

Green Pesantren: Best Practice of Integrating Green Technology and Sustainable Agriculture for Eco-friendly Education

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ABSTRACT

Unwise use of the environment has triggered various global problems, such as natural destruction, declining biodiversity, climate change, and the depletion of natural resources, which are indicators of crisis, including in Indonesia. This study aims to examine the application of green technology and sustainable agricultural systems at the Pangrango Nature Islamic Boarding School in West Java. The method used is a qualitative approach, with data collected through in-depth interviews with purposively selected informants, supported by document analysis, and tested through triangulation to ensure the validity and reliability of the findings. The results of the study show that the application of green technology and sustainable agriculture is realized through various real practices, such as the manufacture of organic liquid fertilizer from waste fermentation, the management and recycling of organic and non-organic waste, the application of vertical agriculture, and the use of mulch on beds to maintain soil fertility. This practice is not only effective in environmental management but also a means of contextual learning for students in understanding the importance of nature conservation. In addition, these findings expand understanding of the Bronfenbrenner and Jean Piaget habituation theory, which asserts that individual development occurs through dynamic interactions with the surrounding environment. The implications of this research underscore the importance of integrating green technology practices and sustainable agriculture into the Islamic boarding school education system, ensuring that learning is not only theoretical but also practical and contextual. In terms of the model, this research proposes a *practice-based green pesantren*, an educational model that emphasizes the habituation of environmentally friendly behavior and the integration of curriculum and field practice, and can be applied in other pesantren to form a generation that cares about environmental sustainability.

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INTRODUCTION

According to a report by the Ministry of Environment and Forestry (MoEF), the environmental conditions in Indonesia in the last two decades have faced considerable challenges. Since 2000, more than 9 million hectares of forest have been lost to deforestation and fires, most of which occurred due to land clearing for plantations and mining. The Ministry of Environment and Forestry's data for 2024 also shows that the net deforestation rate will reach around 175,400 hectares, an increase from the previous year of 121,100 hectares. Currently, the area of Indonesia's forest area is around 95.5 million hectares or 51.1% of the total land. In the 2015–2019 period, net deforestation was recorded between 439,000 and 629,000 hectares per year. In addition, environmental conditions are also increasingly depressed because more than 60% of major rivers in Indonesia are in moderately to severely polluted conditions (Indonesia Environment and Energy Center). In addition, Indonesia also receives waste from developed countries for recycling, but some of it is burned as fuel for tofu production. This high-risk practice, which can produce toxic substances such as dioxins and polybrominated diphenyl ethers has been going on for more than 20 years (Mangunjaya, 2021). According to data from the Directorate General of PPKL, most of the waste in Indonesia's oceans is in the form of plastic (42%), wood (24%), and rubber (13%). Meanwhile, land conversion has also triggered forest fires that worsen air quality, especially in Sumatra, where the area of land burned reached 79,967 hectares in 2018 and rose to 84,834 hectares in 2019 (Puniasih & Prakoso, 2022). Environmental damage in watersheds due to waste disposal (hazardous and toxic materials) was revealed after it was discovered that there were companies that dumped coal waste into the waters, albeit in limited quantities. This action still has the potential to have a major impact on the ecosystem, which ultimately harms environmental sustainability in Indonesia (Riyadi et al., 2022). According to the National Disaster Management Agency, most of the natural disasters that occur in Indonesia are hydrometeorological disasters, such as floods and landslides, one of which is climate change; In the period 2014–2023, at least 27,775 hydrometeorological disasters were recorded, while other climate change impacts were also seen from rising temperatures, changes in rainfall patterns, and shorter rainy seasons in a number of regions, which directly affected the agricultural sector and worsened public health problems (Testriono, 2024). When compared to the issue of environmental damage, Indonesians' attention is more focused on health, crime, and corruption issues—57.9%, 57.0%, and 55.4%, respectively—so the information they receive tends to be filtered based on the priority scale. This confirms that employment, health, poverty, and education are seen as more pressing agendas, while environmental issues are only considered a priority by about 27% of the total population (Al-Barakat et al., 2025; Geng et al., 2019; Hadisi et al., 2025; Junaidah et al., 2025).

