Integrated smart building for sustainable agriculture as a solution to food security and future land constraints

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Integrated Smart Building for Sustainable Agriculture as a Solution to Food Security and Future Land Constraints

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Abstract. Indonesia forests are the largest tropical forests in the world with an area of +137,090,468.18 ha. However, deforestation is a problem that has not been solved until now. Deforestation is triggered by the growing needs of basic foodstuffs. The National Statistics Agency (2020) noted, in the period 2010-2020 Indonesia experienced an average population growth of 1.25% every year. As the population increases, agricultural land in Indonesia is decreasing while the need for food will increase. Various efforts in maintaining food security in Indonesia have been made but have not resulted in significant changes. Therefore, we initiated a building design that we hope to use in the future. This building has a length of 44 m and a width of 40 m with the number of enlargement rooms of cattle and goats each is 2 rooms and has a consecutive area of the room is 24 x 14 m, 14 x 8 m. The second and third floors there is a rice enlargement room with a total area of 1,344 m2. Total hydroponic space reaches 6.72 m2. In one year this building can give results of 24 tons of rice.

INTRODUCTION

Indonesia's forests are the largest tropical forests in the world with an area of +137,090,468.18 Ha [1]. Indonesia with the largest tropical forests in the world is expected to be a counterweight to the continuity of existing ecosystems and biosphere, apart from other natural forests such as in the Amazon region, Brazil [2]. However, deforestation is a problem that has not been solved until now. Deforestation can be interpreted as the transfer of the function of forests from supposedly buffering the lungs of the world into conventional land such as agricultural land [3]. This is triggered by the growing population and increasing food needs.

The National Statistics Agency (2020) noted, in the period 2010-2020 Indonesia experienced an average population growth of 1.25% every year. As the population increases, agricultural land in Indonesia is decreasing while the need for food will increase [4]. Some efforts are made such as the transfer of forest functions into agricultural land, but the transfer of forest functions into agricultural land in order to meet food needs can threaten the sustainability of nature in Indonesia.

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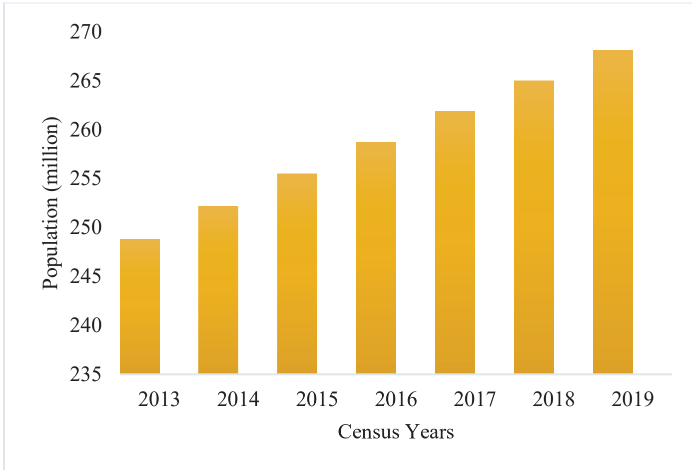


FIGURE 1. Indonesia population growth graph 2013-2019.

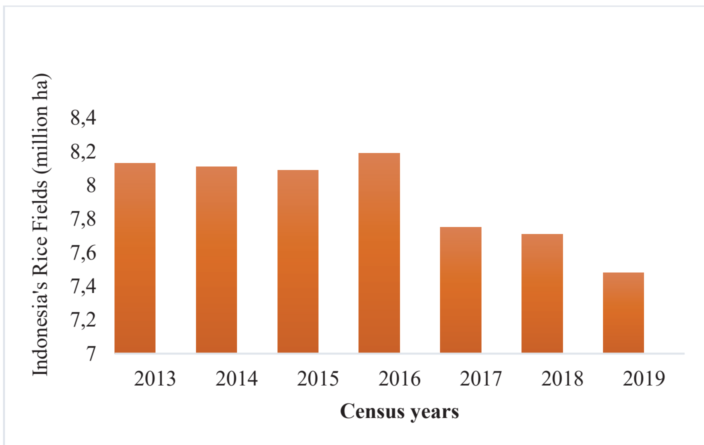


FIGURE 2. Graph of decline in rice field area in Indonesia 2013-2019

Reporting from indonesia's central statistics agency, the area of rice fields from 2013-2019 decreased this along with the increase in the number of people in Indonesia. Therefore, the Food and Agriculture Organizattion warns that there will be a food crisis in the world. One of the main problems is the growing population and fewer agricultural land. Efforts to increase the productivity of rice fields which now average about 5.2 tons of grain per ha are also not easy to run [5].

