factors were school resources, initiatives, students' preferred foods, feasibility of free meals, family conditions, eating behavior, friends, and principal and senior leaders' priorities. The conclusions of this study indicate the need to consider student and school factors when developing school food policies [15].

Previous research by Fischer [14] discussed the role of plant biodiversity in school gardens in providing healthy food to students in Germany. The results revealed the importance of biodiversity in school gardens to support students' dietary health and to maintain food biodiversity, especially local foods in urban areas, which are disappearing and becoming increasingly unknown to students.

These two studies are examples of the importance of FBC for student health and the future. Local biodiversity should be part of students' everyday lives. This understanding is important so that students can survive and contribute to the world through the local food that they grow. Instead, they become dependent from childhood to adulthood. Even more tragic is that their food biodiversity is extinguished before it is used.

The destruction of biodiversity in a region and worldwide is caused by irresponsible human behavior [18, 19]. Building behavior is performed through educational activities, including building friendly behaviors toward biodiversity [9]. Thus, biodiversity conservationists are individuals who have the opportunity to educate on biodiversity [7]. Inadequate knowledge and attitudes will result in people who behave badly and irresponsibly, causing damage in the short term and destruction in the long term [12].

The Indonesian government has implemented a voluntary policy for schools to implement an environmentally friendly school program called the Adiwiyata School Program. This program prioritizes conservation and sustainability efforts in environmental aspects, including biodiversity [20]. The Adiwiyata Program defines the steps of environmental education management in schools. Schools that already have experience in environmental education management will find it easier to implement the FBC program because it is considered a form of Adiwiyata program development.

2.2. Reference to FBC Management in Non-School Educational Institutions in Indonesia

Indonesia is known to have three models of educational institutions recognized by the government: the school education model (called formal educational institutions) and non-school educational institutions in the form of *pesantren* (a traditional Islamic boarding school in Indonesia, a name for informal educational institutions, and courses called non-formal educational institutions) [21].

Food biodiversity conservation activities have been ongoing for a long time and are considered integrated into pesantren educational institutions [22, 23]. This is because of the history of the establishment of the pesante itself, whose establishment and operation cannot be separated from two main things: religious education and agricultural life skills. Students called "*santri*" learn religion from a teacher called "*kya*" without having to pay fees but by helping the kya plant, tend, and harvest food crops and manage other agricultural enterprises [24]. In this way, santri learn and master two sciences at

the same time, namely religious science and agricultural science [23].

The motivation of pesantren leaders in FBC is not only based on need but also on philosophical thinking [24]. A pesantren educational institution is a philosophical and scientific institution. Therefore, it is very natural that pesantren managers' attitudes and behaviors in education and conservation are also based on philosophical thought and knowledge [25].

Some important philosophies adopted by pesantrens in FBC are the belief that human beings have a duty as *Khalifah* or representative of God who must be fair, care, protect, and responsible for their environment [25, 24]. As education in Indonesia continues to prioritize religious aspects as part of educational development, it is likely that pesantren cultures will also become a part of the culture of education in schools [26].

3. Research Methodology

This study identified aspects of FBC management that meet students' nutritional needs and build school food security. The research is exploratory, using mixed methods (qualitative-quantitative) to explore aspects of FBC management and to qualitatively examine the relationship between aspects and sub-aspects.

3.1. Research Design

Exploratory research was conducted at several stages of data collection. Participants were selected using a *sequential sampling* method [27] by gradually reducing the number of participants during the research process. Participants were selected based on the criteria that schools implement FBC activities to meet the nutritional needs of students. The selection of participants was determined after observing data development during each research process. Data that met the criteria were selected for the next stage of the research [27].

The research steps, including population determination, sampling, data collection, data validation, data analysis, and drawing conclusions, are shown in Figure 1.

3.2. Data Collection Instruments

The research instruments included open-ended and closed-ended questionnaires, survey sheets, and workshops [27]. The screening workshop instrument was used to select schools that had implemented FBC and those that had not. The FBC practitioner workshop instrument was used to obtain more in-depth data on the implementation of FBC in schools from teachers, principals, non-teaching work teams, and school supervisors. Oral data from the presentations and discussions were transcribed into text using *voice-to-text* software.