Because of this, it is clear that the unwise use of the environment has caused various global problems. Nature destruction, reduced biodiversity, climate change, and depletion of natural resources are the main signs of this crisis (Assegaf et al., 2025; Mukul, 2024; Vrbanoć Lisac et al., 2025). In fact, the global ecological crisis is reflected in the widening carbon inequality due to an unfair international trading system, where some countries gain huge economic benefits while others bear a heavier burden of environmental emissions (Guo et al., 2024). Although there have been many international environmental agreements, the results are often not optimal because they are hampered by economic interests. If not addressed immediately, this crisis could threaten the lives of humans and other creatures in the future. Therefore, it takes courage to make a decision and act now, because delaying will only worsen the damage and burden the next generation (Aulia et al., 2026; Humaida et al., 2026; Muhalli, 2023; Sukabdi et al., 2025).

According to Kamal Basir et al., the application of green technology not only contributes to environmental conservation efforts, but also becomes part of the process of revitalizing the noble values of Islamic civilization. This condition forms a positive reciprocal relationship, where a strong

understanding of the principle of sustainability in Islamic teachings encourages the development of environmentally friendly technology, as well as fostering public awareness to practice Islamic values in daily life (Kamal Basir et al., 2025). Until now, the implementation of the eco-pesantren program tends to focus on preventive efforts through environmental awareness education, while the aspect of resource efficiency in sustainable infrastructure development has not received adequate attention. In fact, Islamic boarding schools have a great opportunity to develop sustainable infrastructure facilities by utilizing natural energy optimally, so that they can increase the efficiency of energy use—both electricity and water—and reduce the burden of operational costs (Widiastuti, 2024). Based on the results of PPIM UIN Jakarta's research on 361 Islamic boarding schools, as many as 269 Islamic boarding schools (74.52%) were recorded as having environmental care programs, which generally focused on tree planting and waste management. Islamic boarding schools that run environmentally friendly programs tend to show higher ecological behavior than Islamic boarding schools that do not have similar programs. In response to environmental issues, Islamic boarding schools creatively integrate religious values with ecological issues through various innovations such as the concept of waste alms, oxygen alms, and spring water waqf. These initiatives not only contribute to the preservation of nature, but also form an ecological consciousness rooted in religious teachings. Although religious values have proven to be a powerful driver for environmental action, the sustainability of these efforts still requires cross-sectoral synergy (UIN 2025). Iim Halimatusa'diyah, through his study, it was reported that Islamic boarding schools located near mountains, hills, and large rivers tended to have a waste and waste management program of more than 60%, because the large number of students—around 300 people—produced a large volume of waste that needed a sorting and processing system so as not to damage the environment, especially river flows (Halimatusa'diyah, 2025). Meanwhile, Islamic boarding schools around protected forests, large plantations, or industrial estates are more likely to develop alternative energy programs such as solar panels and microhydro (more than 30%) as a solution to PLN's limited access to electricity. The Islamic boarding schools in coastal areas generally have other programs such as fisheries and livestock (28.12%). Through *green pesantren* activities, it is hoped that students can form behaviors that care about the environment intensively, so that they can have a positive impact in increasing ecological awareness of the surrounding environmental conditions (Katoningsih et al., 2025; Khuadthong et al., 2025; Wahyuningsih & Masyhuri, 2024).

Concretely, various studies have examined the concept of *green pesantren* in terms of Islamic integration with environmentally friendly values and the application of an environment-based curriculum in Islamic boarding schools. A number of studies on eco-pesantren have also paid attention to the real practice of such a blend. For example, some eco-friendly Islamic boarding schools develop organic agriculture, waste management systems, the use of renewable energy, and water conservation programs as a form of implementation. However, the pesantren that is the focus of this study, namely the Alam Pangrango Islamic Boarding School, West Java, Indonesia, is different from other similar pesantren of this kind. This pesantren carries the concept of a *green pesantren*, with distinctive ecological characteristics compared to other green pesantren. One of them is located on a mountainside area. This geographical location opens up space for students to interact directly with natural conditions that are more authentic than in urban areas, both in terms of soil, water, and air. Thus, the learning process does not only take place conceptually, but also through lived experiences. This process of interaction through daily life activities then succeeded in forming the habits (habituation) of the students on how to treat (maintain) the surrounding environment (Almughyiri, 2025; Salabi, 2026). From this habituation process, at the next level, it succeeds in fostering self-awareness, ecological sensitivity, and optimizing the self-potential of the students. From the high intensity and duration of the students' interaction with the environment (nature), a balance is created between intellectual, spiritual, and ecological aspects in the students. This balance then becomes the frame of the harmonious relationship between students-

