

Student-Led Service-Learning for Pesticide Safety Awareness and SDG 3: A Community-Based Project in Rural Indonesia

Rully Adi Nugroho¹, Desti Christian Cahyaningrum², Debora Natalia Sudjito³, Desi⁴, Michael Bezaleel Wenas⁵, Novriest Umbu Walangara Nau⁶

^{1,2} Faculty of Biology, Satya Wacana Christian University, Salatiga, Indonesia

³ Faculty of Science and Mathematics, Satya Wacana Christian University, Salatiga, Indonesia

⁴ Faculty of Health Sciences, Satya Wacana Christian University, Salatiga, Indonesia

⁵ Faculty of Information Technology, Satya Wacana Christian University, Salatiga, Indonesia

⁶ Faculty of Social Sciences and Communications, Satya Wacana Christian University, Salatiga, Indonesia

* Correspondence e-mail; rully.nugroho@uksw.edu

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Abstract

This study examined pesticide-handling practices among smallholder farmers in Kendal Hamlet, Semarang Regency, Central Java, Indonesia, and explored the role of community-based education in promoting pesticide safety. Using a qualitative approach, the study involved 14 Environmental Management undergraduate students and 63 farmers in a three-day live-in service-learning project. Data were collected through community observations, farmer interactions, field notes, community responses, students' reflection journals, and group discussions. The initial assessment identified unsafe pesticide mixing, inconsistent use of personal protective equipment, and household pesticide storage as key concerns. In response, students developed six posters and six infographics, conducted 63 household visits, organized a farmer meeting and composting demonstration, and delivered a storytelling session for 15 children using pop-up books and flashcards. Community responses indicated initial engagement and awareness of pesticide safety, while students reported gaining practical learning experiences through direct interaction with environmental health issues and community needs. However, the absence of pre- and post-tests, a control group, and long-term follow-up limited the assessment of sustained changes in knowledge and behavior. This initiative supports Sustainable Development Goal 3, particularly Target 3.9, by promoting community-based education to reduce health risks associated with hazardous chemicals.

Keywords

community education; environmental health; pesticide safety; service-learning; sustainable agriculture



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1. INTRODUCTION

Pesticides are among the most commonly used agricultural chemicals to control pests and diseases and protect crop yield. Pesticides are an important occupational-health issue in agricultural workers because they may be repeatedly exposed during pesticide preparation, mixing, application, equipment cleaning, and other agricultural tasks (Burns & Juberg, 2021; Damalas & Koutroubas, 2017; Mostafalou & Abdollahi, 2017; Nwadike et al., 2021; Shekhar et al., 2024). Pesticide exposure can be dermal, by inhalation, or ingestion, and the level of occupational exposure depends on the type of pesticide, the task involved in its application, the frequency and duration of use, and work practices (Burns & Juberg, 2021; Dugheri et al., 2018; Muñoz-Bautista et al., 2025; Tudi et al., 2022). Recently published systematic reviews have highlighted deficiencies in safe pesticide use practices among farmers of developing countries and a high prevalence of pesticide-related acute symptoms (Desye et al., 2024).

Pesticide-exposure-related health risks make safe pesticide handling a critical aspect of agricultural health protection. Good protective measures, such as the use of personal protective equipment (PPE), the safe storage and handling of pesticides, and following pesticide-label instructions, can minimize exposure risk (Damalas & Koutroubas, 2017; Dugheri et al., 2018). Nonetheless, knowledge is not the only determinant of the adoption of these practices. Risk perception, education and training, experience in farming, availability of information and PPE, working environment, and financial issues are potential factors that influence farmers' pesticide-safety practices (Desye et al., 2024; Jallow et al., 2017). A systematic review of pesticide-exposure interventions similarly finds that educational and behavioral interventions can increase knowledge and some safety-related outcomes, but the heterogeneous nature of intervention design and methodological quality means that evidence for sustained behavioral effects is weak (Afshari et al., 2021).

The distinction between knowledge and practice is especially relevant in agricultural communities. Indonesian farmers were found to have relatively high levels of knowledge about recommended pesticide practices. Still, they did not consistently implement them, including the use of gloves and masks, safe pesticide mixing, and proper unclogging of blocked spray equipment (Istriningsih et al., 2022). Studies among Indonesian vegetable farmers have also shown incomplete adherence to recommended PPE use during pesticide handling, suggesting that knowledge of safety requirements does not always translate into full compliance with protective measures (Joko et al., 2020). This knowledge-practice gap highlights the need for

pesticide safety education to be relevant to the contexts in which farmers make decisions about pesticide use.