Minister of Agriculture 2014-2019 Amran Sulaiman tried to provide an idea for rice fields with the Serasi program (Save the Swamp, Prosper Farmers) on peatlands precisely on the islands of Sumatra and Kalimantan, but has not had a significant enough impact. In 2020 the Indonesian president jokowidodo in the food estate program plans the expansion of rice fields in peat lading as well. But there is debate by experts because the program causes some natural damage and the potential for forest fires is higher.

Here the author wants to contribute ideas in the form of agricultural buildings that can overcome the limitations of land and food sustainability in the future. This idea is a sustainable and environmentally friendly agricultural and livestock system. This idea takes the form of a building. The building consists of 4 floors and a basement. Each part of this building will be equipped with Artificial intelligence (AI) technology, this building will be used to farm, raise and process agricultural waste or land into alternative electrical energy.

This agricultural building can process agricultural waste such as livestock manure and fish manure into alternative electrical energy using Microbial Fuel Cell (MFC) technology. This MFC utilizes the metabolism of microorganisms to produce electric currents from various organic substrates [6]. The building will also be productive at all times regardless of the season or climate that is happening. This is expected to increase the amount and quality of rice production.

METHODS

Design of the building was carried out between June 19 and June 27, 2021. The computer software we use in visualizing our ideas is AutoCAD, SketchUp, and Enscape. The definition of visualization is found in the online Indonesian (2016) Grand Dictionary, which is "Disclosure of an idea or feeling using the form of images, writings (words and numbers), maps, graphs, and so on".

AutoCAD

AutoCAD software is used to design the initial sketch of the building such as the division of space, the division of the area of the room, determining the location of the door and the direction of the wind based on a 2-dimensional (2D) model. AutoCAD is a computer software program that provides 2D and 3D layer views, used to create drawing designs [7].

SketchUp

SketchUp software is used to change shapes from 2D to 3D models. after the sketch is made using AutoCAD software, the sketch is entered into the SketchUp software to convert 2D shapes into 3D. In addition, in this software, agricultural building technology is designed such as hydroponic systems, solar panel systems, MFC systems, livestock systems, and others.

Enscape

The Enscape software is used to render and add building features. Enscape is a 3D rendering application. In working on the sketch of this smart farm building, besides being used for rendering, the software can also be used as an addition to architectural components such as human objects, animals, plants, and so on.

