# Evaluation of Education Buildings for Green Roof Construction in Maejo University, Chiang Mai, Thailand

Chollatip Jalanugroh and Nachawit Tikul

*Abstract*—**This research evaluate the potential of education buildings in Maejo University to be constructed with green roof. There are four main factors to be considered in this research, include of; building and roof's structure, roof's slope and materials, roof's space and accessibility, and the ability of management and maintenance. The result shows that, from twenty six education building, three can be built intensive green roof immediately, seven can be built but gardeners are needed and sixteen can be built with extensive green roof.**

*Index Terms*—**Education building, intensive green roof, extensive green roof, LL (Live load), roof's slope, roof's materials, flat slap, accessibility, gardener.**

## I. Introduction

The global climate change will affect people and the environment in many ways, especially global temperatures will continue to rise for decades to come [1] which cause to rising demand for air conditioning. Thailand is no exception. The educational sector in Thailand, particularly the higher education sector must play increasingly active roles to reduce green house's gas and energy, they need to find the solution to reduce the heat and save more energy. According to the Thailand's Ministry of energy [2], the energy usage for education sector should be less than 79.3 kWh/m$^2$-year.

As of August, 2016. According to the office of the higher education commission, there were a total of 155 colleges and universities in Thailand, including *Maejo University* [3]. These universities have significant impacts on environment and society in Thailand since, the education sector is the largest public sector energy consumer, with approximately 54% of the energy consumption of the public sector [2].

Maejo University is located in Chiang Mai province, the northern part of Thailand. The university has faced the over consuming energy for air conditioning system. The buildings in the university can be functionally separated into 5 groups, including educational building (28 buildings), office building (22 buildings), entertainment-building (10 buildings), residential building (10 buildings) and infrastructure building (10 buildings) [4]. According to the building power consumption survey result found that there were 22 buildings had higher consumption than the 79.3 kWh/m$^2$-year [2]. Most of them are educational and official building groups since the lighting system, electronic devices, lifts and the most of all is an air conditioner system [5] and it's going to increase in the future.

Manuscript received September 5, 2016; revised February 5, 2017.

Chollatip Jalanugroh and Nachawit Tikul are with the Environmental Design and Planning, Faculty of Architecture and Environmental Design, Maejo University, Chiang Mai 50290 Thailand (e-mail: chollatip21@hotmail.com, nachawit@gmail.com).

Therefore, Maejo University tries to solve the problem and aim to be a Green University with slogan *Maejo University of life*, which means University should create a balance, respectful and friendly to nature and preserving a great culture and goodness. There are three road maps that would create happiness and sustainability, which is to become *Organic, Green and Eco University*. Better infrastructure and transportation are also required to support green activities, for example; footpath, bike lane and green building reduce energy usage and greenhouse gas [6].

The main reason about rising building's temperature is global warming that bring more heat into the building by wall and roof, especially the 70% of a building's heat are from the top of it. If we can reduce roof's heat absorption, we would have cooler building [7]. There are many solutions, for example; Installing thermal insulation materials on roofs, Using heat reflective roofing materials, Designing roof's shape and color that absorb the minimum of heat from sunlight and planting on roof tops, called *Green roof* or *Roof garden*.

In addition green roof can be insulation and energy efficiency by reducing 8.5% of sun's heat from outside through building [8]. It's also useful in helping the environment, reduce air pollution, urban heat island effect, rain management issue, ecological conditions in the city by enhancing biodiversity and beautiful landscape. However, there are some factor have to be concerned about the construction such as the ability to load, plants, maintenance system, etc., to achieve security and convenience conditions and also suitable for buildings [9].

From the previous study [10] found that 4 factors have to be concerned before making decision to have a roof garden i.e. building and roof's characteristics, accessibility, and policy management. These factors lead to capability of building to construct the garden on the roof and types of green roof. So, this study aimed to estimate the potential of the education buildings in Maejo University follow the factors for the next study which creating suitable design and construction part.

## II. Types of Green Roof

*Green roof or roof garden* means roof, which is completely or partially covered by plants over the waterproofing membrane that make building's users feel more comfortable and directly benefit the environment. Green roof can be divided by utilization into 2 groups [11].

