Permaculture model for fulfilling nutritious food needs students of IPB dormitory

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Abstract. Food quality is determined by food system, from the food production process to food consumption. The production process is related to the agricultural landscape planning. Bogor Agricultural University (IPB) as the centre of excellence of agricultural science and technology, can be a potential sample for implementation of agricultural planning for production. Thus, the concept of permaculture, which is cover agricultural productivity based on socio-economic, and ecological has a big chance to be applied. The objective of this research is to compose permaculture model for fulfilling the nutritious food needs of IPB’s dormitory students. The potential research surveyed in 8 campus experimental gardens and 4 business development sites. All of the site samples can be used as the potential of commodity business. The result showed the nutritious food needs row materials for IPB’s dormitory students as much 2 299.14 tons for plant resources production per year and 406.1 tons for animal resources production per year which considered of 18 commodities. The results showed that there is a potential about 33.53% plant resources and 13.25% animal resources to supply nutritious food needs for students of IPB dormitory. This approach could be used by IPB to created food self-sufficiency model by taking advantage of the land owned.

Keywords: agriculture landscape, IPB’s dormitory students, nutritious food, permaculture

1. Introduction

Bogor Agricultural University (IPB) is a college that provides a dormitory for students at first year. However, based on average calorie needs showed 12.5% underweight and 23% very thin, that expected unbalance between student activity and food consumption [1]. According to the World Health Organization the common risk factors for illness are unhealthy food consumptions. Thus, should be consideration of nutrition fulfillment for IPB’s dormitory students [2]. IPB have a purpose Tridharma of these higher learning institutes, such as education, research, and community extension service. Then, IPB having supporting facilities for all these activities, that includes experimental gardens, ponds, marine laboratories, cattle grazing fields, and forest education [3]. Therefore, IPB as a centre of excellence based on agricultural science and technology has a big chance for applied agricultural model. In addition, IPB has cooperation with some villages surrounding IPB campus as a part of collaboration community services. Agricultural model releated with food sufficiency, and if IPB can making the model, is represented food self sufficiency in the scope of institution. Therefore, the model of permaculture can be carried out in several experimental garden and some villages surrounding IPB
campus. Permaculture is a combination of words permanent and agriculture, which means agriculture technique from involves dynamics of the existing practice about traditional and scientific knowledge. Permaculture concept are integrating between plants, animal, human, and landscapes. Permaculture planning based on science observation and patterns from nature, then an integrated science and arts [4]. The main aim of this study was to explore permaculture model on the campus sites to fulfilling nutritious food needs student of IPB dormitory. The benefits of that aim, to know about supply and demand at the institution scope. Then, product from self sufficiency from agriculture business can make the good quality product [5].

2. Method

2.1. Location and time of study

The location of research is located in IPB Experimental Garden and some villages surrounding IPB campus in Bogor District and Bogor City, West Java Province. The land is located in 14 Experimental Gardens and 10 villages surrounding IPB campus. The experimental gardens are Babakan, Sawah Baru, Cikabayan, Cikarawang A and B, Leuwikopo, Pasirkuda, Sindang Barang, Experimental Ponds BDP FPIK, Sabisa Farm, ADS Cikarawang, Agribusiness Development Station (ADS) Cikarawang, FAPET Field Laboratory, and Sabisa Farm. 14 villages surrounding IPB campus is located in Dramaga and Ciampea Sub-districts. The villages in sub-district of Dramaga are Cikarawang, Babakan, Dramaga, Cihideung, Sinarsari, Neglasari, Petir, Purwasari, Sukawening, and Sukadamai villages. The villages located in Sub-district of Ciampea are Cihideung Ilir, Cihideung Udik, Cibanteng and Benteng villages. Furthermore, data collection of IPB’s students dormitory and interviewees was conducted at Dramaga IPB Campus (Figure 1). The study was conducted from January to August of 2017.

![Figure 1. Research location.](image)

2.2. Stages of data collection

The research method was clearly by using mixed method, that is the method whose compare quantitative and qualitative data analysis [6]. Planning of permaculture model based on the planning stages from Gold 1980 [7]. The planning stages include the pre-research, inventory, analysis, synthesis, and planning. The research conducted by interviews, questionnaire, and involving several research objects. The first object is nutritional status of students. The student respondents was 25 male and 25 female from IPB’s students dormitory. The second object is the person who responsible for the management
agriculture landscape from several fields. That person were 14 field managers from the research location and used stratified random sampling [8]. The third research objects were 20 practitioners of agriculture in 3 Sub-districts, which is done by random sampling method.