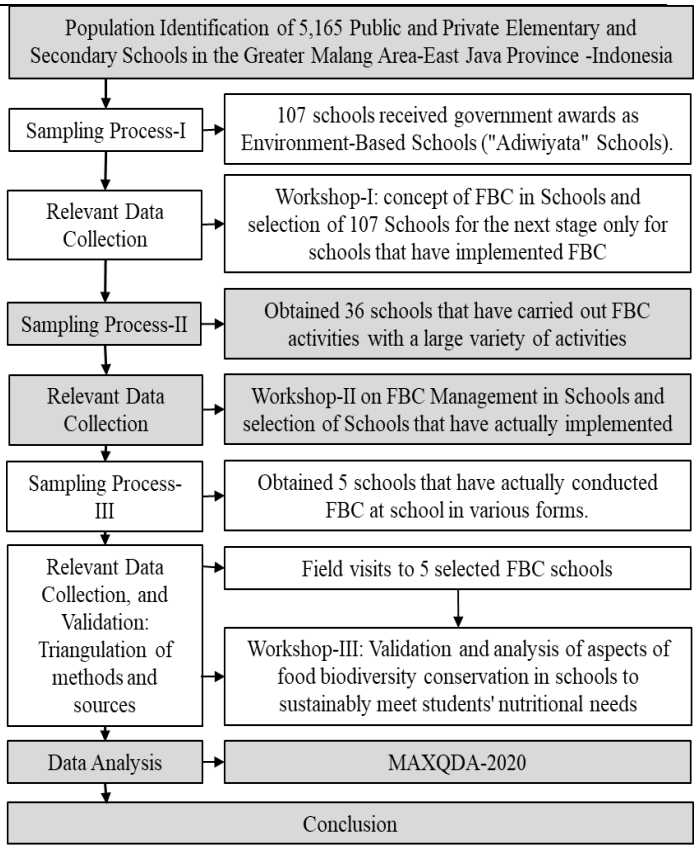

Figure 1. The research steps: sequential sampling, data collection, data validation, data analysis, and drawing conclusions (developed by the authors)

Open-ended interviews were conducted with participants during the site visit. The tools for the confirmation workshop were mapping sheets and flip charts for mapping aspects and relationships between the aspects and sub-aspects of FBC in schools.

3.3. Phases of Research Activities

3.3.1. Workshop I: Initial Selection

The initial participants were 107 schools in the Greater Malang area (consisting of two cities and one district). The participating schools were comprised of 47 public and private elementary schools, 33 public and private junior high schools, 15 senior high schools, and 12 public and private vocational high schools.

Selection activities were carried out through workshops to obtain an agreed-upon understanding of FBC management in schools. After the workshop activities were completed, initial data collection was carried out by sending questions via Google Form about whether the participating schools had conducted FBC activities as described in the workshop. If they did, they were asked to explain their activities. If not, the participants were excluded from the next stage of the study.

3.3.2. Workshop-II: FBC Actors in Schools

Based on the results of the screening workshop, participants had conducted FBC under different conditions (32 schools). The FBC Actors Workshop in Schools was identified as necessary to answer the questions and validate the data. The participants included teachers, principals, non-teacher FBC implementation teams, and school supervisors.

The workshop speakers were teachers, principals, and supervisors who were considered to have implemented FBC well in schools. The materials and discussions presented by the workshop participants constituted the research data, which were recorded for analysis using the Voice to Text program.

3.3.3. Field Visits

Field visits were conducted to validate the data presented in Workshop II. Unstructured interviews were conducted during these visits. The resulting data were recorded as photographs and transcripts.

3.3.4. Workshop-III: Data Validation

The participants in the validation workshop were identified as five schools with stricter criteria for schools that implemented FBC, although under different conditions. The confirmation workshop participants from each school comprised the principal, two teachers, a non-teaching work team representative, and a supervisor.

A workshop was conducted to confirm the findings of workshop II. This is the stage of analysis, further validation, and saturation of the analyzed data, as suggested by Patton [27]. The data saturation process was carried out until the participants felt that there was sufficient data and no more needed to be added.