- *Intensive green roof*, which is a garden which can have activities as ordinary garden, for example; lawn, productive garden, playground even a pond. Although, many things have to be considered. A roof's shape that must be a flat slap

and accessibility. A roof's area which should be larger than 3.0625 $m^2$, the average required area for a person [12]. In addition, building's live load structure have to be more than 180 $kg/m^2$ and also irrigation and maintenance system, moreover its cost always high [13]. Fig. 1 shows the example of the intensive green roof [14].

Fig. 1. Intensive green roof.

• *Extensive green roof*, which is easy care or careless garden which using for environmental benefits even inaccessibility. There are several things have to be concerned. The roof's slope must be less than 30 degrees. Careless garden that mean maintenance, irrigation and gardeners are inessential so plants which are chosen should be survive in sun, wind and drought situations for example; succulents, grasses, cactus. Fig. 2 shows the example of the extensive green roof [14].

Fig. 2. Extensive green roof.

There are many different characteristics about intensive and extensive green roof, which are garden's weight considerations. The ability to access the roof, the depth of planting system, the types of plant materials, the irrigation and maintenance system and also gardeners. The following criteria can be used to characterize two different forms of green roofs (Table I).

TABLE I: THE FOLLOWING CRITERIA CAN BE USED TO CHARACTERIZE TWO DIFFERENT FORMS OF GREEN ROOFS

| Characteristic | Intensive Green Roof | Extensive Green Roof | References |
|---|---|---|---|
| Garden's weight | -180 – 500 $kg/m^2$ | -60 – 150 $kg/m^2$ | International Green Roof Association (2016) |
| System build - up height | -15 – 40 cm. | -6-20 cm. | International Green Roof Association (2016) |
| Roof's slope | -Relative flat | -Slope up to 30 ° | William McDonough (2012) |
| Roof's accessibility | -Accessibility | -Accessibility or inaccessibility | William McDonough (2012) |
| Irrigation | -Regularly | -No | William McDonough (2012) |
| Maintenance | - 1 per week<br>- High maintenance cost<br>- Gardener needed | -No<br>-Low maintenance Cost | William McDonough (2012) |
| The use of garden | -Designed for human at least 3.0625 $m^2$<br>-Recreation: gardening, socializing, lawn yard etc. | -Usually non-accessible and non-recreational<br>-Only ecological protection layer | International Green Roof Association (2016) |
| Plants | - Lawn or perennials, shrubs and trees | -Moss sedum herb succulent cactus and grass | International Green Roof Association (2016) |

## III. THE STUDY METHODS

Fig. 3 shows the study flow. The construction engineer specialist suggested that the most significant factor to be evaluated first is the building and the roof's construction. By using their live load (LL.) to get rid of the buildings which are unable to load more. After that, we considered next factor, roof's slope and materials, roof's space and accessibility, and the ability of management and maintenance, to make a decision on which types (intensive or extensive green roof) is the most suitable base on their characteristics.

### A. Population and Location

Education building (28 buildings) in Maejo University which be shown in Fig. 4.

### B. Research Tools

Building characteristics checklist which contains points of building and roof's structure, roof's slope and material, roof's space and accessibility and last point is the management and maintenance ability. This checklist was verified by three specialists before collecting data

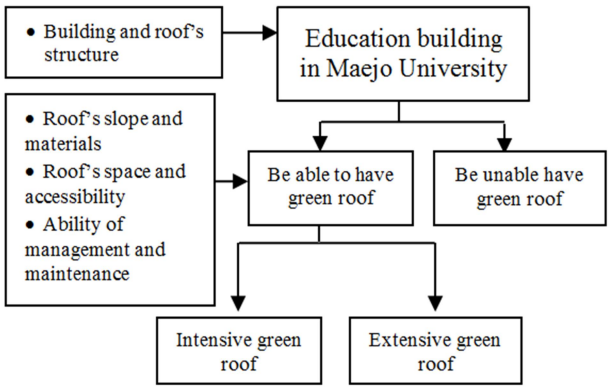


Fig. 3. Study flow.