pesantren-environment. This statement is reinforced by Jean Piaget's view that human behavioral and cognitive development takes place through the process of adaptation to the environment. The adaptation process involves two main mechanisms, namely assimilation and accommodation. Through these two processes, individuals adjust their cognitive structure based on experiences gained from the environment so that cognitive balance is achieved (Walsh, 2023). Even B. F. Skinner emphasized that behavior that is carried out repeatedly and supported by consistent reinforcement will get stronger, so that in the end it develops and settles into a habit (Martin, n.d. 2025).

The Alam Pangrango Islamic Boarding School, from here, then chose to adopt the natural school curriculum in the Islamic boarding school learning system. This curriculum, by the Islamic boarding school, is believed to be more effective in fostering awareness and love for the environment. Through the outdoor schooling approach, students are invited to interact directly with nature, as well as learn to live in harmony and harmony with the surrounding environment. This learning model not only strengthens conceptual understanding, but also shapes attitudes and behaviors of caring for the environment in a more profound and sustainable manner at various levels of education (Halimatusa'diyah et al., 2024). This Islamic boarding school is regionally located in Bojong Murni Village, Ciawi District, on the slopes of Mount Pangrango. It was founded in 2016 by Kiai Ahmad Zarkasyi and his family. This Islamic boarding school designed the "Green Boarding School" program in response to the characteristics, topography, and typical ecosystem of mountainous areas. Recognizing the high risk of deforestation and the threat of plastic waste in the region, this program was officially launched on July 14, 2023 with an emphasis on the integration of ecological values in an Islamic perspective through nature-based curriculum, endemic tree planting activities, and sustainable waste management. This initiative also involves cooperation with the Gunung Gede Pangrango National Park Office and the active participation of the local community as a tangible form of pesantren commitment in realizing the vision of *rahmatan lil 'alamin*.

METHODS

This research uses a qualitative method which is an investigative approach that does not rely on numbers or statistical analysis in the process of data collection, processing, and presentation. This method aims to explore and understand various phenomena that cannot be quantitatively measured, such as personal experience, language use, historical background, and cultural aspects. This method was chosen because it is able to explore the meaning behind the actions, policies, and habits of pesantren residents in responding to environmental issues (Bhangu et al., 2023). This research also conducted in-depth interviews with caregivers, ustaz, and students to explore their understanding, experience, and commitment in implementing environmentally friendly values. Meanwhile, the data analysis process uses triangulation techniques, namely data obtained from various sources are used to strengthen findings, enrich understanding of research problems, and provide more in-depth explanations. This technique also plays a role in reducing the possibility of methodological and subjective bias, as well as increasing the validity and applicability of research results more broadly (Donkoh, 2023). In other words, this study conducted direct interviews with the caretakers of the Alam Pangrango Islamic Boarding School, four teachers, and 10 students from junior high and high school levels to obtain more in-depth information about the object of the research.

To sharpen this research, it uses an ethnographic approach that develops from various philosophical backgrounds, disciplines, and diverse directions of thought. One of its forms, critical ethnography, stands out as a community-oriented research method. The ethnographic approach to green pesantren is used to deeply understand the practices, values, and environmental culture that grow in the daily lives of students and the pesantren community. Through participatory observation and in-depth interviews, researchers can explore how pesantren form environmentally friendly habits,

such as waste management, organic farming, and the use of renewable energy (Dutta, 2016). This research is also supported by the Bronfenbrenner ecological theory or *Ecological Systems Theory*. According to Bronfenbrenner, human development occurs through dynamic interactions between the growing individual and the surrounding environment, where the individual is seen as a flexible creature and can fit in in its social context. Every system has an important role in shaping one's experience and development (Crawford, 2020). In other words, Bronfenbrenner highlights that individual development and behavior are influenced by the surrounding ecological environment, either directly through interactions with family, school, and the workplace, and indirectly through policies, resources, and social expectations. A positive and safe social environment is considered crucial for optimal development (Rus et al., 2020).