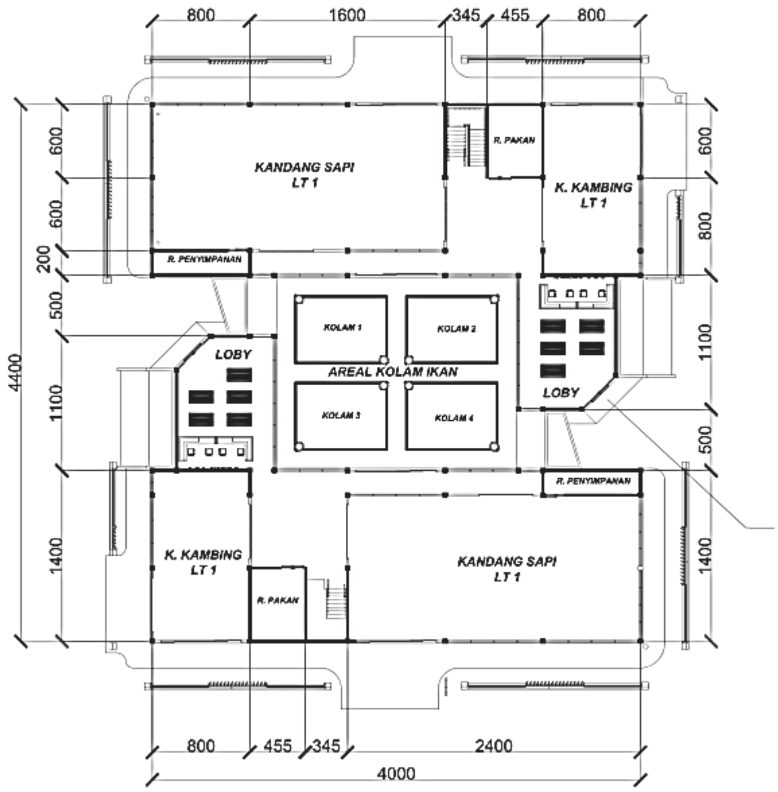
RESULT AND DISCUSSION

The results presented in the form of designs from smart buildings, this design is the result of workmanship using assistive software, namely AutoCAD, SketchUp, and Enscape.

Result

The following is the result of a building sketch design from AutoCAD software

A)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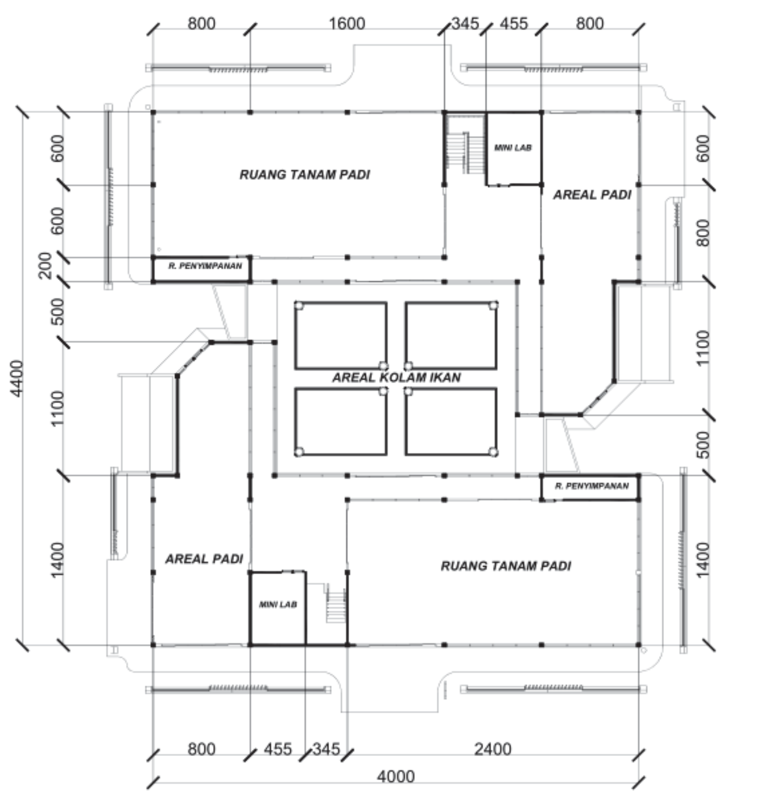
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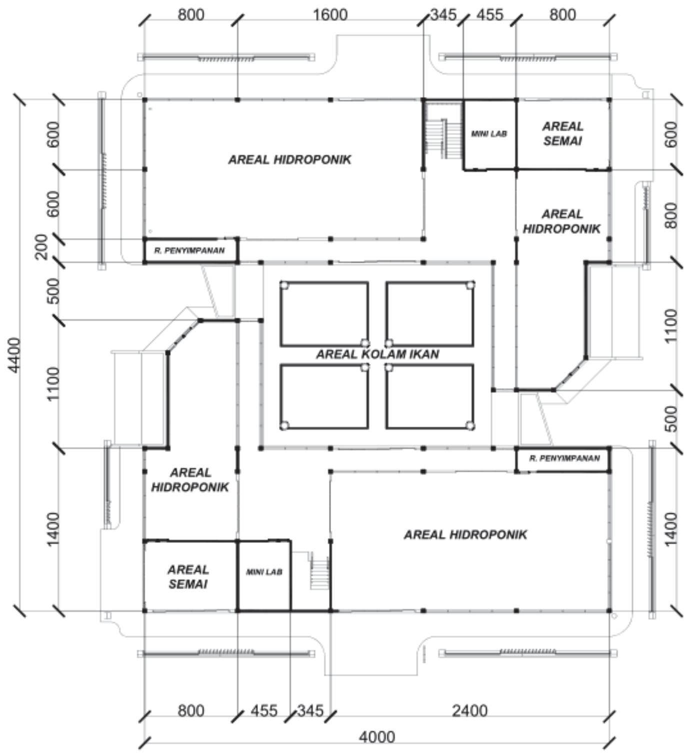