2.3. Food needs analysis and nutrition status of IPB’s dormitory students
The nutritional status analysis was done by direct research, by distributing questionnaires to 25 male and 25 female students. Nutritional status data obtained from measurement of body weight and height. Analysis of nutritional status is based on data form of identity of respondents covering gender, height, age, and type of physical activity tabulated, then analyzed descriptively. The energy needs of IPB boarding students can be estimated by grouping physical activity by weight or lightness of activity. The nutritional needs rate, food requirement, commodity requirement, and the area of land needed for planning are obtained from the 2006 research data with modification [1].

2.4. Analysis of agricultural potency in experimental garden and village surrounding IPB Campus
The analysis of the location of the research to find out boundary treads and geography, climate, soil type, topography, rainfall, vegetation, animals, facilities and accessibility. Each shows the general situation of the research site.

2.5. Analysis of the land area needs for permaculture model planning
Analysis of land area can be interpreted from the calculation of commodity needs in one year, cropping pattern, and land condition.

\[
\text{LLdR} = \frac{\text{KKt} \times 365}{\text{PPKt} \times D} \tag{1}
\]

Remarks:
LLdR = land area of design (ha)
KKt = total requirement commodities per day IPB’s dormitory students (g)
PPKt = potential production of related commodities (kg / ha)
D = number of cycles per year

2.6. Analysis of cropping pattern
Analysis of plant and animal requirements was analyzed using a simple analysis, the calculation of each livestock and fishery business with the number of commodities produced.

\[
\text{RL} = \frac{\text{LPt}}{\text{Ln}} \times 100\% \tag{2}
\]

Remarks:
RL = Ratio percentage of potential land to land area requirement (%)
LPt = Potential agricultural land for plants resources (ha)
Ln = Overall land requirement (ha)

2.7. Synthesis of food sufficiency for students of IPB dormitory from permaculture model
Food sufficiency is synthesized through the data previously obtained. Then, commodity needed adjusted with current condition at IPB Experimental Garden. That aims to find out how the contribution of IPB Experimental Garden in supporting the fulfilling of nutritious food needs. The analysis of technical assumptions in farming efforts in some research sites that have been determined. The main concept of permaculture is energy can not be created and destroyed, but only changes from one to another. Energy flows are used for waste management. The concept of permaculture model included the main crop, plants, and animals at surrounding of the lands.
2.8. Analysis model of permaculture
The entire data were analysed by mixed method. This method combines several methods in a phenomenon [9]. Use of this method to search for the same object from different angle of data retrieval [10]. Mixed methods produce combined knowledge, which arises through the integration of various types of information [11].

3. Results and Discussions

3.1. Nutritional food needs of IPB’s dormitory students
The result from observation on 25 male and 25 female students showed that the percentage of students with normal category is 64%, while the lowest percentage of 2% goes into the category of students with nutritional status is very fat. Students with nutritional thin status are 24% and the status was very thin with 6% (Table 1).

Requirement energy in a day can be estimated from Basal Metabolic Rate (BMR) which is analyzed from body weight and height variable. The results showed that the BMR score of the male students was 1 352.95 kcal / day and the female students was 1 273.75 kcal / day with an average calorie of 1 313.35 kcal / day. From the calculation of caloric requirement per day, the results obtained for male 2 410 kcal and women of 2 311 kcal with the overall average caloric requirement is 2 360 kcal (Table 2).

The results showed that 86% of students agree if the food supply is managed by IPB. Furthermore, 94% of the students approved the catering business managed by IPB (Table 3). According to health is closely related to the nutritional adequacy obtained from quality food consumption.

| Table 1. Body mass index and nutritional status of dorm students. |
|---------------------------------------------------------------|
| Nutritional status  | Body Mass Index | Male (individual) | Female (individual) | Percentage (%) |
|---------------------|-----------------|-------------------|---------------------|----------------|
| Very thin           | <17.0           | 3                 | -                   | 6              |
| Thin                | 17.0-18.4       | 5                 | 7                   | 24             |
| Normal              | 18.5-25.0       | 15                | 17                  | 64             |
| Fat                 | 25.1-27.0       | 1                 | 1                   | 4              |
| Very Fat            | >27.0           | 1                 | -                   | 2              |

| Table 2. Calories of IPB’s dormitory students. |
|-----------------------------------------------|
| Gender            | BMR (kcal/day) | Calories needs (kcal) |
|-------------------|----------------|-----------------------|
| Male              | 1 352.95       | 2 410                 |
| Female            | 1 273.75       | 2 311                 |
| Average           | 1 313.35       | 2 360                 |
Tabel 3. Preferences of IPBs dormitory students based on food needs.