Therefore, interventions that incorporate both education and context-relevant communication may be more effective than interventions based solely on the transfer of technical information. Educational programs have been shown in previous intervention studies to improve pesticide-related knowledge, attitudes, risk perception, and some protective practices (Afshari et al., 2021; Ahmadipour & Nakhei, 2024). Recent controlled studies show that increased knowledge and more positive attitudes do not always lead to measurable improvements in every safety practice (Ssekkadde et al., 2025). This matters when assessing brief community programs: without follow-up, it is not possible to assume that safer pesticide-handling habits will persist over time.

Safety in pesticide use interfaces with SDG 3 in general, and Target 3.9 in particular, which aims at significantly reducing the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination (United Nations, 2026). Education on exposure routes and safer pesticide-handling practices at the community level may, hence, contribute to preventive health for SDG 3. Still, such education alone cannot address the broader determinants of pesticide exposure or demonstrate its impact on health outcomes.

Service-learning offers a potentially appropriate educational model for linking community health issues to higher education (Aramburuzabala, 2025; Diez-Ojeda et al., 2025). Service-learning is an instructional strategy that deliberately integrates academic learning with meaningful community service and structured reflection, and is differentiated from community service that does not involve explicit academic learning (Aramburuzabala & Cerrillo, 2023; Choi et al., 2023; Cress et al., 2023; Filges et al., 2022; Resch & Schrittmesser, 2023). In an experiential-learning framework, students build knowledge by engaging in concrete activities, reflecting on them, forming abstract concepts from the reflection, and testing those concepts in new situations (Lin et al., 2025; Mtawa & Nkhoma, 2020; Salinas-Navarro & Palma-Mendoza, 2026; Wang et al., 2025). This framework is especially relevant to environmental health problems, as students can experience problems in their social and environmental contexts, use disciplinary knowledge to address needs identified at the local level, and evaluate their responses. Recent literature has also highlighted service-learning as an experiential learning methodology that can integrate higher education, sustainability education, and community engagement, while emphasizing

the need for systematic evaluation of student and community outcomes (Álvarez-Vanegas et al., 2024).

This process can be enhanced through community immersion, in which students directly observe practices and interact with community members in their natural environment. This type of engagement can help students see that environmental health practices are influenced not only by technical aspects but also by how people make a living, social relations, the availability of information, and local know-how. Nonetheless, the results of service-learning should be viewed with caution, as indications of student engagement or self-reported learning are not necessarily indicative of gains in objectively assessed competencies or outcomes for the community in the longer term (Aramburuzabala & Cerrillo, 2023; Cress et al., 2023; Filges et al., 2022).

Although the literature on pesticide safety is expanding and service-learning is increasingly utilized in sustainability education, there is little reporting on student-led service-learning that promotes pesticide safety awareness in agricultural communities while exploring students' learning. Cross-generational pesticide-safety communication is also an important area to be addressed, as farmers, household members, and children could be exposed to different pesticide-related risk scenarios.

The present study addresses that gap with a three-day live-in service-learning in Kendal Hamlet, Semarang Regency, Central Java, Indonesia. The project melded community immersion and needs assessment with the development of student-created educational programs for farmers, households, and children (including visual communication, household participation, practical demonstrations, and age-group storytelling). Instead of assuming that a brief educational intervention would result in discernible changes in behavior or health, this investigation focused on pesticide-related concerns raised during community immersion; the design and delivery of culture-relevant educational interventions; community reactions to the interventions; and student reflections on the knowledge gained.

Therefore, the study was designed to: (1) characterize the indigenous knowledge and pesticide-handling practices within the community observed during the service-learning immersion; (2) develop and deliver context-based educational interventions on pesticide safety; and (3) assess community engagement in the interventions and student learning outcomes through reflection. By integrating pesticide safety with community-based environmental health education and experiential learning, the research investigates how service-learning can advance efforts to contribute to SDG 3 at the community level.

2. METHODS

2.1. Study area and community context

The research was carried out in Kendal Hamlet, Semarang Regency, Central Java, Indonesia (7°23'12.865 "S, 110°27'28.277 "E). The population is rural, and horticultural farming is a significant source of income in the community. The farmers' major monoculture crops are cabbage, green beans, tomatoes, chili, and tobacco. Other household endeavors include small-scale entrepreneurship and dairy farming.