FINDINGS AND DISCUSSION

Implementation of Green Technology as an Effort for Environmental Conservation at Pesantren Alam Pangrango

The Alam Pangrango Islamic Boarding School implements an education system that does not fully follow the government's 2013 Curriculum, but combines elements of the natural school curriculum and the typical curriculum of the Islamic Boarding School. This curriculum was independently designed by the founders and facilitators, then compiled into a single unit known as the natural pesantren curriculum. Unlike formal schools, this curriculum is flexible and not tied to national standards. Administratively, Islamic boarding schools are under the Ministry of Religious Affairs, while the PKBM program which is part of the community education pathway is managed under the Ministry of Education and Culture. Although it is not registered as a formal educational institution, the learning process is still active, especially for compulsory subjects that still refer to the 2013 Curriculum as the basis for the implementation of exams (Al-Faruqi, 2025).

Students at Pesantren Alam Pangrango are actively involved in various environmental management activities, ranging from recycling kitchen waste and producing compost to integrating a kitchen garden with the boarding school's kitchen system. In addition, the pesantren utilizes bamboo leaves as mulch, develops BSF maggot feed for poultry, and produces eco-enzyme that is distributed to farmers in nearby villages to help reduce dependence on chemical fertilizers. Although a fully organic system has not yet been implemented, Zone 1 of the pesantren has developed an integrated farming concept, in which kitchen, garden, and livestock activities are interconnected within a single system that serves as a holistic learning medium.

Interestingly, K.H. Ahmad Zarkasy, through a statement conveyed by Ustadz Arga, emphasizes the importance of maintaining a balanced ecosystem as an integral part of life, as reflected in the following statement:

"He often says, "Pay attention to your food." This means that we must be mindful of where our food comes from and whether it is halal and tayyib—beneficial for both the body and the environment. Good food originates from healthy soil; therefore, we must begin by paying attention to the soil ecosystem. The waste we produce can be processed and returned to the soil to enhance its fertility. From there, we can build a healthy ecosystem. If the soil is damaged, the food source will also be compromised, and ultimately, humans will lose their balance. He advises Islamic boarding schools across Indonesia to revive soil ecosystems and restore the microorganisms that sustain the earth. This is especially important today, as much soil has become barren due to the excessive use of chemical fertilizers. We must restore the soil so that future generations can live from a fertile and healthy earth".

Furthermore, the Green Islamic Boarding School Project is one of the flagship programs at the Pangrango Nature Islamic Boarding School which aims to form an attitude of care, responsibility, and ecological awareness of students. Through this program, students not only gain a conceptual understanding of the importance of preserving nature, but also actively engage in various real practices,

such as environmental conservation activities, agricultural management, and waste management in a sustainable and responsible manner. In the implementation of the Green Islamic Boarding School Project, the students showed a high level of enthusiasm and participation, which was reflected in their active involvement and positive response to various activities based on environmental awareness and conservation. One of the main agendas in the Green Islamic Boarding School Project is the challenge of planting with an intercropping system for 45 days, where students are guided to cultivate a variety of plants, such as vegetables and medicinal plants, side by side in one land. The intercropping method was chosen because it is considered more environmentally friendly and able to increase soil fertility naturally through the diversity of plants planted. Throughout this period, students are thoroughly involved from the seedling, planting, maintenance, to harvesting stages, so that they not only understand the plant growth cycle comprehensively, but also cultivate discipline, perseverance, and patience in achieving optimal results.



