Suburban Self-sufficient Living:
An implementation of the Philosophy of Sufficiency Economy

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ABSTRACT

Sufficiency signals a combination of having enough and being satisfied. In Thailand, the idea of sufficiency has been reintroduced as the philosophy of Sufficiency Economy. Self-reliance and self-sufficiency are playing a big part of its implementation. This paper suggests a hypothetical adaptation of suburban lifestyles under such philosophy, where the immediate environment of the house is considered the main source for exploitation of food, water, and energy. It illustrates the possibility of being more self-reliant at a household level. The link between outcomes and the reduction of environmental impacts through simple Ecological Footprint estimation affirms that practice of self-sufficiency and sustainability are compatible.

Keywords: *self-reliance, self-sufficiency, sufficiency economy, suburban, household*

1. INTRODUCTION

Sustainable development stresses the limitation of resources. There is inarguably only one Earth that is suitable for human living. Rapid population growth increases the urban population and transforms much of the countryside into new suburban areas. This also means less productive land and fewer primary resources in the near future. It is high time to call for a more self-reliant, self-sufficient, and sustainable lifestyle among present and future population. Being more self-sufficient means that a person can rely more on oneself. It will increase security as well as remove oneself from competition over resources, therefore, providing more rooms for others who are in need.

Self-sufficiency may not be seen as necessary for suburban life since people can buy all they need close-by. Knowing full well that suburban households can normally earn enough money to pay for whatever they want, this paper draws attention to an alternative lifestyle in such an area. It aims to promote a higher level of self-reliance in suburbia. The benefit of such a practice in lessening the human impacts on the environment is the major key interest of this paper.

This paper examines a possibility of self-reliant practices within suburban areas. The single house was chosen to represent suburban living. An appropriate implementation of self-sufficient living from the philosophy of Sufficiency Economy was suggested. The main idea taken from the philosophy is to consider the immediate environment as the most important resource and use it wisely. The potential of implementation as well as the benefit to the environment through a simple Ecological Footprint estimation is included.

2. SELF-RELIANCE, SELF-SUFFICIENCY, AND SUSTAINABLE DEVELOPMENT

The idea of one Earth as a finite resource has been stressed through the World Wildlife Fund's (WWF)*'Living Planet Report'* series since the year 2000 by comparing current Ecological Footprint (Wackernagel and Rees 1996) and the Earth's biological capacity. The current WWF report (2010) reveals that during the 1970s the annual Ecological Footprint matched the Earth's annual biological capacity for the first time. After the 1970s the Earth's population began consuming renewable resources faster than ecosystems can regenerate them as well as releasing more CO_2 than ecosystems can absorb (WWF, 2010). By 2007, the Earth's population already needed 1.5 Earths to sustain its consumption patterns. Overusing the Earth's capacity can mean fewer or completely depleted resources in the near future. Therefore, over consumption can be viewed as the action preventing sustainable development. The idea of self-reliance and self-sufficiency is an alternative to fight back the norm of over consumption. Thailand is also among the countries that overshoots its own biological capacity as illustrated through the *Living Planet Report* series, and the deficits are likely to increase through the years (see Table 1). Therefore the idea of a higher rate of self-reliance and self-sufficiency at all levels should be implemented to help lessen the human impacts on the environment.

3. SUFFICIENCY ECONOMY AND NEW THEORY AGRICULTURE

Buddhism plays an important part in Thai's culture. The principle of the "Middle Path" is one of the valuable teachings to guide appropriate conduct in all activities. The term "Middle Path" could be equivalent to the word "Moderation" in the English sense. By taking the Middle Path as the underlying principle, the philosophy of "Sufficiency Economy" was formally established in 1997 by His Majesty King Bhumibol Adulyadej (Rama IX) (NESDB, n.d.). The origin of the philosophy can actually be traced back to the year 1974, but it was officially recognized under the name "Sufficiency Economy" throughout the country only from 1997 (Phanthasen, A., et al. 2003). The meaning of "Sufficiency" in the philosophy of Sufficiency Economy "…means moderation, reasonableness, and requirement of a self-immunity mechanism to cope with internal and external changes" (NESDB, n.d.). Therefore, Sufficiency Economy is about encouraging people to know what is enough, learning to be satisfied with what one can have or trying to be more self-reliant and self-sufficient without being too extravagant. So, in short, Sufficiency Economy is a holistic concept of moderation and contentment (NESDB, n.d.). As a philosophy, it can be adapted to all thinking and activities.