Chemical pesticides are routinely applied by farmers to control insect pests and diseases in crops, and are mostly purchased from local agricultural input suppliers. The community was chosen because its agricultural milieu was ideal for studying pesticide-handling practices and implementing a community-based educational intervention on pesticide safety. The proximity of farms to homes was another factor that made pesticide safety relevant not only to farmers but also, potentially, to other household members.

This study was conducted as a community-based service-learning project and was not an attempt to generalize to all farmers in Semarang Regency or to the whole of Indonesia. Rather, the local setting was used as a framework to guide the identification of pesticide safety issues and the development of community-appropriate educational strategies.

2.2. Participants

Four groups of undergraduate students in the Environmental Management degree program were formed, each with 14 students, to work on the service-learning project. The students were the lead service-learning participants who engaged in community observation, interaction, educational activities, and reflection.

63 farmers were community respondents who shared information on their pesticide application practices, storage, use of personal protective equipment (PPE), and their health risk perception associated with pesticide application. They also participated in the farmers' interventions related to this project: non-farmer community members who took part in several specific activities, as well as the hamlet head, farmers' family members, and children. This hamlet is located in the district capital.

The 63 farmers were recruited for their participation in community activities during the study; hence, the sample was community-based rather than statistically representative of farmers across the broader Semarang Regency. As the project was intended as a service-learning project with a community-based needs assessment, the

participants were selected for their community involvement rather than through probability sampling.

2.3. Service-Learning Design

The project incorporated a full-time, service-learning approach that integrated community involvement, experiential education, and guided student reflection. The event was staged over three days with 14 students staying with host families in Kendal Hamlet and engaging in community activities. The intention of the live-in was for students to witness agricultural and household work in a real social context, and to meet with farmers and other rural people.

Students held informal conversations with farmers throughout the immersion; they also observed pesticide-handling procedures and noted problems associated with pesticide application, storage, protective equipment, and health risks as they perceived them. These observations and community engagement served as a needs assessment and informed the content of the next educational effort. Next, groups of students brainstormed and conducted educational sessions in response to issues highlighted during the immersion.

Service-learning design reflected the integral role of reflection. Students documented their experiences in written reflective journals. They engaged in group discussions to reflect on the environmental and health concerns they encountered, their interactions with community members, and the process of translating academic knowledge into context-relevant educational units. Hence, the design integrated community-based observation and service with academic work and student reflection, rather than presenting community experiences as an isolated outreach activity.

2.4. Educational Interventions

The educational interventions were developed by the students based on the pesticide-safety concerns identified during the live-in observation and community interactions. The activities used several communication formats to address different community groups and learning contexts.

For farmers and the wider community, students developed six posters and six infographics on pesticide safety, including the appropriate use of PPE, safe pesticide handling and storage, risks associated with improper pesticide mixing, and adherence to product label instructions. The materials were displayed at several locations in the community to provide accessible visual information beyond direct student-farmer interactions. A farmer meeting was also conducted to discuss pesticide handling, PPE, pesticide mixing, and label instructions.

Students conducted 63 household visits, distributed across the four groups (15, 16, 17, and 15 visits), to extend pesticide safety communication into household settings. A practical composting demonstration was conducted with farmers to introduce an alternative approach to managing organic material and nutrients relevant to local agricultural practices. However, it was not presented as a direct substitute for pesticide use.

For children, the students held a storytelling session with a group of 15 children, using pop-up books and flash cards that illustrate pesticide-related risks in age-appropriate visual and narrative formats. The formats varied to suit the audiences: visual materials for reiterative messaging at the community level, direct discussion and demonstration with farmers, household visits for personalized interaction, and illustrated stories for children.

The students also showed how to make a tobacco-based biopesticide using locally accessible plant material. Since tobacco itself is poisonous (nicotine), the activity was taught with due safety precautions, and the message was that a plant-based pesticide is not automatically safe.

2.5. Evaluation Approaches

The project employed a qualitative process evaluation approach to capture how communities responded to the educational interventions and students' learning trajectories. Community responses were recorded as questions and comments from participants during activities, informal conversations with farmers and other community members, and students' field notes. These data were analyzed qualitatively to identify signs of engagement and shifts in awareness within the project, rather than to measure intervention effectiveness.

Student learning was assessed via written reflection journals and focus groups during and after the community projects. The reflections center on students' experiences of using their academic knowledge to engage with community members, recognize environmental and health issues, and formulate place-appropriate educational responses.