Figure 1. The students pick the vegetable harvest

The Alam Pangrango Islamic Boarding School also develops innovations in waste management through the manufacture of paving blocks made from plastic waste. The process is carried out by processing the shredded plastic, then mixing it with sand and other supporting materials, then heating and molding using a special mold to form a paving block that is ready to be used. These efforts not only contribute to reducing environmental pollution due to plastic waste, but also open up opportunities for economic value from previously untapped waste. However, its production and utilization are still limited and have not been widely distributed to the community, because the results of paving blocks are currently only used for needs in the pesantren environment (Listi: 2024).



Figure 2. The students made paving blocks from garbage

Thus, this initiative is not only a practical solution in overcoming the waste problem, but also emphasizes the commitment of Islamic boarding schools in building a sustainable environmentally friendly culture, as well as equipping students with relevant and valuable life skills in the midst of today's ecological challenges.

Some people around the pesantren are now no longer dependent on the purchase of fertilizer from outside the region, such as Ciawi, because they have gained knowledge and skills in processing local ingredients into effective and environmentally friendly liquid fertilizer. A number of farmers have even used ecoenzymes to improve the fertility of their vegetable crops, and some of them routinely request supplies from Islamic boarding schools. Although the application of this method has not yet taken place widely, there are at least six to seven farmers in one RT area who have implemented it in real terms. The impact is starting to be felt, but the spread is still limited because more intensive and sustainable assistance is needed so that this practice can be applied consistently and comprehensively.



Figure 3. The students make ecoenzymes

The processing of organic liquid fertilizer through the fermentation of kitchen waste and plant residues is one of the environmentally friendly innovations developed in the pesantren environment. This effort not only plays a role in increasing soil fertility naturally and sustainably, but also becomes a tangible manifestation of the wise use of organic waste. Thus, this practice at the same time supports a sustainable agricultural system and instills ecological awareness in students to manage resources effectively and responsibly.

Table1. Pangrango Alam Islamic Boarding School Program

No	Program Initiative	Activity Description	Objective	Benefits
1	Liquid Organic Fertilizer	Production of liquid fertilizer through organic waste fermentation	Reduce waste and produce environmentally friendly fertilizer	Improve soil fertility and reduce dependence on chemical fertilizers
2	Waste Recycling	Processing organic and non-organic waste into useful products	Reduce environmental pollution	Increase environmental awareness and efficiency in waste utilization
3	Vertical Farming	Cultivation of plants vertically on limited land	Optimize land use	Increase productivity and space efficiency
4	Mulch Beds	Use of mulch on planting beds	Maintain soil moisture and reduce weeds	Improve crop quality and maintenance efficiency

DISCUSSION

Transformation of Islamic Boarding Schools through Green Technology and Environmentally Friendly Agricultural Practices

This pesantren also integrates religious teachings and environmental issues which are manifested through the development of learning materials such as environmental fiqh and morals towards living things that are directly linked to nature conservation efforts. For example, when discussing the concept of *trust* as a caliph on earth, the students were taught that preserving the environment is part of the spiritual responsibility inherent in each individual. In addition, in tafsir and hadith lessons, Islamic values are often associated with concrete practices such as maintaining cleanliness, saving water use, and avoiding indiscriminate felling of trees, so that religious teachings are not only understood theoretically, but also applied in daily life ecologically (Huda 2025). Concern for the environment is a tangible manifestation of Islamic teachings, because faith is not only reflected in ritual worship, but also in the attitude towards the preservation of nature. Love of the environment reflects the perfection of one's faith (Amin et al., 2025; Bronfenbrenner, 1979; Rahman et al., 2025; Sari, 2025; Triyono et al., 2023). In other words, this pesantren emphasizes the concept of *green pesantren* as an integral part of its educational vision, with the foundation of understanding that the Qur'an is not only present as a written normative text, but also manifested in the reality of the universe and the human self as *kauniyah* verses. This perspective gives birth to an educational approach that combines spiritual appreciation with ecological awareness, so that environmental conservation efforts are seen not just as a social activity, but as a form of implementation of Qur'anic values in real life.