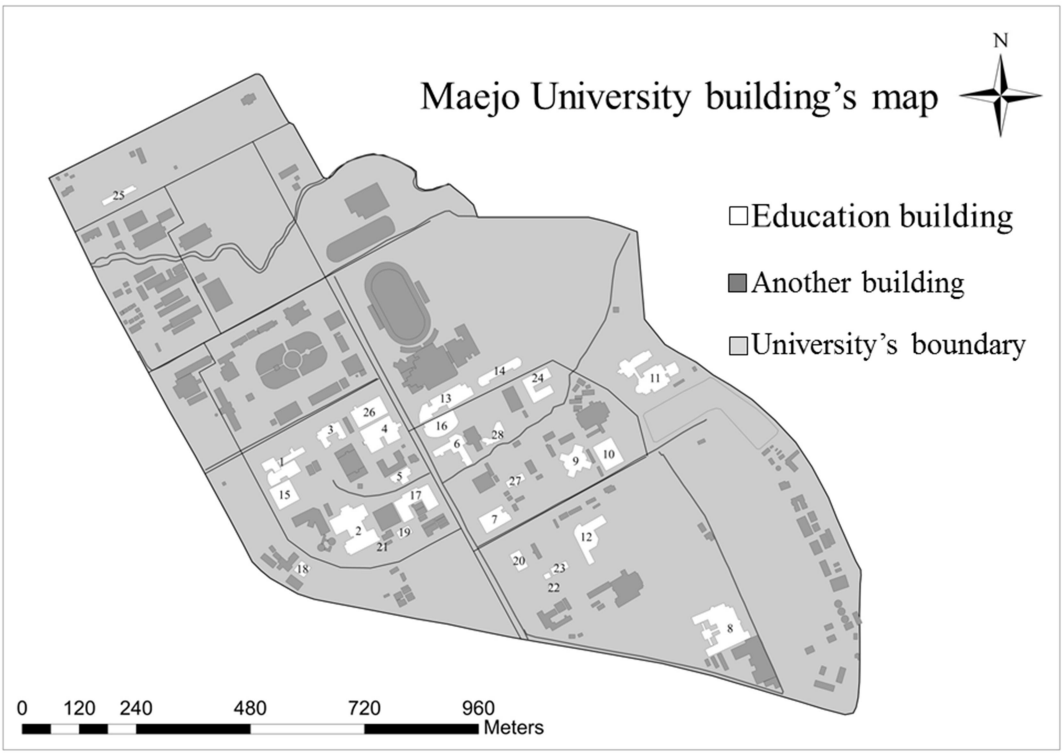


Fig. 4. Education building in Maejo university.

## IV. Discussion and Results

### A. Intensive Green Roof

Table II shows the checklist of the intensive green roof. Building and roof deck's live load must be at least 180 kg/m$^2$. The area of concrete flat slap roof deck required at least 3.0625 m$^2$. Accessibility and building's gardeners are also needed.

As a result, we can divide education buildings into 3 groups. The first group (3 buildings) was a group of buildings which determined to be built with an intensive green roof by complete structure and maintenance performance. The second group (7 buildings) was a group of buildings which cannot be built with intensive green roof immediately because of the lack of building's gardener even though the structure were ready. The last group (18 buildings) is a group of buildings which still lack of structure, accessibility and maintenance. They are unable to be built with and intensive green roof.