No formal single-group pre-test or post-test, control or comparison group, standardized knowledge scale, or long-term follow-up was employed. Therefore, the evaluation does not allow for causal inferences about farmers' knowledge acquisition, changes in pesticide-handling behavior, improved health status, or sustained adoption of safer practices. As such, the results are framed as community reactions, perceived shifts in awareness, and student learning rather than a quantitative measure of intervention efficacy.

2.6. Ethical Considerations

Participation in community activities was noncompulsory. Oral informed consent was obtained from the 63 farmers who provided information during project implementation, and the hamlet head was allowed to participate in the work. In household and community sessions, students communicated the sessions' objectives. They informed participants that they did not have to participate in the sessions to receive the education or other community services.

For activities involving children, the students and project team conducted them with the knowledge and permission of the children's parents or guardians. Personal identifying information was not collected or reported in the study. The educational interventions were designed to be minimal risk and were targeted towards environmental and health education, not clinical assessment or pesticide-exposure testing.

3. FINDINGS AND DISCUSSION

3.1. Findings from the Live-in Observation

The three-day live-in was an opportunity for the 14 students to witness farming methods and meet farmers and their families in their own homes. Four student teams found that farmers' perceptions and practices regarding pesticide handling may lead to health and environmental hazards. These findings were not treated as a means of measuring exposure, health impact, or the effectiveness of the intervention, but were considered a community-level needs assessment to inform the subsequent educational intervention.

One of the concerns that emerged from the immersion is that of pesticide mixing. All four student teams noted farmers mixing products: 30 of 63 farmers interviewed (47.6%) said they routinely mix more than one pesticide. The observations did not reveal whether specific product combinations are chemically incompatible. Still, they demonstrate that farmers occasionally mix products without knowing whether the products are compatible or why they are mixing them. This is an important distinction because agricultural practice may call for the use of pesticide mixtures, but only with products that should be mixed and applied according to the label instructions in compliance with the agricultural label instructions and safety measures (FAO & WHO, 2025; WHO, 2021).

PPE is a related issue of concern. Forty-five farmers out of 63 (71.4%) said they did not wear gloves while spraying with pesticides, and 47 farmers (74.6%) said they did not wear a mask. Furthermore, none of the farmers observed by the student groups

were wearing goggles during the activity. As summarized in Table 1, limited use of PPE was among the most frequently identified safety concerns. These results suggest that opportunities for dermal and inhalation contact are consistent with other reports showing that safe pesticide use practices are poor among many farmers in developing-country contexts (Desye et al., 2024; Keleb et al., 2024). In a recent systematic review, it was also reported that multiple factors, such as knowledge, attitude, risk perception, education, information and training, and agricultural extension services, affect farmers' protective measures (Kangavari et al., 2024).

Table 1. Unsafe pesticide-handling practices and perceptions were identified during the live-in observation.

Unsafe practice or perception	Evidence source	n/N (%)	Student-group observation
Mixing ≥ 2 pesticides	Farmer interview	30/63 (47.6%)	Observed by 4/4 student groups
Not wearing gloves	Farmer interview/observation	45/63 (71.4%)	Observed by 4/4 student groups
Not wearing a mask	Farmer interview/observation	47/63 (74.6%)	Observed by 4/4 student groups
Not wearing goggles	Student observation	0 observed wearing goggles	No farmer observed wearing goggles
Storing pesticides inside the home	Farmer interview/observation	12/63 (19.0%)	Identified during the live-in activity
Belief that stronger or more frequent pesticide application increases yield	Farmer interview/discussion	12/63 (19.0%)	Identification during farmer interactions

Among the 63 farmers, 12 (19.0%) were reported to keep pesticides in their houses. Pesticides were said to be stored or observed to be stored in sitting rooms and under beds. As indicated in Table 1, this practice affects not only occupational exposure but also household storage, which may create opportunities for exposure among family members who are not directly involved in applying pesticides. International pesticide management guidelines advocate for safe storage away from

dwelling, sleeping areas, food, children, and unauthorized individuals (FAO & WHO, 2025). The divergence between knowledge and actual pesticide-safety behavior has also been reported in the Indonesian context, including the use of gloves and masks and adherence to label instructions (Istriningsih et al., 2022).