3.4. Data Analysis

Thematic data analysis was conducted by grouping the data obtained into themes and subthemes agreed upon by the researchers and participants. Furthermore, in this study, themes and sub-themes were referred to as aspects and sub-aspects, respectively. The steps of thematic analysis were as follows [28]: 1) understanding qualitative data, 2) coding, 3) identifying codes into codes and subcodes, 4) validating codes and subcodes, 5) determining codes as aspects and subcodes as subaspects, and 6) writing results and visualizing thematic maps of FBC aspects in schools.

MAXQDA-2020 software was used for further data analysis. This software is very helpful in conducting integrated data analysis (i.e., qualitative and quantitative at the same time) and visually presenting the results of the analysis. The stages of analysis are the same as thematic analysis by coding qualitative data; then, the program converts qualitative data into quantitative or visual data, as needed [29]. The results of the analysis are presented in the form of quantitative tables and figures that provide information about the dominant aspects and their relationship with the aspects and sub-aspects of FBC in schools.

3.5. Limitations of the Study

This study has limitations; namely, the number of participants who fit the criteria is still limited because of the limited number of schools conducting FBC activities in the Greater Malang area. The resulting model is expected to be tested in a larger number of schools with national coverage.

4. Results and Discussion

The results of the data validation revealed three aspects with 27 sub-aspects of FBC management in schools. These three aspects are philosophy, policy, and implementation. The philosophy aspect has 10 sub-aspects, the policy aspect has 11 sub-aspects, and the implementation aspect has 6 sub-aspects and 52 sub-sub-aspects. The frequency of the application aspect is most often given with a more detailed explanation; therefore, it must be given in the form of sub-aspects. There are subaspects that are parts of two or three aspects. Each aspect is explained by its sub-aspects as follows:

4.1. Philosophical Aspects

The Philosophical Aspect describes the results of deep thinking about phenomena and the meaning of participants' lives. This aspect is built on the self-awareness of the participants as fellow human beings and God's creatures who have responsibilities to fulfill. Thus, philosophical sub-aspects are often answers to the background and purpose of FBC in schools.

The philosophical aspect has 11 subaspects: food and nutrition safety, responsibility, sustainability, educator duties, curriculum, academic achievement, food independence, intelligence and health, SDGs, worship, and motivation. The highest sub-aspects are: 1) the importance of food safety and nutrition for students (18.75%). The other sub-aspects had almost the same percentage: responsibility (11.2%), sustainability (11.2%), and duty as an educator (10.00%). The percentages of philosophical subaspects are listed in Table 1.

Thoughtful consideration of food safety and student nutrition were the highest. Participants understood that food safety affects the health and intelligence of students both now and in the future. Likewise, food safety in the future is the responsibility of students. It has been recognized that improving and maintaining sustainability are human duties, especially as educators.

Table 1. Philosophical sub-aspects (source: Own research data, 2024)

#	Sub-Aspects	Segments	Percentage
1	Nutritional Food Security	15	18.75
2	Responsibility	9	11.25
3	Sustainability	9	11.25
4	Educator	8	10.00
5	Curriculum	7	8.75
6	Achievement School	7	8.75
7	Food Independence	6	7.50
8	Health Intelligence	6	7.50
9	SDG'S	5	6.25
10	Worship	5	6.25
11	Motivation	3	3.75
	TOTAL	80	100.00

Realistic thoughts that arise, such as curriculum implementation, food independence, student health, and intelligence, and SDGs are still based on long-term thinking and a form of worship (devotion to God).

The teacher sub-aspect ranked fourth after sustainability thinking. Participants felt that teachers were useless if they were not concerned about the food and nutrition security of current and future students, and if they did not have a sense of responsibility and sustainability thinking. It does not matter who the teacher is if they have these philosophical ideas. A visual representation of the relationship between philosophical aspects and subaspects is shown in Figure 2.