On the other hand, Islamic boarding school scholars play an important role in dealing with global crises such as global warming and climate change by combining Islamic theology, Islamic law, and environmental science. They view that protecting nature is not only a matter of the world, but also a form of worship to God, so that destroying the environment is considered a great sin. Through the *halaqah* forum involving scholars and scientists, various strategic fatwas were produced, such as the permissibility of industrial activities as long as they are profit-oriented and the recognition of carbon trading as one of the global solutions (Sobirin & Khasanah, 2023). Islamic boarding schools, as institutions for fostering Islamic character and morals, need to integrate the values of environmental concern in their education. More than just mastering religious science and science, Islamic boarding schools are required to be an example for future generations who are committed to environmental conservation (Herdiansyah et al., 2016)

The Pangrango Nature Islamic Boarding School applies environmentally friendly technology such as making organic liquid fertilizer from fermented kitchen waste, plant residues, and animal manure as one of the environmentally friendly efforts made to fertilize the soil and support sustainable agricultural practices in the pesantren environment (Al-Faruqi, 2025). Moreover, Bio-fertilizer is a biological product that contains microorganisms to support plant growth and soil fertility. Available in both solid and liquid form, liquid bio-fertilizers are considered more effective because they can extend shelf life, while solid bio-fertilizers require a carrier material that is safe, inexpensive, and easy to process (Phibunwatthanawong & Riddech, 2019). In other words, organic liquid fertilizer is an effective sustainable solution as a nutritional supplement in agriculture. Made from natural materials such as agricultural, animal, and plant waste, this fertilizer not only provides essential nutrients, but also improves soil structure and supports the activity of microorganisms. Regular use of organic liquid fertilizers can improve the health of agroecosystems, accelerate nutrient availability, and encourage optimal plant and fruit growth (Choi, 2020).

Furthermore, the processing of organic waste into eco-enzyme liquid fertilizer is a practical way to reduce waste while providing environmentally friendly nutrients for plants. This process is carried out by fermenting various fruit skins for three months using a mixture of water, coconut sugar, and

fruit waste. The result is a clear brown liquid, with a typical fermentation flavor, with a pH of about 3.5. When applied to plants, a 10% solution has been shown to increase plant height by about 15% as well as accelerate bud growth. This shows that the eco-enzyme from the fruit peel is quite effective in supporting plant growth (Khuadthong et al., 2025). Not only that, the use of eco-enzymes as fertilizers, soil improvement, and plant nutrient sources has been proven to be able to increase plant growth and yield, such as onions, by improving soil fertility, increasing the availability of nutrients, and supporting vegetative development such as the number of leaves, tuber size, and crop weight (Kesmayanti et al., 2025).

In simple terms, the organic waste produced from the activities of the pesantren kitchen and the daily activities of the students is not necessarily disposed of, but is managed through the composting process to produce fertilizer that is beneficial for plants. This activity is a means of contextual learning for students in understanding the principles of recycling and ecological-based waste management. The process of making compost is carried out with a simple but educational method, utilizing natural materials such as vegetable residues, dry leaves, and water, so that students can understand the concept of the material cycle in the ecosystem, namely that every element that comes from nature can return to the soil in a more productive and sustainable form (Khuadthong et al., 2025; Maghfiroh et al., 2024; Reuter, 2015). Through this activity, students not only understand that leftover vegetables and fruit peels from the kitchen can be processed into compost, eco-enzymes, or fish feed to reduce the amount of waste, but also equipped with practical skills that they can apply when entering the community, so that organic waste that was previously disposed of can be processed into more useful and useful products (Setiati et al., 2024).

This Islamic boarding school implements sustainable agriculture through the manufacture of mulch beds, which are mounds of soil covered with plastic or straw to maintain moisture, suppress weeds, and reduce evaporation. This method is not only efficient in managing limited land, but also an educational means for students to learn about environmentally friendly agriculture (Argha, 2025). Mulch plays an important role in maintaining soil conditions by reducing evaporation, retaining moisture, stabilizing soil temperature, suppressing weed growth, and stimulating microorganism activity. In addition to these agronomic benefits, the application of mulch also provides added value economically, aesthetically, and ecologically in agricultural practices and landscaping (Iqbal et al., 2020). So that soils that use mulch show a higher amount of microbial biomass than soils that are herbicidal, and this positive impact persists even after the use of herbicides is stopped. In addition, mulch also affects the community structure of soil microorganisms and increases the availability of nitrogen, thus contributing to maintaining the biological function of the soil and supporting the sustainable growth of plants (Omidvar et al., 2023).