A theory named "New Theory Agriculture" was also initiated by King Rama IX as an example of the practical implementation of the philosophy for rural development by taking all principles of Sufficiency Economy into account. The theory aims at farmers in rural communities. It guides farmers to be able to provide themselves with enough food and water for everyday life before aiming for trade. This idea responds to the principles of self-immunity and reasonableness. To practice and achieve the goal of the theory, acts of moderation and reasonableness are crucial, especially for achieving reasonable use of land, labor, and consumption. The theory consists of three steps from the smallest scale taken by a family to the third step for the wider community. The essential part of the theory is about

Table 1: Thailand's Ecological Footprint and biological capacity reported by the '***Living Planet Report'*** series

Living Planet Report	Data in	Total Ecological Footprint	Biological capacity	Ecological deficit
		(global hectares per person)		
2000	1996	2.70	1.35	-1.35
2002	1999	1.53	1.37	-0.15
2004	2001	1.60	1.0	-0.6
2006	2003	1.40	1.0	-0.4
2008	2005	2.10	1.0	-1.2
2010	2007	2.36	1.0	-1.36

the proper management of land use and how to develop the economy. The essence of the first step of the theory is land and resource management. The main concept is based on producing enough products to be consumed in the family and with some extra products for them to sell. The theory suggests farmers proportionally manage their land by dividing it into four parts: a rice field (30%), a pond (30%), plants/crops (30%), and housing and other necessary buildings (10%). The suggestion of land arrangement is based on the amount of food each family needs to consume each year as well as the water needs for food production and consumption. Surplus land can be used for producing extra products for sale, if the family can manage to do it without overstretching themselves. Even though approximate portions were suggested, the key is for farmers to reasonably divide according to individual needs, ability, and labor.

After successful practice of the first step, there is expected to be enough food for each family. The second step is to pool efforts and look for co-operation within a community. The co-operative setting suggested by the second step will help to create a strong relationship based on interdependence in a community. The third step is creating a relationship to the outside community for improving the local economic status. This step can help a community to reduce its capital costs and progress into a stronger position in the production and marketing field. This step will lead farmers to be more efficient and have an economic marketing operation.

There are a number of successful stories among the rural population: well-fed families, less expenses, more income from selling their surpluses, and year round work, reducing the need for family members to migrate to find jobs in the city outside planting seasons (Promthong, 2001; The Chaipattana Foundation, 1997; 1998; 1999). According to the philosophy of Sufficiency Economy and New Theory Agriculture, the first step of self-reliance is one of the major keys to success. A vital lesson drawn from the successful experiences of farmers is that the combination of a self-reliant and self-sufficient attitude with a practical arrangement of available land designed to suit their lifestyle.

3a. Area of Implementation

This study takes the successful implementation of Sufficiency Economy in rural areas through New Theory Agriculture as an example to find the key implementation for suburban areas. Suburban areas can also apply three scales of application: family, community, and national levels, applying the philosophy to this structure respectively. According to the theory, the focus on the family level is centered on self-reliant lifestyle through the help of practical land management. In addition to self-reliance in food and water, energy is also taken into account in suburban lifestyle. These three basic suburban needs are examined later by looking at average consumption and the physical capability for on-site production.

With the main focus in this paper on the first step, it is important to point out that a house with smaller plot may have less potential for self-reliance, especially in food production. Therefore, the second step of the theory, where collaboration within the community or the whole subdivision will be the next step for the implementation. Community scale co-operation on basic needs, such as providing a community reservoir, local water supply, local electricity service, community kitchen garden, and a local market, could be managed so all community members can participate and benefit from such activities. Then relationships to other communities in will be the third step to fulfill suburban demand in all categories. As suggested by New Theory Agriculture, application of the theory should be done in steps, in order to build a strong community from the smallest scale. This study is not suggesting to limit application to a household level, but rather promotes more self-reliant to suburban houses as oppose to solely relying on rural areas for food and centrally supplied water and energy. Further research could be done on the implementation of the second and third steps for suburban community in Thailand based on the same framework.