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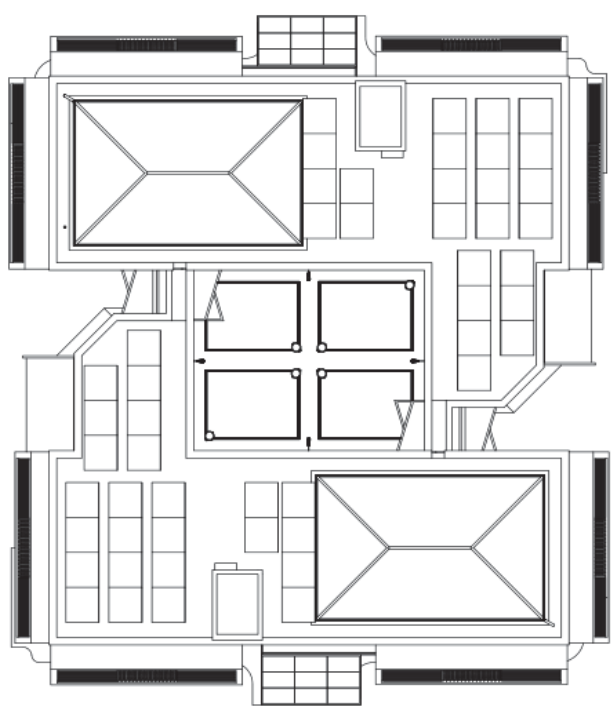

FIGURE 3. 2D building sketch. A. 1st-floor sketch, B. 2&3 floor sketch C. 4th floor sketch D. building roof sketch