More than that, the kitchen zone and the courtyard of the pesantren are designed in an integrated manner to support food security through the cultivation of fresh vegetables. Kitchen waste such as used water for rice washing or leftover vegetable pieces can be used to water plants. Vegetables such as kale, spinach, or chili peppers can be grown in the yard using vertical or simple bed planting methods. This concept teaches students the importance of food independence while strengthening the relationship between consumption and production in a sustainable manner (Al-Faruqi, 2025). Islamic boarding schools that implement vertical agriculture show innovation in overcoming land limitations by cultivating crops in stages in the narrow spaces available. Through this system, pesantren can use walls, building roofs, or multi-storey shelves to grow various types of vegetables and medicinal plants needed daily (Arif et al., 2024; Arif, Nasir, et al., 2025; Arif, Zekkari, et al., 2025; Fatah et al., 2025; Happyana et al., 2025). Even with technologies such as hydroponics, aeroponics, and artificial lighting, vertical farming can increase yields per square meter while reducing the need for conventional farmland (Al-Kodmany, 2018).

In addition, this pesantren processes inorganic waste such as plastics, bottles, and other non-biodegradable waste, into valuable products such as paving blocks. The process of making paving blocks is carried out by mixing the chopped plastic waste with sand and certain additives, then heated and molded using a special mold. In addition to reducing environmental pollution, this innovation provides economic added value and is a form of ecological education for students in managing waste creatively and productively (Listi, 2025). Because paving blocks made of plastic have the advantage of very low water absorption compared to cement blocks. The use of plastic waste for paving block materials is an innovative solution in reducing plastic waste pollution while supporting environmental conservation efforts. In terms of economy and durability, plastic paving blocks are proven to be sturdier, durable, cost-effective, and more resistant to high temperatures and corrosion compared to concrete paving blocks (Folorunsho & Amadi, n.d.). This means that in an effort to handle inorganic waste, the use of planting media from plastic waste that cannot be decomposed naturally can be an effective alternative to minimize the volume of inorganic waste, while reducing the level of environmental pollution caused by the accumulation of plastic waste (Prodyanatasari & Fernanda, 2023).

The use of alternative energy such as biogas produced from livestock waste is one of the environmentally friendly programs implemented at the Pangrango Nature Islamic Boarding School to support energy independence while reducing environmental pollution (Huda, 2025). Biogas production through anaerobic digestion is used because it offers a number of benefits, including relatively low operating costs, environmentally friendly properties, the ability to reduce harmful pathogens, and produce organic fertilizers as by-products that are beneficial to agriculture (Khalil et al., 2019). Biogas is an efficient solution for the reuse of organic waste, which can be used as an energy source to generate electricity and heat at the same time. Resources derived from the livestock and agriculture sectors have promising prospects in bioenergy production, mainly due to their abundant availability and production costs that tend to be more economical (Ardebili, 2020). He explained that the application of anaerobic digestion (biogas) technology has proven to be able to effectively process organic waste directly at the source, with a waste reduction rate of around 54%. In addition to helping to reduce environmental pollution such as odors and harmful gas emissions, this process also produces biogas energy that can be used for daily needs, such as cooking. Therefore, biogas technology is an alternative to sustainable waste management in pesantren while supporting energy efficiency and a more environmentally friendly environment (Bilqis et al., 2023).

Not only that, the Pangrango Nature Islamic Boarding School utilizes gravitational water flow sourced from the springs at the foot of Mount Pangrango as an alternative energy, so that it can reduce dependence on conventional electricity. The use of natural resources not only reflects energy independence, but is also in line with the spirit of sustainability and environmentally friendly principles carried out by pesantren (Al-Faruqi, 2025). The wise use of natural resources can be realized through efficiency in the use of water, energy, and organic materials. The application of technology that supports environmental sustainability can be done by using modern agricultural innovations that are efficient and do not cause damage to the ecosystem. Efforts to preserve biodiversity also need to be carried out by maintaining the balance of nature and avoiding the use of harmful pesticides that can interfere with environmental sustainability.