4. SUBURBAN HOUSEHOLDS

Suburban development is widely known to have resulted from the development, expansion and decentralization of cities. The term suburb is used to identify areas that possess characteristics of both urban and rural areas. This is the case in Thailand, where suburban land is generally cheaper than in the city, and normally the cost of transportation to the heart of the city is affordable. A working definition of suburban areas in Thailand for this study is drawn from existing official definitions for different types of community types. The definition of an urban area relies heavily on municipal administration, which

is based on the density of the population, revenue, and number of inhabitants in the area. Municipality administration is one current local administration systems in Thailand and was founded in order to increase the process of decentralization and give more power to local government as well as provide facilities for more people. The current Thai local administration systems include Provincial Administrative Organization (PAO), Municipality (Tesban), Sub-district Administrative Organization (SAO), and two special forms of local administration for Bangkok and Pattaya. The administration of a municipality is called "Tesban" and has three levels according to the population of each area. These three local levels are "Tesban Nakhorn" or city municipality, "Tesban Muang" or town municipality, and "Tesban Tambon" or sub-district municipality. General definitions and characters of each "Tesban" as given in the Municipality Act, B.E. 2496 (1953) are presented in Table 2. It can be seen that "Tesban Muang" and "Tesban Nakhorn" can be defined clearly as urban areas. In contrast, the areas outside Tesban normally have less access to facilities, and are mainly rural areas.

In addition, definitions given to urban, suburban, and rural areas from the Royal Institute (1989) provide a clearer approach to each area in relation to its characteristics as shown in Table 3. Accordingly, not all Tesban areas can be urban areas, however, only Tesban areas with more than 10,000 people are urban areas. These definitions suggest that a suburban area is the area with the ability to access facilities, meaning the area within a Tesban, but which has less people than an urban area. By combining all of the given definitions together, Tesban Tambon, the area which lies between the definitions of urban and rural areas from the Royal Institute, will serve as the most suitable definition of a suburban area in Thailand.

Even though, Tesban Tambon is chosen to represent suburban areas in Thailand, they do not all possess the characteristics of suburban areas. For example, not all are located close to a city. However, it is reasonable to assume that the ones located close to a city will have suburban characteristics. In this paper, two Tesban Tambon very close to the city center in Phitsanulok province were selected as examples of general Thai suburban areas. The two are Tesban Tambon Banmai, located within the same district as the city center with around 600 households, and Tesban Tambon Wang Thong, located on a main highway connecting to the northeastern region with around 1,500 households. Settlements of 120 plots in Banmai and 540 plots in Wang Thong were studied to find the average ranges of land holdings and housing footprints. Examples of houses and studied plots in the selected areas can be seen in Figures 1 and 2. The most common area for land holdings in the area is ranged from 200-400m^2 with an average of 50-100m^2 building footprint. Land holding ranges

Table 2: General definition of three levels of community for Thai local administration

Tesban	Character
Tesban Nakhorn	A community that has a population not less than 50,000 with adequate revenue and has received official permission from the Ministry of Interior.
Tesban Muang	A community that has a population not less than 10,000 with adequate revenue or the area contains the provincial hall and has received official permission from the Ministry of Interior.
Tesban Tambon	A community that is proved suitable for being established as Tesban Tambon and received official permission from the Ministry of Interior.

Source: all definitions translated from Municipality Act. B.E. 2496 (Municipality Act., B.E. 2496 (1953), Dated 17 February 1953)

Table 3: Definitions of urban, rural, and suburban from the Royal Institute

Areas	Definitions
Urban	Urban area is a Tesban with at least 10,000 people.
Suburb	Suburb is the area around big or small cities. A suburb may have a separate administration independent from the city to which it belongs, but economic systems still rely on the urban economy.
Rural	Rural area is the area outside an urban area or Tesban in which people are involved in agricultural activities.