An additional observed result was that 19.0% (n=12) of the farmers believed that increasing the strength or number of sprayings may improve crop protection and increase yields. Together with the other findings summarized in Table 1, this belief implies that pesticide use is not simply a matter of knowledge deficit. Farmers operate within livelihood contexts where considerations such as crop losses, productivity, input costs, and perceived pest pressure all matter. Findings from pesticide-safety research also show that preventive action is influenced by the interplay of various individual, social, economic, and institutional factors (Desye et al., 2024; Kangavari et al., 2024).

Collectively, the observations suggested that pesticide safety at the community level was a function of interconnected factors, including pesticide mixing, low use of PPE, storing pesticides in the home, and beliefs about how increased pesticide use relates to crop yield. These results were directly used to develop the interventions outlined in Section 3.2. In particular, the visual material and conversations with the farmers emphasized the use of PPE, safe practices for handling and mixing, and adherence to label instructions. Storing the product at home to keep families and children safe was the reason for the farmers' communication with their families.

However, the results should be interpreted with the study design's limitations in mind. The project also did not measure pesticide exposure, evaluate clinical health outcomes, or conduct a formal pre-intervention knowledge assessment. The results thus reflect practices and perceptions within the participating community and do not generalize to evidence of pesticide-caused illness or to farmers in Semarang Regency or Indonesia.

3.2. Implementation of Educational Interventions

The educational interventions were tailored to the issues raised during the on-site observation and were not based on a pesticide-safety presentation format. The activities are addressed to various community actors and include visual communication, interactive face-to-face discussion, home visits, practical demonstration, and storytelling. Table 2 provides an overview of the number, target group, and documented reach of the activities, while Figure 1 illustrates some examples.

Six infographics and six posters on pesticide safety topics such as PPE, safe handling and mixing, and following product label instructions were created. The items were left at several community sites. During subsequent interactions with the students, 12 farmers read the materials placed along the dotted lines and discussed PPE, pesticide mixing, and label instructions. This is not to say that these materials were not seen by others, but these are the farmers who were focused on through the work and interviewed about the specific materials. Since there was no effort to systematically count total exposure to these materials, the materials are identified as a communication activity rather than an intervention reach.

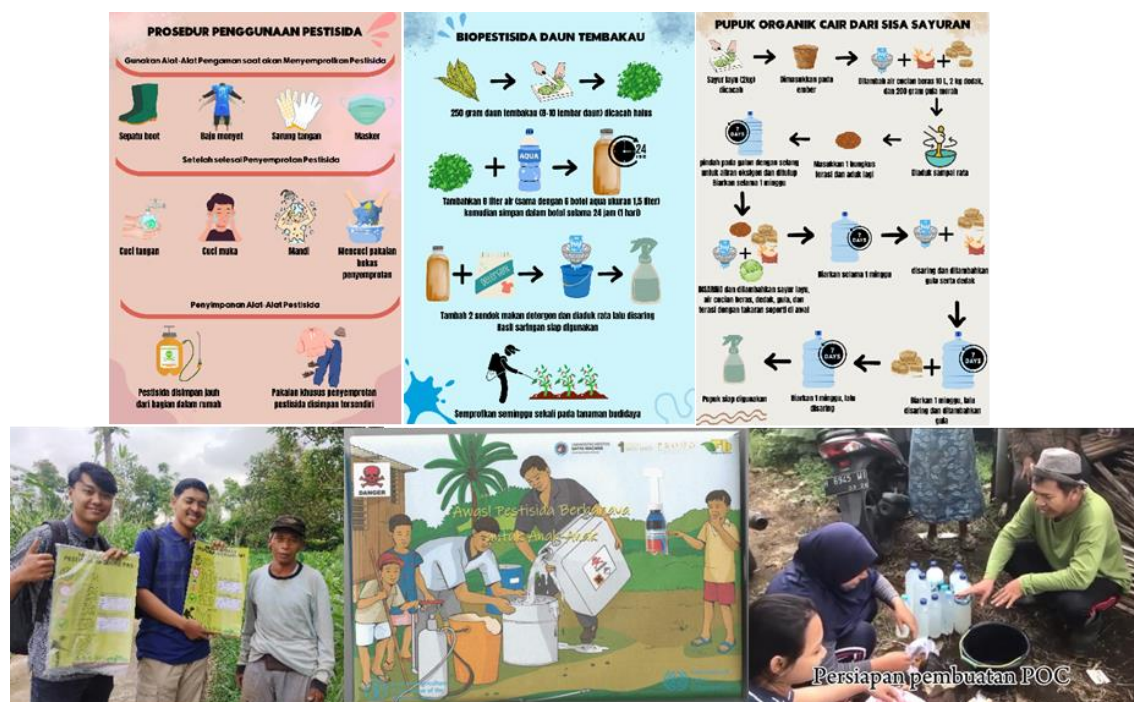


Figure 1. Samples of student-designed educational interventions: posters, storytelling materials, and composting demonstrations were presented during sessions with community groups.