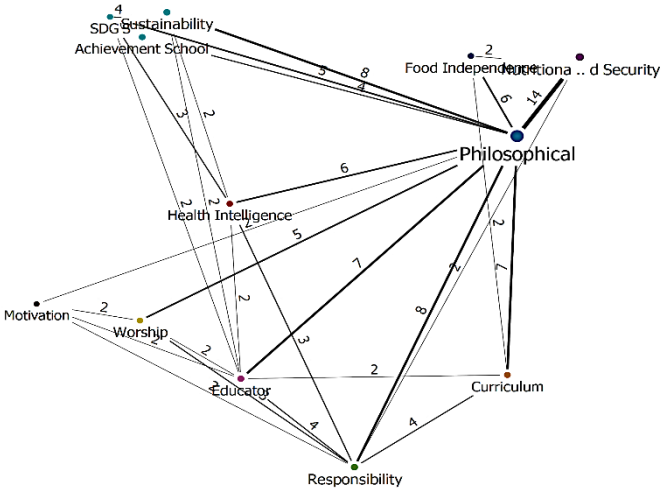

Figure 2. Relationship between philosophical aspects and sub-aspects (source: Own research data, 2024)

This philosophical paradigm is the same as that of pesantren educators, who have been conducting FBC activities in educational institutions for much longer [21]. Participants' statements quoting religious teachings (e.g., about worship) show the influence or similarity of aspects adopted by pesantrens and schools [22]. The existence of philosophical aspects is the main foundation of schools that implement FBC. Conservation efforts have been performed seriously because they have a strong philosophical foundation [24-25].

4.2. Policy Aspects

The policy aspect comprises 13 subaspects. The three aspects with the highest percentages were working team (19.74%), curriculum (14.47%), and Adiwiyata or environmentally friendly school (13.16%). The other sub-aspects with smaller percentages are principal, decree and sop, government, sustainability, healthy cafeteria, food chemistry, collaboration, budget, work motivation, and supervision.

Table 2. Policy Sub-Aspects (source: Own research data, 2024)

Sub-Aspects	Segments	Percentage
Team Work	15	19.74
Curriculum	11	14.47
Adiwiyata	10	13.16
Headmaster	8	10.53
Government	7	9.21
Decree & SOP	7	9.21
Sustainability	5	6.58
Healthy Canteen	4	5.26
Food Independence	3	3.95
Collaboration	3	3.95
Budget	2	2.63
Supervisor	1	1.32
TOTAL	76	100.00

The sub-aspect of the existence of a "work team" formed by the principal had the highest percentage. This indicates that the principal must have a high level of commitment to the programme. The program will not be implemented without committing to the principal.

For schools that have participated in the Adiwiyata program, the curriculum sub-aspect is the same as the Adiwiyata sub-aspect because the implementation of the FBC program is the same as that of the development or innovation program in Adiwiyata. Thus, the Adiwiyata subaspect can be displaced by the principal subaspect. The relationships between the aspects and subaspects of the policy are shown in Figure 3.

The school principal must approve and support the FBC program in schools and integrate it into learning innovations. Thus, the provision of food in schools is not only to meet students' nutritional needs but also for learning activities, improving knowledge, attitudes, and good behavior toward food, which will be very useful for students in the future.

The principal's policy is set in the form of a decree with a Standard Operational Procedure (SOP), for example, on the work team, healthy canteen, and cooperation. The existence of this decree and the SOP is necessary for the work team to conduct FBC activities in the school.

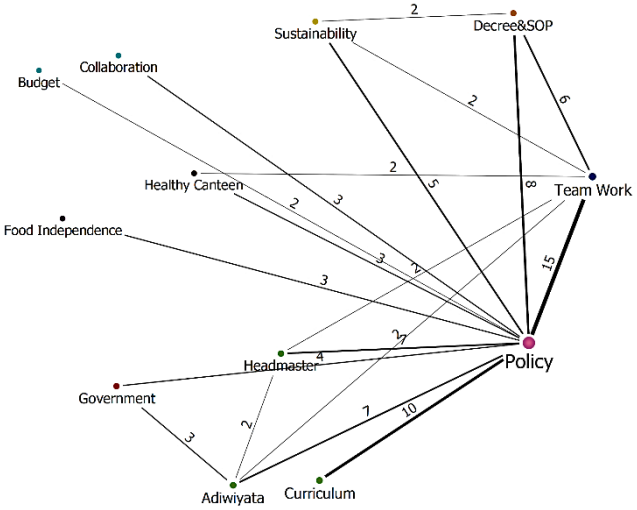

Figure 3. Relationship between aspects and sub-aspects of the policy (source: Own research data, 2024)

4.3. Implementation Aspects

The implementation aspect of the FBC program received the most attention from participants. This is because most program activities are implemented. The implementation aspect of the program consisted of three dominant sub-aspects: curriculum (38.10%), innovation (33.33%), and collaboration (22.92%). The smaller sub-aspects were the evaluation (3.27%) and budget (2.38%), as shown in Table 3.