Source: all definitions translated from Dictionary of Sociology (The Royal Institute, 199, p.316, 387, and 408)

in the chosen areas are quite big compared to those around the big cities, especially Bangkok, which can be as small as 120m^2 for a single house. However, the paper is aimed at focusing on the majority of suburban single houses of Thailand, where great potential of self-sufficiency can be easily promoted. Since it is quite difficult to select a common style found in the selected suburban areas, this study observes standard housing plans similar to the houses in selected suburban areas. In Thailand, some standard housing plans were provided free of charge for the public by the Department of Public Works and Town & Country Planning (DPT). These house plans are provided for free, and therefore it is likely that more people would be interested in using them. According to the National Statistical Office (NSO), the number of new single houses applying for building permits within urban and suburban areas in the northern region jumped from 10,181 in B.E. 2552 (2009) to 12,409 in B.E. 2553 (2010) with about 90% is concrete construction and externally rendered in brick. Hence, it is expected that more standard houses will be built each year.

To date, DPT provides 33 housing types arranged in five categories as emergency houses for natural disasters, economy houses, urban houses, contemporary Thai houses, and contemporary Thai row houses. Among these standards, urban houses are chosen to represent housing in selected suburban areas, because of the similarity to the existing houses. Within the ranges of land holdings and housing footprints found in selected suburban areas, several standard house plans can be used in this study. However, only the house with the smallest footprint can fit into the smallest land plot (200m^2) shown here. This is chosen to show how a family with a small house and small land holding can be more self-sufficient. The selected house will provide information about the roof styles for the investigation on energy and water production.

According to the condition of housing footprint and landholding ranges as well as the number of rooms possible for accommodating average household size (about four people/family), urban house type 3 is selected. The characteristics of the house