The following is the result of a building design from the SketchUp software

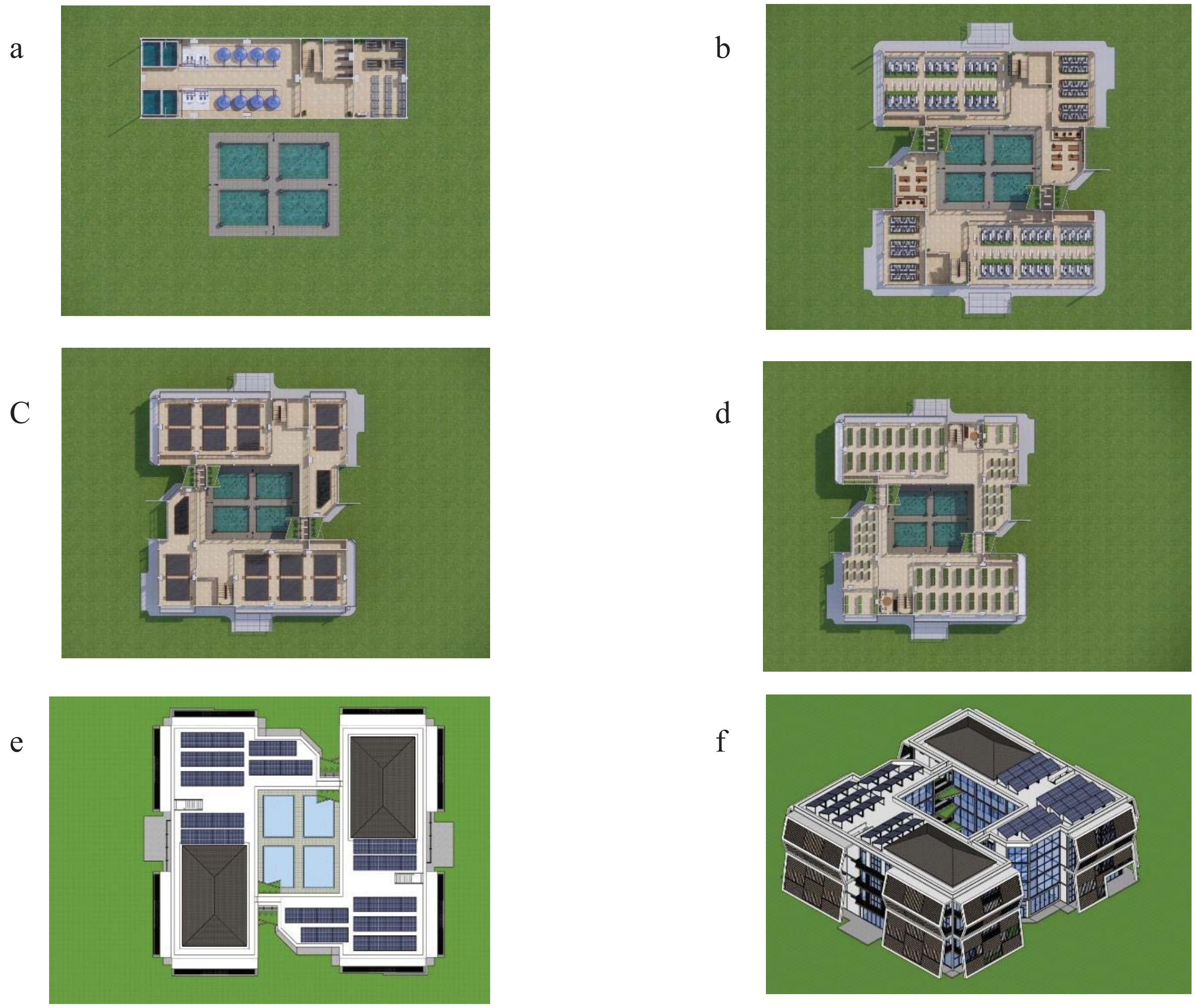

FIGURE 4. Sketch of the building using SketchUp. a. basement, b. 1st floor, c. floors 2-3, d. 4th floor, e. The roof of the building, f. smart farm building

The following is the result of a 3D design using the Enscape software

a

a

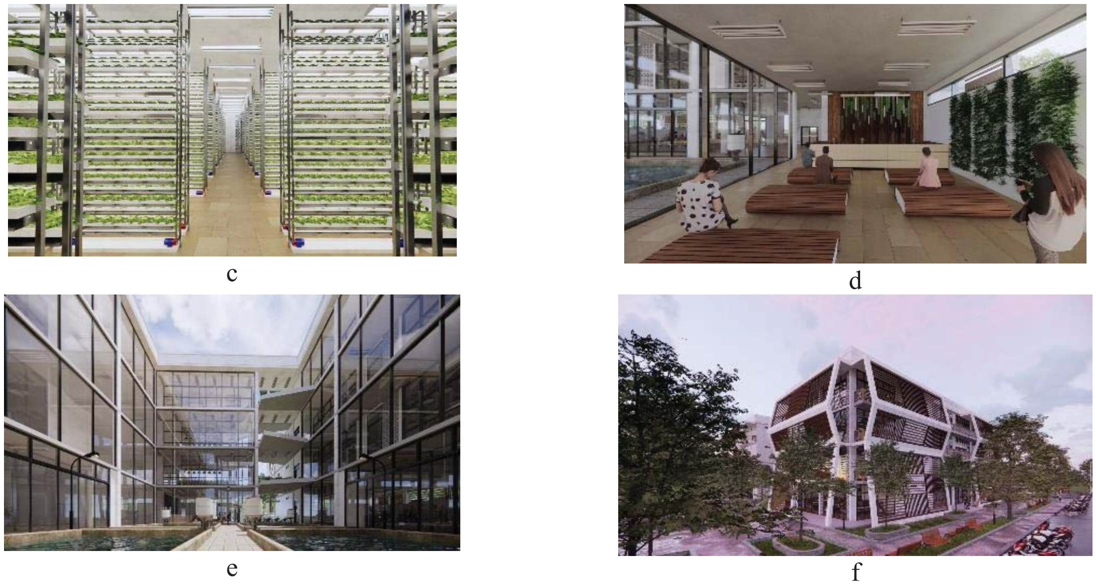

FIGURE 5. Sketch of the building using SketchUp. a. farm animal room, b. rice growing room, c. hydroponic room, d. lobby room, e. the building seen from the fish pond, f. building seen from outside

Discussion

The idea of this building hopes to contribute ideas for Indonesia in overcoming food security and land limitations in the future, so that forest sustainability is maintained and the transfer of forest function will be reduced.