A farmer meeting provided a more direct avenue for addressing the issues that had emerged during the immersion, especially PPE use, pesticide mixing, and product label instructions. The use of both visual aids and face-to-face discussion was in line with pesticide-management recommendations that emphasize easy educational information and clear instructions for pesticide users (FAO & WHO, 2025). Recent intervention studies have also shown that structured pesticide-safety education can improve knowledge and safety outcomes, particularly when baseline and follow-up assessments are employed (Akkouch et al., 2025; Ssekkadde et al., 2025). However, these outcomes were not explicitly measured in the current project.

Table 2. Educational interventions implemented during the service-learning project

Educational intervention	Target group	Implementation	Participant/reach
Posters (6) and infographics (6)	Farmers/ community	Displayed at several community locations; used to discuss PPE, safe pesticide handling, mixing, and label instructions	12 farmers specifically interacted with/read the materials when displayed; total reach not quantified
Farmer meeting	Farmers	One meeting addressing PPE, pesticide mixing, safe handling, and label instructions	Farmers; attendance not quantified
Home visits	Farmer households	63 household visits conducted by four student groups (15, 16, 17, and 15 visits)	63 farmer households
Composting demonstration	Farmers	One practical demonstration of composting for organic material and nutrient management	Farmers; attendance not quantified
Pop-up books and flashcards	Children	One storytelling session using age-appropriate visual materials to discuss pesticide-related hazards	15 children
Tobacco-based biopesticide activity	Students/ community	Preparation/demonstration using locally relevant tobacco plant material	Number not specified

In addition, the students performed 63 household visits among the four groups (15 from Group 1, 16 from Group 2, 17 from Group 3, and 15 from Group 4). As summarized in Table 2, these visits brought pesticide safety communication into the home and enabled discussions about pesticide use and storage in the environments where they occur. The household focus was especially relevant, as pesticide storage within homes had been identified as a concern during the live-in observation.

A composting demonstration was also conducted with farmers as a complementary activity related to organic material management and soil fertility. This was not presented as a direct alternative to pesticide use, as composting is a practice to manage nutrients and organic matter, not pests. Several farmers expressed interest in attempting composting, partly because of its potential to reduce some input costs. This was considered an expression of interest rather than adoption, as no follow-up assessment was conducted.

A storytelling session was held with a group of 15 children using pop-up books and flashcards created by the students. As shown in Figure 1, the materials communicated pesticide-related risks via age-appropriate visual narratives—questions rather than technical information on chemical toxicity. The variations in communication formats mirrored the difficulty of tailoring a single overarching message about the environment and health to different audiences.

The project also featured a demonstration of a tobacco-based biopesticide. As tobacco is a source of nicotine and handling tobacco leaves may lead to dermal absorption of nicotine, the activity was associated with safety measures and was not implied to be less harmful than chemical pesticides (WHO, 2023). This caveat was critical because introducing a plant-based pesticide without assessing its own risks would be inconsistent with the project's emphasis on reducing chemical exposure.

Overall, Table 2 and Figure 1 illustrate how the needs assessment manifested in a range of community engagements, such as visual materials and discussions with farmers, home visits to further the discourse on pesticide use and storage, a composting demo that complemented the discourse, and child-focused storytelling. These activities thus expanded pesticide-safety communication beyond a single farmer-training session and challenged students to translate scientific information into messages suitable for different community audiences.

3.3. Community Responses and Perceived Changes in Awareness

Community responses were recorded from questions and comments asked during activities, informal conversations with farmers and other community members, and students' field notes. The main responses documented across the different interventions are summarized in Table 3. Farmers asked about pesticide mixing, PPE, and product label instructions, indicating that the interventions prompted discussion of practices that had been flagged as issues during the live-in observation. A few farmers also expressed interest in trying composting after the demonstration.

Table 3. Community responses to the educational interventions.