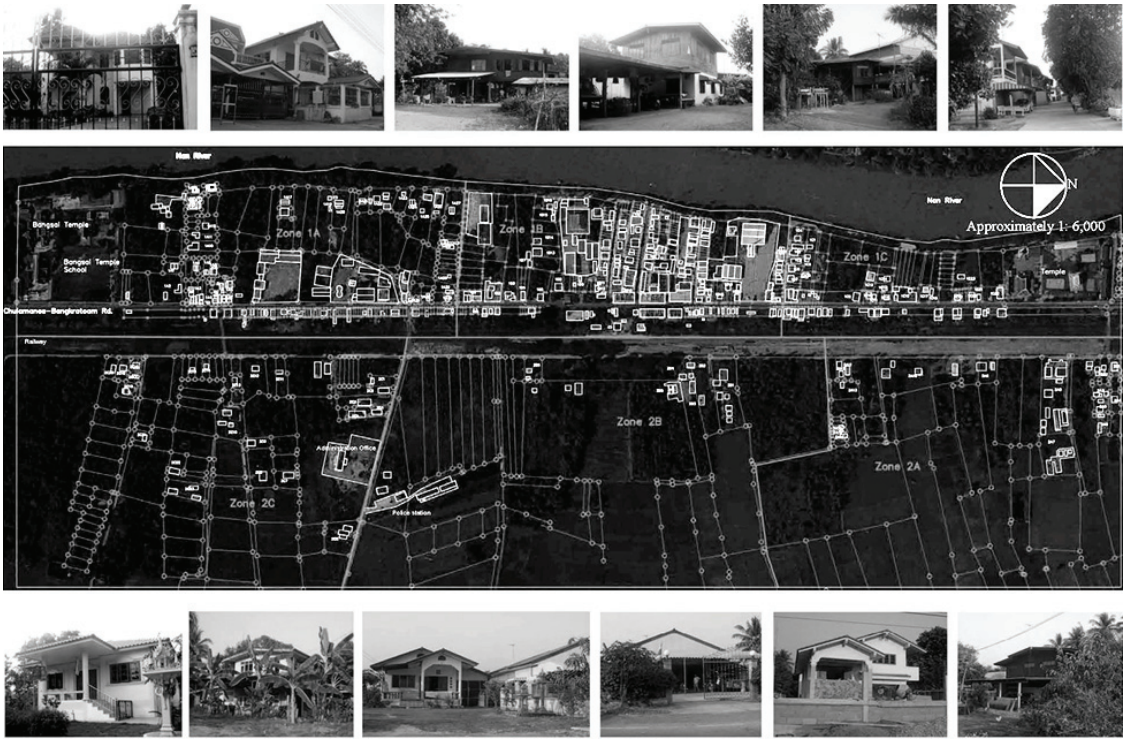


Figure 1:
Map of TesbanTambonBanmai and examples of houses in the areas

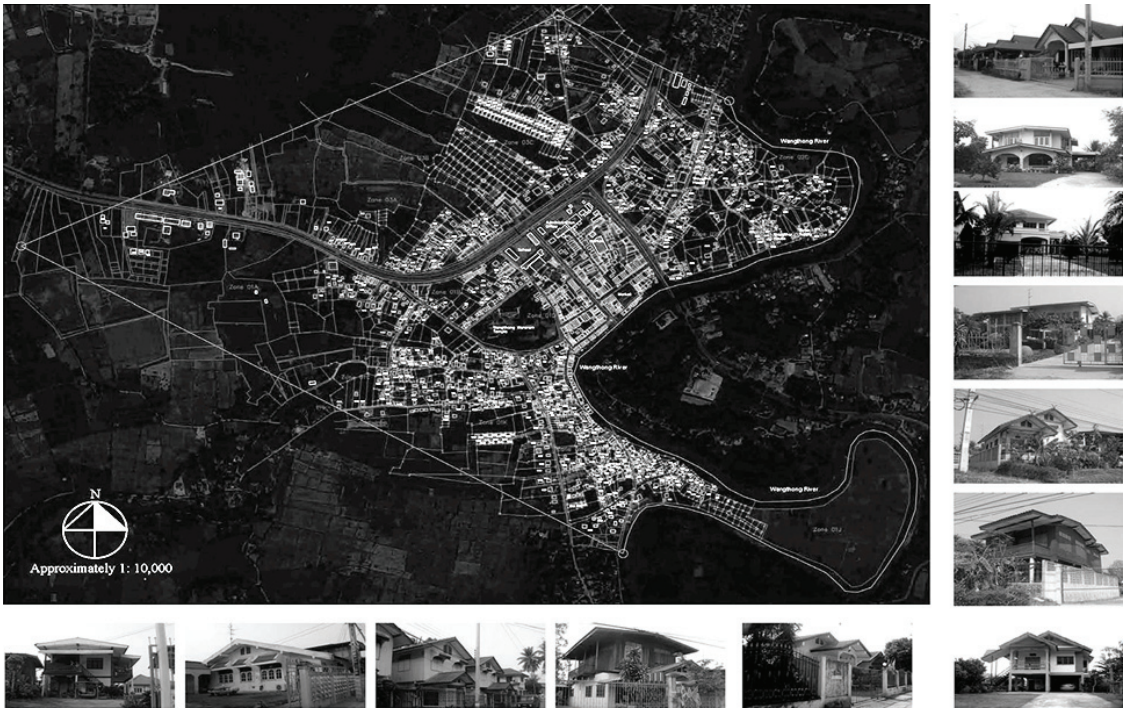


Figure 2:
Map of TesbanTambon Wang Thong and examples of houses in the areas

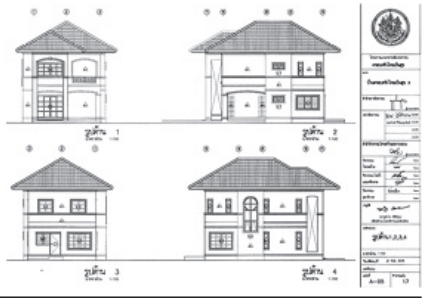
can be found in Table 4. It can be seen that the house can fit into the 200m^2 land plot, which is the smallest of the land holding range of the selected areas. Almost all of the standard houses are hipped roof. This shows current popularity of roof styles in Thailand, unlike the existing houses in the selected areas, which are mostly gable roof. Therefore, when consider solar power harvest from the rooftop, the hipped roof is less likely to provide a very high yield. This is because of its form, which can only allows approximately 1/3 available space for photovoltaic cells installation.