Students at the Pangrango Alam Islamic Boarding School are educated to be independent through the activity of growing vegetables and various types of fruits that they consume themselves in their daily lives. This farming activity is not only a means of practical learning, but also instills the value of responsibility, hard work, and concern for the environment. Interestingly, when the harvest is abundant, some of it is often distributed to residents around the pesantren as a form of solidarity and social contribution, as well as strengthening the relationship between the pesantren and the

community (Hadi, 2025). In addition to emphasizing environmentally friendly practices in Islamic boarding schools, ecological transformation also includes efforts to empower the surrounding community. Pesantren often plays a role as a center of social and economic activities for local residents, so its position is very strategic to provide education and involve the community in environmental conservation actions. Through various community development programs, such as sustainable agriculture training, waste management, and environment-based entrepreneurship, pesantren can contribute to improving welfare while fostering ecological awareness in the surrounding area (Badrudin et al., 2025).

The habituation of ecological awareness in this pesantren takes place through several integrated stages, the initial stage starts from instilling value by introducing the principle of sustainable living as an important part of education, so that students understand that sustainability must be designed and carried out consciously (Aisah et al., 2025; Amalia et al., 2025; Ma'arif et al., 2024; Supriyanto et al., 2025). The next stage is the provision of knowledge and practical skills, so that students are able to apply these values in their daily lives, such as independent waste management. Furthermore, there is a deepening stage through direct practice carried out by some students who focus on integrated agriculture, including livestock management, compost production, and plastic recycling. The final stage is capacity building through technical training and continuous assistance from Islamic boarding schools, so that the competence and professionalism of students are increasingly developed, with the hope that they can implement this ecological awareness in real terms when they return to the community.

Thus, this pesantren integrates *ulumuddin* knowledge or religious sciences with nature-based education in a holistic and applicative manner. The students are not only equipped with a theoretical understanding of religious teachings, but also trained to manage and utilize nature in accordance with the principles of fitrah and ecological balance taught in Islam. The implementation of this integration is realized through various environment-based projects that are designed in a structured manner, so that students are able to internalize spiritual values while developing practical skills in managing natural resources responsibly and sustainably.

CONCLUSION

The results of research at the Pangrango Nature Islamic Boarding School confirm the strong commitment to implementing green technology and sustainable agricultural systems through various innovations. This is realized through the processing of organic liquid fertilizer based on waste fermentation, management and recycling of organic and non-organic waste, the development of vertical agriculture, and the use of mulch beds in cultivation practices. These initiatives not only reflect concern for environmental conservation, but also contribute to building an independent, efficient, and ecologically sound agricultural system. In addition, this practice serves as a contextual learning medium for students to understand the importance of environmental sustainability. The novelty of this research lies in strengthening the concept of green pesantren as an integral strategy in maintaining ecosystem balance, by emphasizing the use of adaptive and environmentally friendly green technology.

This study expands the theory of habituation by showing that the involvement of students in various agricultural programs is repeatedly able to form sustainable habits. This theory emphasizes that behaviors that are carried out consistently and supported by reinforcement will be strengthened until they settle down as part of the lifestyle. In addition, this study also underlines that individual development and behavior cannot be separated from the influence of the surrounding ecological environment, which plays an important role in shaping awareness and environmentally friendly living practices.

This research still has limitations because it is only carried out at the Alam Pangrango Islamic Boarding School so that the results cannot be representative of all Islamic boarding schools in Indonesia. In addition, this study has not quantitatively measured the effectiveness of the application of green technology and sustainable agricultural systems in the long term. Therefore, further research is recommended to involve more pesantren in various regions and use a quantitative approach or mixed methods in order to obtain more comprehensive results regarding the application of the concept of green pesantren and its impact on environmental awareness and pesantren independence.

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