Table 3. Implementation sub-aspects (source: Own research data, 2024)

Sub-Aspects	Segments	Percentage
Curriculum	128	38.10
Innovation	112	33.33
Collaboration	77	22.92
Evaluation	11	3.27
Financial	8	2.38
TOTAL	336	100.00

The amount of information about the implementation of FBC in schools leads to a breakdown of the implementation sub-aspects into sub-sub-aspects. The results of tracking the codes and subcodes of program implementation aspects using MXQDA-2020 are listed in the matrix shown in Figure 4.

The three dominant subaspects of curriculum, innovation, and collaboration are interrelated and mutually reinforcing. Innovation and collaboration should strengthen the implementation of curriculum development. Collaboration is needed if teachers, principals, and FBC teams are not able to design and implement innovative programs. Collaboration will bring new perspectives into these activities.

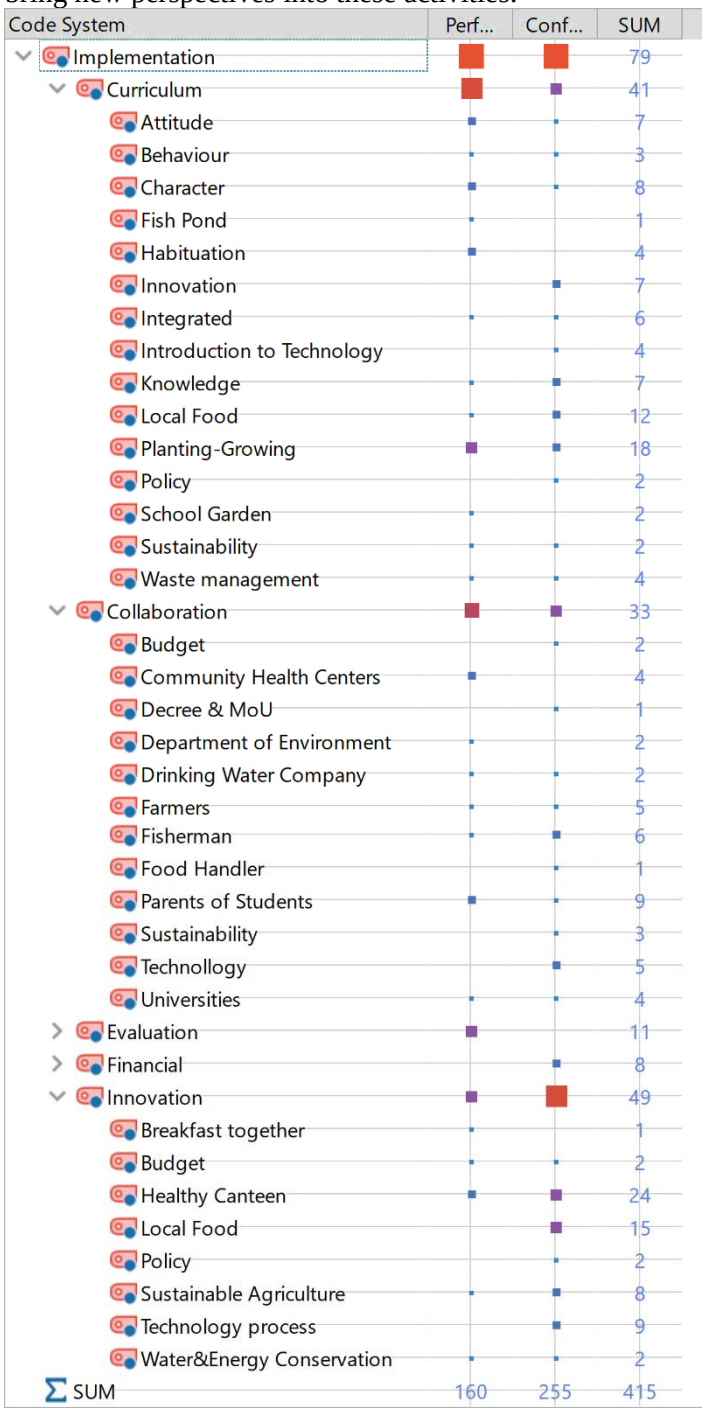

Figure 4. Code matrix browser for implementation aspects and sub-aspects (source: Own research data, 2024)

The relationship between the sub-aspects and sub-sub-aspects of the implementation is shown in Figure 5.