5. POTENTIAL OF SELF-RELIANCE IN SUBURBAN HOUSE

The potential for self-reliance in current suburban households is examined to see whether or not the physical characteristics of the selected suburban households can supply the estimated consumption in the three areas of food, energy, and water. Accordingly, a series of investigations into the average consumption by a family is done. Average household size for the whole country surveyed in

Table 4: Physical features of selected house

Description	Urban house type 3
Number of floors	2
Number of car parks	1
Number of bedrooms	3
Total building footprint	77m^2
Total floor area	126m^2
Type of roof	hipped
Total roof area	110m^2
Smallest plot to fit	200m^2



2010 is 3.2 people/family (NSO, 2012). Based on this, four people are assumed for each household in the investigation. Table 5 shows the result of the investigation into the potential of self-reliance in the selected suburban house. It can be seen from the table that the rate of self-reliance is quite high in all categories.

5a. Food Category

From the fact that suburban areas have limited land, complete self-reliance in food production is not possible. Fruit and vegetables are seen as the most suitable types of food production for limited area as well as the level of skill involved. According to this assumption, only the consumptions in fruit and vegetables categories are presented in this study. Amount of fruit and vegetables consumption suggests by FAO and WHO (2004) is around a minimum of 400g/person/day. Higher portion in fruit and lower in vegetables is also mentioned. As a result, a family with four people will need around 350kg of fruit and 234kg of vegetables each year.

The study selected 3 types of fruit: guava, papaya, and banana; 13 types of vegetables: cabbage, cauliflower, Chinese kale, Chinese flowering cabbage, leaf lettuce, Chinese cabbage, water spinach, yard long bean, cucumber, pumpkin, tomato, angled gourd, and okra; and 10 types of herbs: coriander, long coriander, kitchen mint, galangal, ginger, chili, lime, lemon grass, sweet basil, and holy basil. These plants were selected in this study due to flexibility in planting and harvesting seasons. All of the selected plant can bear fruit all year round, therefore this give a family a chance to fulfill their requirements. While the choice of plants is very limited compares to the vast variety of fruit and vegetables available in Thailand, the selection was made based on what is commonly planted in a household as well as the level of production/year and data availability. In addition, plants that can be grown easily or can be harvested all year round were considered. An investigation involving area needed for each plant, length of time, and productions is being examined on a monthly basis to investigate balance of the produce. An area between 133m^2 and the maximum of 150m^2 is needed for all plants. The different portion of area needed at a certain period of time allow possibility of shifting plots between short-life plants. Fruit trees need the area up to 88.5m^2, therefore, vegetables assume to be planted first if there is not enough area for all plants, due to their higher productivity. Since fruit trees do not require close attention, a productive garden will only leave a family with between 25-42m^2 to take care of daily needs. Growing new vegetables will take about one afternoon of each month, but this can be viewed as a quality time with one's family.

Table 5: Potential for food, water, and energy in selected suburban house

Description	Urban house type 3
Food (fruit and Vegetables)	
-200m^2 land plot	40%
-250m^2 land plot*	70%
-300m^2 land plot*	≥100%
Water (rainwater)	
-Conventional	48%
-Water saving fixtures	68%
-Water saving fixtures and graywater reuse	≥100%
Energy (electricity)	
Mono-crystalline Silicon/ Multi-crystalline Silicon	
-Low user	≥100%
-Intermediate user	82%
Amorphous Silicon	
-Low user	≥100%
-Intermediate user	49%

**Note: Though the paper focuses on the smallest land plot at 200m^2, the two extra plot sizes are for the benefit of comparison.*

Even though this study is aimed at promoting more self-reliance to lessen human impacts on the environment, the benefit of having a productive garden in terms of food security and a way to reduce food cost could also be mentioned here. About a third of household expense in Thailand is from food (NSO, 2012). According to suggestion about the proportion of food consumption/day (grams) by Nutrition Division (2007), the proportion of fruit and vegetables is accounted for 40% of total food consumption per day. So, a productive family will be able to save up to 13% of their expense by growing their own fruit and vegetables. These extra savings will compensate for the money that was laid out for the investment of the productive garden, for example tools and plant stock.