Intervention/issue	Community response documented	Interpretation
Pesticide mixing	Some farmers questioned the indiscriminate mixing of pesticides and asked about appropriate mixing and label instructions.	Indication of engagement and increased attention to pesticide-safety information
PPE use	Farmers asked questions about gloves, masks, and other protective equipment.	Increased discussion of personal protection; behavioral change was not assessed
Composting	Several farmers expressed interest in trying composting, particularly because of its potential to reduce input costs.	Initial interest; subsequent adoption was not assessed
Household pesticide storage	Discussion of pesticide storage raised concern about potential household exposure.	Increased attention to the household dimension of pesticide safety
Children's storytelling	Children pointed to images, asked questions, and expressed concern about chemical exposure.	Immediate engagement; learning gains were not formally measured

These responses are best understood as signs of engagement and increased awareness, rather than as indicators of measurable improvements in knowledge or behavior. This distinction matters because knowledge does not always directly translate into safer pesticide practices. Studies among Indonesian farmers have shown discrepancies between knowledge and actual use of recommended pesticide-safety practices, and systematic reviews have found that risk perception, social norms, access to information, and practical barriers influence preventive behavior (Istriningsih et al., 2022; Kangavari et al., 2024).

The discussion of pesticide mixing demonstrates this point. Farmers who wondered whether certain formulations were valid mixtures were addressing an issue encountered in the immersion. Similarly, questions about gloves, masks, and other protective gear suggested an interest in personal protection. Yet, these exchanges should not be read as implying that farmers have changed. Studies reporting changes in pesticide-safety-related behavior tend to employ challenging interventions with

baseline and follow-up assessments. For instance, recent intervention research has shown improvements in safety knowledge and behavior using pre-post or controlled designs (Nasrabadi et al., 2025; Ssekkadde et al., 2025).

The composting activity had a similar effect. Farmers' willingness to experiment with composting in their own land signaled that the demonstration spurred discussion about locally available resources and the cost of agricultural inputs, but did not track eventual adoption. Likewise, the 15 children who came for the storytelling session asked questions about pesticide-related hazards while pointing to pictures. As summarized in Table 3, these observations indicate that people engage with the educational materials but do not show learning gains or changes in household behavior.

The intergenerational aspect, however, added another dimension to pesticide-safety communication. The messages for children and families were added to the farmer-focused activities because pesticide storage had been reported in some homes. The project also exemplifies a key aspect of service-learning: students communicated with various audiences about an identified community issue, but customized their communication rather than using a one-size-fits-all instructional model (Álvarez-Vanegas et al., 2024).

So, the responses in Table 3 provide evidence of dialogue, questioning, and the beginning of engagement with pesticide safety issues. They do not show long-term changes in knowledge, attitudes, behavior, pesticide exposure, or health outcomes. The three-day project was long enough to identify local issues and begin community involvement, but not long enough to conclude whether the responses became practices that persisted.

3.4. Student Learning Outcomes

The 14 students in Environmental Management who participated in the service-learning project had the chance to take what they learned in the classroom and apply it to a childhood asthma issue in their own community. Over the course of the three-day immersion, students watched as farming was done, met farmers and their families, noted pesticide-safety issues, and attended to these issues by crafting educational initiatives in response to what they had seen. Student achievement of learning was evidenced in written reflection journals and group discussions, not through formalized competency testing.

The reflections suggested learning in several interrelated domains. The students perceived that they had improved their knowledge of pesticide handling, the associated health and environmental threats, and the difficulties involved in

conveying scientific knowledge to the communities. They also needed to modify their communication for diverse audiences: technical and pragmatic exchanges with farmers; household-level conversations during home visits; and visual narratives for kids. This task required students to translate their disciplinary understanding into information they could share in a manner appropriate to the given context.

A key element of the learning was the recognition that environmental-health issues do not necessarily lend themselves to resolution by technical information alone. Students in the program came into contact with pesticide protocols as a part of farming systems, livelihood logics, frames of access to information, and narratives of agricultural risk. So, the experience fostered students' thinking about environmental management in terms of scientific, social, economic, and communication problems. Such findings are in line with research demonstrating that experiential learning environments, in general, have the potential to promote generic competencies such as critical thinking, communication, and self-regulation (Duchatelet et al., 2024).

Reflection helped students link what they observed in the community to what they had learned in class. In journals and group discussions, they considered how ideas about environmental management, workplace health, communication, and sustainable farming applied to the situation. Bringing community service together with academic learning and reflection reflects key features of service-learning and its value in sustainability education (Álvarez-Vanegas et al., 2024).

This learning process also had a cross-generational communication aspect. Students needed to deliver relevant messages about pesticide safety to farmers, families, and children, using different media and varying levels of complexity. It was hands-on experience in knowledge translation and community engagement that would be hard to replicate in its entirety through classroom-based instruction alone.