The existence of a healthy canteen is helpful for the implementation of nutritious meals for students. Students' meals were more controlled in terms of nutrition, including eating habits. The menu served by the vendor must meet the standards and SOPs of the

FBC working team established by the school principal. A local food consumption program was implemented.

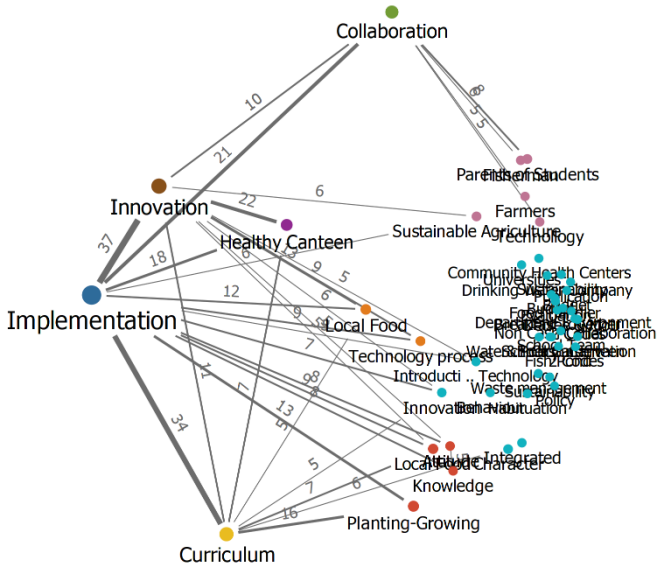

Figure 5. Relationship between the aspects and sub-aspects of FBC program implementation in schools (source: Own research data, 2024)

Thus, based on the school's observation that students are experiencing a fish-eating crisis, a healthy canteen is required to provide seafood 3 days a week. For example, chicken soup is changed to fish soup, beef meatballs are changed to fish meatballs, beef nuggets are changed to fish nuggets, etc.. Sea fish sources were provided by the FBC work team in cooperation with the parents of students who worked as fishermen and at fish auctions. The health and freshness of fish must be clarified. All the items were inspected by the school's FBC team.

The canteen must be free of prohibited ingredients such as preservatives, flavorings, sweeteners, dyes, and thickeners. Likewise, drinks and snacks must try to make use of local biodiversity; for example, the use of moringa leaves (*Moringa oleifera*), known to be very rich in vitamins, pudding, tendons, fresh drinks, juice, peppers, and chips. These innovations will continue to be teaching materials for students regarding the processing of the wealth of local biodiversity for food.

The Healthy Canteen must be plastic-free. All the food containers must be washable and reusable. Students were required to immediately tidy up or wash all eating utensils and store them in the designated area. Students must also line food up in an orderly manner. Thus, a healthy canteen is also a place where students learn to queue, be patient, and respect others.

The sub-aspect of the budget has not been raised much by schools that have implemented FBC. The budget is no longer perceived as a problem, because it is supported by the principal's policies and SOPs in the use of canteen profits and cooperation. The funds generated by FBC business activities can finance co-curricular and extra-curricular learning activities.

4.4. Relationship between Aspects and Sub-aspects of FBC Management in Schools

The results of the Code Relation Browser analysis using the MAXQDA-2020 program demonstrate the relationship between aspects, sub-aspects, and sub-sub-aspects. The strength of the relationship can be seen from the thickness of the line showing the frequency (frequency ≥5) between the aspects and between the sub-aspects (Figure 6).