According to the arrangement, with an allowance for driveway, it can be seen from Figure 3 that the house on the 200m^2 plot can only grow some fruit trees, but has enough area for vegetables if it includes some of the shaded areas. However, if excludes the shaded areas it can produce up to 40% of the yearly consumption. On the other hand, Figure 4 shows the same house on a bigger plot size of 250m^2. It can be seen from the figure that more fruit trees can be planted. In this way the production of fruit and vegetables rises to 70% of the yearly consumption. Therefore, a little more land would contribute to an even higher yield.

5b. Water Category

Both Metropolitan Waterworks Authority (MWA) as well as Provincial Waterworks Authority (PWA) regularly provides average water consumption data at national level. Water consumption per capita from 1997-2006 reported by MWA and PWA revealed that around 240 liters/person/day is used within the MWA coverage, while 150 day/person/day is used in PWA. So, average water consumption for Thailand turns out to be around 200 day/person/day. Even though the suburban example chosen for this study is inside PWA coverage, the more generalized amount of 200 day/person/day is used. In general, water is used for drinking and washing in a household as well as for watering plants and car wash outside. Average proportion of water consumption for different activities (Manager Online, 2003) shows current behavior of Thai people (Table 6). The table also provides two more alternatives for water conservation practice by installing better fixtures and reusing gray water for the out-of-house use. Actually more actions involving behavioral changes can be done to reduce the amount of water consumption, but the two alternatives would be a good start for a water conservation methods that can be easily achieved by all. In total, a family with conventional fixtures will require around 292,000 liters/year, a family with water conservation fixtures who are not

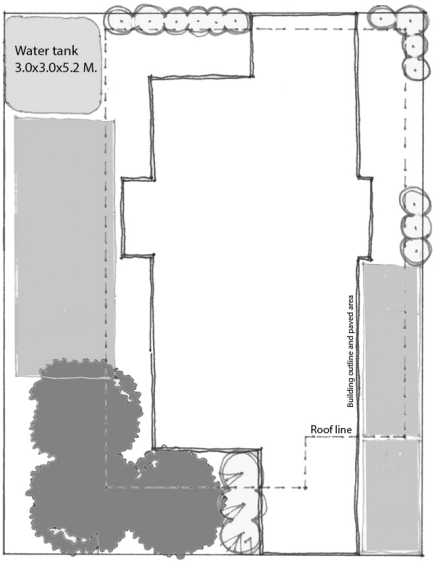


Figure 3:
Urban house type 3 on a 200m^2 plot

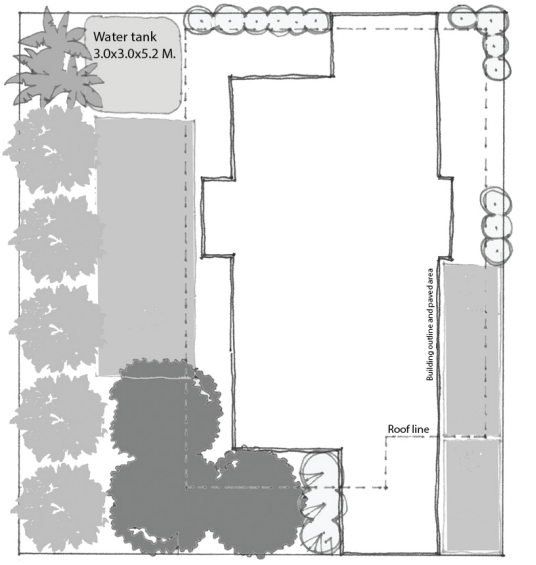


Figure 4:
Urban house type 3 on a 250m^2 plot

reusing their gray water will use 208,780 liters/year, and a family with both water conservation fixtures and reusing gray water will need only 122,640 liters/year.