| No. | Questions                                                                 | Percentage   |
|-----|---------------------------------------------------------------------------|--------------|
| 1.  | Food supply is managed by IPB                                            | 86%          |
| 2.  | Food quality affects the health                                          | 100%         |
| 3.  | Food supply from food catering for daily food needs                       | 94%          |
| 4.  | Prices of food more expensive with better quality                        | 54%          |
|     |                                                                           | 14%          |
|     |                                                                           | 0%           |
|     |                                                                           | 6%           |
|     |                                                                           | 46%          |

3.2. Agricultural potential in IPB experimental garden and village surrounding IPB

Potential land is obtained from synthesis data, searching from literature and bio-physical land. Thus, there are 12 locations that are divided into two groups of food supplements. There are consisting of 8 IPB’s experimental sites as permaculture model and 4 locations of IPB business development. The selection of the location is also determined from the distance proximity of the IPB campus, especially from dormitory students (Table 4). Agricultural commodities needed from the conversion of the student menu are divided into 19 commodities [1]. These commodities are rice, soybeans, corn, papaya, chicken meat, kale, red peppers, spinach, beans, tomatoes, chicken eggs, fish, leek, and celery (Table 5).

IPB Experimental Garden selected to be planned as experimental garden is Babakan experiment Garden, Sawah Baru, Cikarawang A + B, Cikabayan A + B, Leuwikopo, and Sindang Barang and Pasir Kuda. The area that can be utilized for the design of the experimental garden is only 16.75 ha of permaculture model planning and 15 hectare utilization of cooperation with the location of IPB business development. Total land owned by IPB for permaculture landscape planning as a commodity to meet dormitory student food requirement is 16.75 hectare.

Tabel 4. Area of potential permaculture planning.

| No. | Experimental Field            | Distance from dormitory’s IPB for male (km) | Distance from dormitory’s IPB for female (km) | Potential area for Planning (ha) |
|-----|-------------------------------|--------------------------------------------|---------------------------------------------|---------------------------------|
| 1.  | Babakan                       | 1.37                                       | 0.88                                        | 2.49                            |
| 2.  | Sawah Baru                    | 1.35                                       | 0.85                                        | 2.07                            |
| 3.  | Experimental Garden of BDP FPIK| 0.82                                       | 1.05                                        | 1.5                             |
| 1.  | Cikabayan                     | 1.42                                       | 1.61                                        | 2.44                            |
| 2.  | Cikarawang A+B                | 0.38                                       | 0.63                                        | 3.68                            |
| 3.  | Agribusiness Development Station (ADS) | 0.49                                      | 0.74                                        | 4.00                            |
| 4.  | Leuwikopo                     | 1.11                                       | 1.57                                        | 3.19                            |
| 5.  | Sindang Barang-Pasir Kuda     | 8.76                                       | 8.25                                        | 1.02                            |
| 6.  | Pasirkuda                     | 8.74                                       | 8.20                                        | 0.88                            |
| 7.  | Sabisa Farm (Sindang Barang)  | 5.85                                       | 5.45                                        | 0.05                            |
| 8.  | Stasiun Peternakan Fapet      | 1.20                                       | 1.60                                        | 10.00                           |

The location of the experimental garden is located in Sindang Barang, Pasir Kuda, and Sabisa Farm were located in West Bogor District. Sindang Barang-Pasir Kuda is about 8.76 km to reach dormitory’s IPB for male and 8.25 km to reach the dormitory’s IPB for female. Then, Sabisa Farm is 5.85 km to reach dormitory’s IPB for male and 5.45 km to reach dormitory’s IPB for female (Table 4). By using a vehicle, the distance can be reached with 45 minutes-60 minutes journey in the busy road conditions. The location of experimental garden most closest is Cikarawang A + B which is just 0.38 km to reach the dormitory’s IPB for male and 0.63 km to reach the dormitory’s IPB for female. By using a vehicle, the distance can be reached with 15-20 minutes journey in the crowded condition streets (Table 4).
3.3. Food sufficiency students of IPB dormitory

Determination of land for planning is obtained from the meal menu data which is converted into several agricultural commodities. Determination size of the land in the design will vary for each commodity. This is the different-potential production of each commodity [1]. Based on the character of IPB Experimental Garden including lowland and some highland commodities are eliminated. Thus, agricultural commodities that can not be incorporated into the planning of the permaculture landscape are carrot, potato, and cabbage commodities (Table 5).