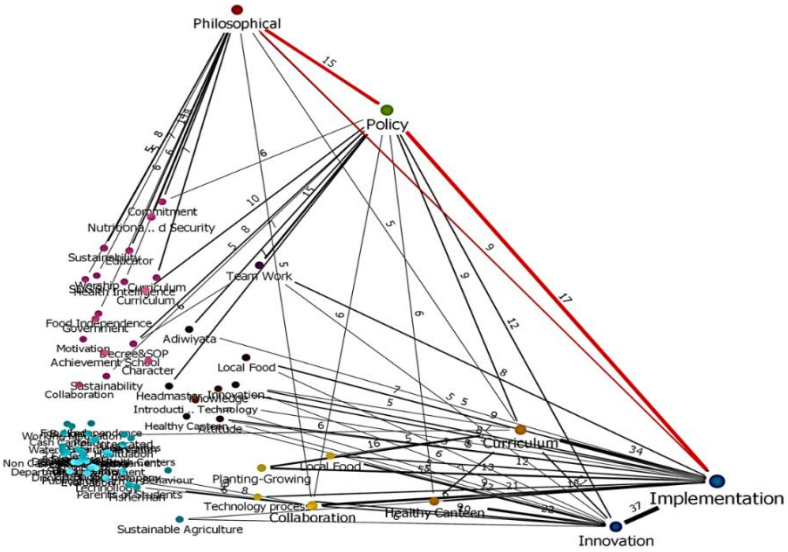

Figure 6. Association between aspects, sub-aspects and sub-sub-aspects of managing food biodiversity to meet students' nutritional needs and school food security. Numbers indicate frequency of association ≥ 5. (source: Own research data, 2024)

The three main aspects of FBC management in schools demonstrate their relationship. This is also the case for aspects, sub-aspects, and sub-sub-aspects. The philosophical aspect is the basis of policy and

implementation. This pattern of relationships forms a triangle between philosophy, policy, and implementation.

The philosophical aspect has only one dominant sub-aspect, student food safety, whereas the other sub-aspects are small and almost equally prevalent. In contrast to the policy and implementation subaspects, the average has three aspects with high frequency. The policy aspect has three dominant sub-aspects: the working team, curriculum, and adiwiyata. As all participating schools have implemented the Adiwiyata program, the curriculum is the same as that of Adiwiyata. Thus, the principal occupies a third position in terms of policy. The implementation aspect consists of three dominant subaspects: curriculum, innovation, and collaboration. Thus, the curriculum subaspect becomes a subaspect of policy and implementation.

The results of the qualitative-quantitative analysis of the relationships between these dominant aspects and sub-aspects show the triangular shape of the aspects at the top and the five-column shape of the dominant sub-aspects at the bottom, as shown in Figure 7.

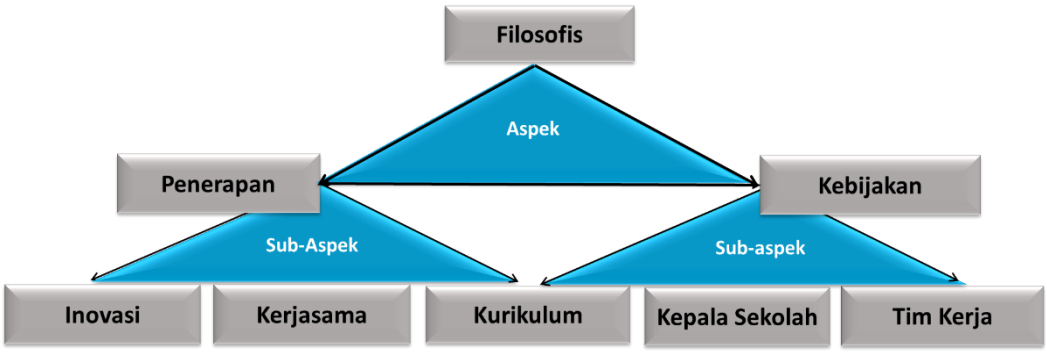

Figure 7. The Triangle and Five-Pillars of the Management Aspect of Food Biodiversity Conservation in Schools to Meet Students' Nutritional Needs and School-Based Food Security. (source: Own research data, 2024)

Based on this model, for the purpose of making it easier to understand and remember the relationship between these aspects and *sub-aspects*, we propose a model called "*The triangle and five-pillars of the Management Aspects of Food Biodiversity Conservation in Schools*" or more briefly called: "*The Triangle and Five-Pillar Management of FBC in Schools*."