TABLE II: The Checklist of Intensive Green Roof

| NO. | Building's LL>180 kg/m$^2$ | Roof1's LL>180 kg/m$^2$ | Roof2's LL>180 kg/m$^2$ | Roof1's slope | Roof2's slope | Roof3's slope | Roof1's material | Roof2's material | Roof3's material | Flat slap >3.0625 m$^2$ | Access | Gardener |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | × | × | × | ✓ | - | - | ✓ | - | - | ✓ | × | × |
| 2 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | × | ✓ | ✓ | × |
| 3 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | × | × |
| 4 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | ✓ | × |
| 5 | ✓ | × | × | × | - | - | × | - | - | × | × | × |
| 6 | ✓ | ✓ | × | ✓ | × | × | ✓ | × | - | ✓ | ✓ | ✓ |
| 7 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | ✓ | ✓ |
| 8 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | ✓ | × |
| 9 | × | × | × | ✓ | × | - | ✓ | × | - | ✓ | × | × |
| 10 | ✓ | × | × | × | - | - | × | - | - | × | × | × |
| 11 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | ✓ | × |
| 12 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | ✓ | × |
| 13 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | ✓ | × |
| 14 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | × | × |
| 15 | ✓ | × | × | ✓ | × | × | × | | - | ✓ | × | × |
| 16 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | ✓ | × |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | ✓ | × | × | × | - | - | × | - | - | × | × | × |
| 18 | × | × | × | × | - | - | × | - | - | × | × | × |
| 19 | ✓ | × | × | × | - | - | × | - | - | × | × | × |
| 20 | ✓ | × | × | ✓ | - | - | × | - | - | × | × | × |
| 21 | - | - | - | - | - | - | - | - | - | - | - | - |
| 22 | × | × | × | × | - | - | × | - | - | × | × | × |
| 23 | ✓ | × | × | × | - | - | × | - | - | × | × | × |
| 24 | - | × | × | × | - | - | × | - | - | × | × | × |
| 25 | × | × | × | × | - | - | × | - | - | × | × | × |
| 26 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | - | ✓ | × | × |
| 27 | ✓ | × | × | × | - | - | × | - | - | × | × | × |
| 28 | ✓ | ✓ | × | ✓ | × | - | ✓ | × | × | ✓ | ✓ | ✓ |

### *B. Extensive Green Roof*

Table III shows the checklist of extensive green roof. Live load of the building and their roof must be at least 60 kg/m$^2$. The roof's slope should be less than 30 degrees.

The results can divide education buildings into 2 groups. The first one (16 buildings) is the group of buildings which are able to be built with an extensive green roof. Another group (12 buildings) is the opposite. Because of the roof structure and the slope, they cannot be built with an extensive green roof.

TABLE III: THE CHECKLIST OF EXTENSIVE GREEN ROOF

| NO. | Building's LL >60 kg/m$^2$ | Roof1's LL >60 kg/m$^2$ | Roof2' s LL >60 kg/m$^2$ | Roof1's slope | Roof2's slope | Roof3's slope |
|---|---|---|---|---|---|---|
| 1 | × | × | × | ✓ | - | - |
| 2 | ✓ | ✓ | ✓ | ✓ | × | - |
| 3 | ✓ | ✓ | × | ✓ | × | - |
| 4 | ✓ | ✓ | ✓ | ✓ | × | - |
| 5 | ✓ | ✓ | - | ✓ | - | - |
| 6 | ✓ | ✓ | ✓ | ✓ | ✓ | × |
| 7 | ✓ | ✓ | × | ✓ | × | - |
| 8 | ✓ | ✓ | ✓ | ✓ | × | - |
| 9 | × | × | × | ✓ | × | - |
| 10 | ✓ | ✓ | - | ✓ | - | - |
| 11 | ✓ | ✓ | ✓ | ✓ | × | - |
| 12 | ✓ | ✓ | × | ✓ | × | - |
| 13 | ✓ | ✓ | × | ✓ | × | - |
| 14 | ✓ | ✓ | × | ✓ | × | - |
| 15 | ✓ | × | - | ✓ | ✓ | × |
| 16 | ✓ | ✓ | × | ✓ | × | - |
| 17 | ✓ | × | - | ✓ | - | - |
| 18 | × | × | - | × | - | - |
| 19 | ✓ | × | - | × | - | - |
| 20 | ✓ | × | - | × | - | - |
| 21 | - | - | - | - | - | - |
| 22 | × | × | - | × | - | - |
| 23 | ✓ | × | - | × | - | - |
| 24 | × | × | - | ✓ | - | - |
| 25 | × | × | - | ✓ | - | - |
| 26 | ✓ | ✓ | × | ✓ | × | - |
| 27 | ✓ | × | - | ✓ | - | - |
| 28 | ✓ | ✓ | × | ✓ | ✓ | - |

## V. Conclusions

This research evaluated education building in Maejo University for the building of green roof. The result shows that here are three buildings which can build an intensive green roof immediately, seven buildings which able to build, but gardener needed and sixteen buildings for extensive green roof.