The food needs from vegetable resources is divided into 14 agricultural commodities i.e. rice, soybeans, corn, papaya, kale, chilli, spinach, beans, tomatoes, leek, celery, potatoes, carrots and cabbage. The total food needs from vegetable resources per year for students of IPB dormitory is 775.08 tons of rice, 189 tons of soy beans, 162 tons of corn, 126 tons of papaya, 126 tons of kale, 1.26 tons of chilli, 126 tons of spinach, 94.5 tons of beans, 126 tons tomatoes, and celery 18.9 tons. Animal food resources for students of IPB dormitory are 126 liters of cattle, chicken eggs 78.75 tons, carp 350 tons, and 210 tons of chicken meat. The location to supply the food needs of students of IPB dormitory is divided into 3 points supply. The first point is obtained from the planned permaculture model planning at 8 IPB Experimental Gardens.

Table 5. Determination of commodity type and area of land in design.

| No. | Type of Food | Needs for serving | Unit | Conversion | Food needs per day (3 500 people) \(^5\) | The Area of Land needs \(m^2/\text{cycle} \(^6\) |
|-----|-------------|-------------------|------|-----------|----------------------------------|----------------------------------|
| 1   | Rice\(^3\)  | 400 Gram          | Paddy| 2.153     | 583 000                          |
| 2   | Tempe\(^4\) | 25 Gram           | Soy  | 175       | 320 800                          |
| 3   | Tofu\(^4\)  | 25 Gram           | Soy  | 350       |                                  |
| 4   | Corn        | 150 Gram          | Corn | 450       | 96 250                           |
| 5   | Papaya      | 100 Gram          | Papaya| 350     | 64 200                           |
| 6   | Chicken meat| 60 Gram           | Chicken meat | 210 | 560                           |
| 7   | Kale        | 100 Gram          | Kale | 350       | 14 000                           |
| 8   | Chili       | 1 Gram            | Chili | 3.5     | 420                              |
| 9   | Spinach     | 100 Gram          | Spinach | 350 | 21 000                          |
| 10  | Beans       | 75 Gram           | Beans | 262.5   | 47 800                           |
| 11  | Tomatoes    | 100 Gram          | Tomatoes | 350 | 39 700                           |
| 12  | Chicken eggs| 1 Buah            | Chicken eggs | 3 500\(^1\) | 280                           |
| 13  | Fish        | 100 Gram          | Fish | 350       | 10                              |
| 14  | Potatoes    | 150 Gram          | Potatoes | 525 | -                               |
| 15  | Carrots     | 150 Gram          | Carrots | 525 | -                               |
| 16  | Cabbage     | 100 Gram          | Cabbage | 350 | -                               |
| 17  | Leek        | 40 Gram           | Leek  | 140       | 5.6                              |
| 18  | Celery      | 15 Gram           | Celery | 52.5   | 10.5                             |
| 19  | Cow milk    | 100 MI            | Cow milk | 350\(^2\) | -                               |

Source: Priandono 2006 [1] with modification

Information: \(^1\) kg tempe = 2 kg soy
\(^2\) liter
\(^3\) rendemen of milled rice = 65%
\(^4\) Total food needs for 3 500 students / day
\(^5\) land area became a reference for permaculture planning

The second supply point is located at the IPB business development location consisting of 4 locations, namely ADS Cikarawang, Sabisa Farm, FAPET IPB Field Laboratory, and BDP FPIK Experimental Pond. The food supply in the third point, obtained from village surrounding IPB campus, which is Cikarawang Village (Table 4). The amount of supply that can be fulfilled from the permaculture model planning is 41 tons of rice, 31 tons of soybeans, 171 tons of corn, 116 tons of papaya, 99 tons of kale, 17 tons of chilli, 41 tons of spinach, 82 tons of beans, 76 tons of tomatoes, 70 tons of onion, and 27...
tons of celery. The total supply from permaculture model is 771 tons which is divided into 14 vegetable food commodities. This means that there are only 33.53% that can be supplied from model of permaculture. The result is still very less, considering that the land used is only 13% of the total assets owned by IPB experimental garden (Figure 2).

The amount of supply obtained from the IPB business development site, which includes ADS Cikarawang, Sabisa Farm, Fapet Experimental Field, and BDP FPIK Production can supply 14.78 tonnes of foodstuff consisting of vegetable commodities of kale spinach, spinach, tomato and papaya. That is, there are only about 0.643% of all the food needs of students IPB dormitory.