Building specifications and capacities

The results of research published in Harvard Business Review explain that smart buildings save 30% of water use, 40% of energy use and 50% of natural gas usage, so smart buildings are considered to be able to change the characteristics of a city into a smart city [8,9]. This smart farm building consists of several parts, namely the basement, floors one to four, the roof of the building and a fish pond. The basement contains an alternative Microbial Fuel Cell (MFC) power plant, a solar panel electrical energy battery and a rainwater reservoir. The first floor contains a lobby room, a room for raising livestock such as cattle, sheep, or goats as well as a control or monitoring room. The second and third floors contain a rice growing area, a storage room and a control room. The fourth floor contains a hydroponic vegetable growing room and a control room. The roof of the building contains solar panels which will be the main electrical energy in this building. The part of the pond located in the middle of the building is used as a place for raising consumption fish such as gurami fish, catfish, or tilapia.

This building has a length of 44 cm and a width of 40 cm with the number of rooms for raising cattle and goats each are 2 rooms and has a successive area of 24 x 14 m, 14 x 8 m. On the second and third floors there is a rice enlargement room with a total area of 1.344 m^2. The total hydroponic space reaches 6.72 m^2. The size of the building can change according to the needs of the builder.

Supporting component

In the case of this building is in dire need of supporting components such as temperature regulators, oxygen, carbon dioxide, nitrogen and light. Temperature, light, humidity, oxygen and carbon dioxide levels are the main factors supporting life. Carbon dioxide and light are needed by plants to photosynthesize, while the nitrogen levels released by farm animals through their veses and urine must be regulated so as not to interfere with the sustainability of this system. Therefore, this building is equipped with advanced equipment such as solar panels, MFC and monitoring rooms on each floor. In addition to solar panel technology, this smart building is equipped with sophisticated components in several parts of the building. Among them there is automatic air and temperature controller or temperature regulator and regulator of life needs for farm animals and plants (nitrogen, oxygen, carbon dioxide, air humidity) automatically, CCTV, Wifi, and Rainwater Management System or rainwater management system. The specifications in each component have an important function in the optimization of the building so as to improve productivity, meet efficiency goals, and the effectiveness of energy performantion.

Effectiveness and Efficiency

Smart Building is able to combine several aspects at once, where all these aspects are interrelated and useful for the operation of the building. Aspects of superior agriculture, livestock, and also the use of solar panel technology in one building are very effective in optimizing the needs of light and electricity in this building.

From data from the central statistic agency of Indonesia (2020) the average in 1 hectare of rice fields can produce 5.7 tons of rice. This building has a total rice planting area of 1440 m2 or more than 1.4 hectares. So if this building operates it will produce approximately 8 tons of rice in one harvest, this building can harvest three times in one year because rice planting uses hydroponic methods so that it does not require processing land that takes a lot of time.

The potential of buildings as a solution to land limitations and food security

This smart agricultural building can be built in all regions in Indonesia. If this building is built in every village or village in Indonesia then this building can provide food security assistance to the area. Where in one year this building can give results of 24 tons of rice. So that food needs in each urban area do not depend on other areas.

Smart Building as Indonesia's Economic Solution in the Future

In addition to the advantages mentioned above, this smart building also has promising potential in economic and social terms. In terms of economy, integrated smart building is able to improve the economy of the community, maintain food security at a time when the country's economic conditions are unstable, and also add jobs for the community. In the management of this building, of course, requires diligent, strong-willed, and also experienced employees. In terms of social, the existence of smart building is expected to reduce the number of unemployed, poverty, and also increase the productivity of the community.

CONCLUSION

The conclusions from this idea are:

1. This smart agricultural building has the potential to solve several problems of the Indonesian state related to education, food security, economy, and social
2. This smart agricultural building can be built in all sectors of the region, ranging from urban, rural, mountainous, coastal and reclamation areas
3. The construction of smart agricultural buildings has great potential to reduce the clearing of forest land to be used as production forests and agricultural fields

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