There are several buildings which are unable to be built with a green roof because of their weak structure, some of them were built before *Building control Act B.E. 2522 (1979)* was proclaimed. They did not have enough structure's evidences for analyzing. If the green roof still required, consultation with construction engineer before design process could be the solution. Safety is the first condition to be realized at any circumstance.

## References


[1] Green Peace Thailand. (2010). Global warming's impacts. [Online]. Available: http://www.greenpeace.org/seasia/th/campaigns/climate-and-energy/impacts/

[2] Energy policy and planning office, ministry of energy, royal Thai government. (2015). Reducing energy consumption in government sector. [Online]. Available: http://www.e-report.energy.go.th/index.php

[3] Office of the higher education commission (OHEC). (2016). Institutions ordinated by OHEC. [Online]. Available: http://www.mua.go.th/university.html

[4] Division of campus buildings and site. (2011). Building and site information system. [Online]. Available: http://building.mju.ac.th/Login/Login.aspx

[5] Fine day forum, presented at the Faculty of architecture and environmental design, Maejo University, TH, January 16, 2013.

[6] Planning division, Maejo University. (2012). MJU physical facility flagship projects to 2026. [Online]. Available: http://planning2.mju.ac.th/goverment/20111119104835_planning/File20131007141449_2241.pdf

[7] Siam cement group. (2014). Reduce heat temperature from a top bringing your comforable live. [Online]. Available http://scgbuildingmaterials.net/SmartIdea-Detail. aspx?SID =13

[8] W. Tanawutwattana, "The efficiency in reducing heat gain by using green roof for hot-humid climate," M.S. thesis, Dept. Architecture. Grad., Silpakorn Univ., Bangkok, Thailand, 2009.

[9] K. Suteethorn, "Green roof: An alternative strategy for Stormwater management," in *Academic Journal of Architecture, Chulalongkorn University*, vol. 1, pp. 125-137, 2005.

[10] C. Jalanugroh, "Important factors in green roof design and construction," in *Proc. the 3rd SAU National Interdisciplinary Conf.,* 2016, pp. 1483–1490.

[11] International Green Roof Association. (2016). Green Roof Types. [Online]. Available: http://www.igra-world.com/types_of_green_roofs/index.php

[12] E. P. Neufert, *In Architect' Data*, School of Architecture, Oxford Brookes University. pp. 16-17, 2000.

[13] W. McDonough. (2012). Some key facts about green roofs. [Online]. Available: https://ecologyurbanismculture.files.wordpress.com/2012/02/greenroof-presentation.pdf

[14] The Greencurator. (2015). Green Roof Project. [Online]. Available: http://www.thegreencurator.com/green-projects


**Chollatip Jalanugroh** was born on February 21, 1992 in Samutprakan, Thailand. She obtained a bachelor degree of Science in Agricultural Development (Second class honors) at King Mongkut's Institute of Technology, Ladkrabang, Bangkok, Thailand. She is currently a graduate student in Environmental Design and Planning at the Faculty of Architecture and Environmental Design, Maejo University, Chiang Mai, Thailand. She was a trainee in Livestock and Breeding Center, Suratthani and Horticulture Research Center, Loei. She is carrying out her research works mainly on Green roof and Green roof design in Maejo University, Chiang Mai. One of her publications was published in the 3rd SAU National Interdisciplinary conference 2016 (Green research for sustainable development) as "Important Factors in Green Roof Design and Construction."

**Nachawit Tikul** was born on February 14, 1974, in Bangkok, Thailand. She graduated Doctor of Engineering (Integrated Product Design and Manufacturing) School of Energy, Environment and Materials, King Mongkut's University of Technology Thonburi, Thailand in 2010. She is a lecturer of architecture in the Environmental Design and Planning Department, Faculty of Architecture and Environmental Design at the Maejo University, Chiang Mai, Thailand. She has been served as Chairman of the Department. She practiced as an architect, a researcher and a lecturer in Thailand for over fifteen years. Currently both her research and her teaching are focused on issues of environment and green architectural practice and design.