The amount of supply obtained from the IPB business development location for animal food resources commodities are 360 liters of cow milk, 0.526 tons of chicken eggs, 30 tons of carp, and 18 tons of chicken meat. That is, there is 13.2% of supply from IPB business development location to supply animal food to IPB dormitory. The amount of supply for the needs of animal food from permaculture planning is 4.23 tons of carp, and 3 tons of chicken meat. That is, there are only 2% of the animal food supply of the permaculture landscape model (Figure 3).

Cikarawang village has a lot of mixed gardens land. Lack of land for the supply of some commodities from dry land, can be inadequate from some mixed gardens in the village Cikarawang. Overall, 61,195 ha of dryland is required for some commodities. There are already 16.73 ha of IPB land that can be used. That is, there is a shortfall of about 44.46 ha. The shortage of dry land can be selected from mixed gardens in Cikarawang Village (Figures 2 and 3).

![Figure 2. Percentage of fulfillment of vegetable food requirement for IPB dormitory students.](image)

![Figure 3. Percentage of fulfillment of animal food requirement for IPB’s dormitory students.](image)
3.4. Permaculture model
The main characteristic in this concept is to conduct highly efficient and intensive cultivation on a farm. For example, on the site it is planned to have at least 4 blocks in each production garden. This is related to efficient land use and the rise of plant diversity (figure 4). Permaculture concept of mutual integration between plants, animals, humans, and landscape into the product symbiotic system of one element can meet other needs. Thus, it can be used to design ecosystems for the needs of the human population without neglecting the natural environment [12]. The most influential factors in permaculture landscape planning are micro and macro climates, land formation, water, vegetation and animals, buildings and infrastructure, zoning, land use, soil following fertility and management, and aesthetics. Permaculture systems can be applied using minimal materials, energy, and labour. The way of recycling is the source can go back into the system as well as minimize pollution [13].
Permaculture model characteristics are the diversity and integration of several agricultural enterprises including agriculture, livestock and fisheries. Thus, can create synergies between one another. The synergies can be seen in the utilization of waste generated from each of these businesses can be complementary.

The main characteristic that emerges in this concept is to conduct highly efficient and intensive cultivation on a farm. For example, on the Cikarawang A Experiment Garden site, Pasirkuda Experimental Garden, and New Rice Field Experiment are planned to have at least 2 land shares in each experimental garden. Furthermore, the Cikabayan Experimental Garden, and Cikarawang B are planned to have 4 land divisions in each experimental garden. This is related to efficient land use at a time. The management approach should meet the global demands for food production and pay attention to ecosystems in the context of resources on land, water, climate change, and extensive ecosystem degradation [14].

8 experimental garden are choosen for permaculture model. There are Cikabayan, Leuwikopo, Babakan, Sawah Baru, Cikarawang A, Cikarawang B, Pasirkuda, and Sindang Barang. The division of the location consisting of four part those are paddiy field, horticulture, palawija, cettle pen, and fish pond. The concept permaculture model ar evident from combination between agriculture and livestock. Then, planting patterns which determined is a plant diverse. In addition, the edge plants that had been selected based on native plants from each location. The next, the plants selected can serve as barier pest. The most important, election agriculture crops using overlapping cultivation system.

In this concept, several IPB Experimental Gardens will be developed into an agricultural production area with the selection of several agricultural commodities to meet food needs. This concept is used to maximize the potential of land with waste that is minimally disposed to the surrounding environment. Disadvantages of the entire land used from the garden IPB will be supplied from the Village Cikarawang as Lingkar Village Campus IPB.

![Figure 4. Model of permaculture.](image-url)
4. Conclusion
The average calorie requirement of IPB male and female dormitory students based on basal metabolic rate is 1 313.35 kcal/day. Men have caloric needs based on their basic metabolic rate of 1 352.95 kcal/day, while female students 1 273.75 kcal/day. The average calorie requirement of male and female students is 2 360 kcal, with details of male students 2 410 kcal and female students 2 311 kcal. Nutrition status of IPB dormitory students has the highest normal status with 64% percentage, 24% status, 4% fat and 2% fat.

The sample of research for the first group point at 8 IPB Experimental Gardens, has 16.28 ha of land area. The percentage of land is obtained only from the total assets of IPB experimental garden of 13.40%. Next, the second point is at the business development location owned by IPB. Of the overall need for sources of animal and animal foods that can be supplied from the research sites point one and two get the percentage of fulfilling requirement of 33.53% for vegetable food sources and 13.25% for animal food sources. That is, the shortage is achieved from Cikarawang Village of 65.84% for vegetable food sources and 86.75% for animal food sources.

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