The philosophical aspect of management plays an important role and can be the starting point of movement in educational institutions [30, 31]. The philosophy adopted by educators in Indonesia is influenced by various backgrounds regarding the knowledge, thoughts, and experiences of perpetrators [24]. In addition to the national philosophy contained in the Indonesian state constitution, namely, Pancasila, religious knowledge as a source of philosophy is used as a basis for thought and action by FBC actors in schools as well as by FBC actors in pesantren [24, 23].

Research in the United Kingdom and Germany [17, 15] suggests the importance of innovation and collaboration in curriculum development. Recent research in Saudi Arabia [32] has also emphasized the importance of prioritizing innovation, collaboration, financial support, and student awareness. The government of Saudi Arabia, Hal, has a strong vision and philosophical thinking to develop a surface green program that will empower schools to reduce their operating costs and promote sustainable living.

5. Conclusion

The results of this study indicate that

There are three main aspects and five dominant sub-aspects of FBC management in schools for meeting students' nutritional needs sustainably. Its three main aspects are philosophy, policy, and implementation. The dominant sub-aspects were curriculum, innovation, collaboration, principals, and teamwork. The aspects and sub-aspects form a distinctive relationship that we call the three- and five-pillar sub-aspect facets of FCB in meeting students' nutritional needs in schools in a sustainable manner.

The results of this study differed from those of previously published studies. In 2024, Maria Bryant emphasized the importance of considering students' tastes when developing school meals. Meanwhile, this study shows that students should be introduced to and familiarized with new menus with better nutritional value and should not just follow their tastes. Meanwhile, Leonie K. In 2019, Fisher emphasized the importance of school gardens in meeting students' nutritional needs. The results also show the same thing about the weak existence of school gardens as a source of FBC that has not been optimized to meet students' nutritional needs. However, unlike Fisher's results, this study found another FBC that was more sustainable, namely, the fulfillment of animal protein needs; thus, this finding complements the model components.

The results of this study are expected to be an input for the community and the Government of the Republic of Indonesia in implementing the policy of Free Nutritious Meals (FNM) for all students in Indonesia, encouraging schools to be self-sufficient in food provision. This effort will help the government overcome technical problems, infrastructure, and limited budgetary constraints without compromising the quality of the nutrition provided to students.

The results of this study were directly validated by stakeholders involved in FBC activities in schools. Therefore, the important aspects identified were tested. However, given the limited research population (only in parts of East Java Province), additional populations (e.g., national) may have additional aspects or sub-aspects owing to cultural and provincial differences.

Recommendations for Future Research

Further research is needed, both applied and development research, starting from the provincial level to the national level. Thus, a more comprehensive model for meeting students' nutritional needs through FBC in schools can be developed at the national level.

Declarations

Author Contributions

Conceptualization, S.S. and S.E.A.; methodology, S.S, S.E.A., H.A.M.; software, S.S. and H.A.M.; validation, S.S., S.E.A., and H.A.M.; formal analysis, S.S., S.E.A., and H.A.M.; investigation, S.S., S.E.A., and H.A.M.; resources, S.S., S.E.A., and H.A.M.; data curation, S.S., S.E.A., and H.A.M.; writing—original draft preparation, S.S.; writing—review and editing, S.S., S.E.A., H.A.M., and U.U.; visualization, S.E.A., H.A.M., and U.U.; supervision, S.E.A. and U.U.; project administration, U.U.; funding acquisition, S.S., S.E.A., H.A.M., and U. U. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

Data are available upon request due to restrictions (e.g., privacy or ethical), and the data presented in this study are available upon request from the corresponding author. The data are not publicly available because there is participant workshop data that can only be shared with the people they authorize. Data can be obtained with permission from https://drive.google.com/drive/folders/12Fy72o70E148yJQEJ5eFMqoKzWvZX0O_?usp=sharing.

Authors' Institutional Review Board Statement

Author's Institutional Review Board Statement 'Not Applicable' as this research does not involve human or animal anatomy.

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Conflicts of Interest

The authors declare no conflicts of interest related to the publication of this manuscript. Furthermore, ethical issues, including plagiarism, informed consent, misconduct, fabrication and/or falsification of data, multiple publications and/or submissions, and redundancy, have been fully addressed by the authors.

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