Nevertheless, they should be viewed as students' learning experiences, not as verified learning outcomes or competence enhancements. There was no formalized pre-post evaluation of student learning. Yet, direct community observation, intervention design and development, implementation, and structured reflection offered an experiential learning process that integrated academic content with a real environmental-health concern.

3.5. Linking to SDG 3 and Sustainable Agriculture

The project is well within the conceptual scope of the SDG 3 Sustainable Development Goal and, in particular, with Target 3.9 of the SDG 3, which gives an idea for a significant reduction in deaths and illnesses due to exposure to hazardous

chemicals and air, water, and soil pollution and contamination (United Nations, 2026). Pesticide safety is connected to this target, as improper pesticide use can threaten those working in the agricultural sector, residents of the house, and the ecosystem. Emerging data continue to report health risks associated with pesticide exposure and linked to unsafe use by agricultural laborers (Desye et al., 2024; Shekhar et al., 2024).

The impact of this present work on SDG 3, therefore, is to be seen in terms of preventive and educational activities rather than in measurable health consequences. The study also showed that certain practices may increase predatory exposure to pesticides, such as pesticide mixing, minimal PPE use, and storing pesticides in the home. These concerns were subsequently challenged through context-specific communication, household interaction, practical demonstrations, and child-appreciative education. The expected route is therefore: detection of exposure-related practices → risk communication tailored to the local context → community conversation and initial awareness → community motivation to adopt safer practices.

This route does not show a decrease in pesticide exposure, poisoning, morbidity, or mortality. The study did not measure any of these outcomes and did not include a pre-post comparison or long-term follow-up. Therefore, it would be an overstatement to say that the project directly improved health outcomes or contributed to a measurable step toward an SDG indicator. Instead, the project is a small-scale, community-based educational intervention aligned with the preventive health focus of SDG 3.9.

The findings are also relevant to sustainable agriculture, as agricultural sustainability is not just about productivity but also about the health of farmers and their families, environmental protection, and the responsible management of agricultural inputs. Pesticide safety issues illustrate how occupational and household health concerns can enter the broader agricultural sustainability dialogue. The composting demonstration also opened up the discussion of locally available organic materials and input management, but this should not be seen as a direct replacement for pesticide-based pest management.

The service-learning model helped turn observation and needs assessment into practical community action and reflection. Recent research presents service-learning as a hands-on approach that enables university students to link their studies with community needs and sustainability challenges. It also stresses the value of assessing effects over time (Álvarez-Vanegas et al., 2024). This project shows how that approach can work locally: students drew on their environmental-health knowledge, addressed

concerns raised by community members, and considered both the social and practical aspects of environmental management.

Overall, the project suggests that student-led service-learning can help initiate conversations about pesticide safety among farmers, households, and children, while providing students with meaningful real-world experience. Its contribution to SDG 3 is best understood as local support for prevention and education, rather than as evidence of improved health outcomes. Ongoing community involvement, repeated learning activities, and well-designed assessments before, during, and after the project would be needed to determine whether early engagement leads to safer pesticide practices and reduced exposure over time.

4. CONCLUSION

This service-learning project highlighted key pesticide-safety issues among farmers in Kendal Hamlet, including unsafe pesticide mixing, inconsistent use of personal protective equipment, and household storage of pesticides. These findings informed a community-based needs assessment that guided the development of relevant educational interventions for farmers, households, and children. Interventions generated initial community involvement and awareness, as evidenced by farmers' questions and discussions about pesticide mixing, protective equipment, and household storage, as well as children's engagement with pesticide-safety messages. The project thus shows the feasibility of student-led, community-immersive service-learning as a trigger for multi-generational pesticide-safety communication. However, the lack of pre- and post-intervention measures, a control group, and long-term follow-up means that improvements in knowledge, practices, or health outcomes could not be quantitatively established. The project also provided students with experiential learning opportunities by linking academic knowledge to real-world environmental health issues and community needs. In this regard, the project supports SDG 3, specifically Target 3.9, through preventive education about the risks of hazardous chemical exposure. To ensure lasting impact, higher education institutions should facilitate repeated community engagement; local agricultural and community stakeholders should continue to provide pesticide safety education and follow-up; and future researchers should incorporate pre-post measures and longer-term evaluation to assess whether initial awareness translates into sustained safer pesticide-use practices.

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