Rainwater is accepted as a substitute for the central supply in the study. An investigation about the capability of water production is divided into two parts. The first part is to test the estimated amount of water for the out-of-house use against the estimated productive area. Then the possibility of rainwater harvested from available roof area can be tested against the total water requirement. The area of 150m^2 is needed for fruit, herbs, and vegetables production. A proportional estimation of water needed for plant above rainfall from New Theory Agriculture as described by Wallop Promthong (2001) is equal to around 625 liters/m^2. A 150m^2 garden will need 93,750 liters/year. Proportion of water for the out-of-house is 70 day/person/day as well as in the case of reusing gray water. So, there will be 102,200 liters available for plants each year. This amount of available water should be enough for all outdoor activities.

The roof area of the housing model is 110m^2, so the selected house can harvest up to 143,000litres/year. However, only a household using water conservation practices involving water saving fixtures and reuse of gray water can harvest enough rainwater for their annual consumption. The others will have to combine rainwater collection with conventional water supply. A container for rainwater storage is also required. Even though the annual average rainfall of the Phitsanulok study area is around 1,300mm, the dry season is quite long, which has a big impact on the size of the required rainwater tank. For example, rainwater storage for a complete self-reliant family with water saving fixtures and gray water reuse would have to be big enough to hold about 47m^3 of water. In general, Thai people normally store a water supply sufficient for up to two days of consumption as a general precaution in case of supply interruption. Water tanks commonly used in the residential sector are normally between 1.5-4m^3. Bigger water tanks are normally used in public buildings and are harder to obtain by individuals. However, if the majority of people see collecting rainwater as an appropriate practice, bigger water tanks would be more common. Water storage will greatly affect the land area available for food production. A custom-made concrete tank can be an alternative for most houses but will definitely increase construction cost. Since the cost of using central water supply is quite low in Thailand, less than 4,500 Baht/year for a conventional family, the pay back period is between 20-25 years. However, if there is a rise in cost of centrally supplied water in the near future, which is very likely, a rainwater tank may be seen as a profitable investment. Using rainwater will reduce the use of portable water as well as reduce the amount of storm water entering the public drainage system. The use of rainwater may cover only the areas where portable water is not necessary required. Using less centrally supplied water, means less energy is needed to treat, pipe, and supply water to each house, therefore less environmental impacts in the future.

In Table 6, a family with water conservation fixtures and gray water reuse ended up saving up to 60% of water used by a conventional family. This means that a family could save a large amount of portable water even without the use of rainwater. The family is likely to have less impact on the environment even before seeking an alternative water supply. The use of gray water in suburban houses is introduced as another alternative practice for water conservation in this study. Installation cost of the systems depends on

Table 6: Estimation of household water consumption per person

Types of use	Proportion (%)	Consumption per capita					
		Conventional fixtures		Water conservation fixtures			
				Without reusing greywater		Reusing graywater	
		liter/day	liter/year	liter/day	liter/year	liter/day	liter/year
Household cleaning	2	4	1,460	4	1,460	4	1,460
Kitchen use	5	10	3,650	10	3,650	10	3,650
Washing clothes	9	18	6,570	18	6,570	18	6,570
Wash basin and shower	23	46	16,790	27.6	10,074	27.6	10,074
Flushing toilet	26	52	18,980	13.5	4,928	13.5	4,928
Out-of-house use	35	70	25,550	70	25,550	10.4	3,796
Total	100	200	73,000	143	52,232	84	30,478

each requirement. To use gray water directly outside may not need much of equipment or treatment compared to reusing it in the toilet. However, the user should be aware of possible contamination.

5c. Energy Category

In this study, energy consumption for a family is chosen from the demand based on the estimation of appliance types and period of use in a household with four people. The study also chose to use only electricity as the source of energy, in order to avoid complication. Two examples of low users and intermediate/higher users were identified based on different types of appliance owned as well as levels of energy consumption. Types of appliance selected to work from in this study are from a series of ownership surveys done by NSO (1996, 1998, 2000, 2002, and 2004). The study estimated the use of 5.9kWh/day for a low user and 18kWh/day for an intermediate/higher user. Estimated types of appliance owned by a low user consists of 11 basic appliances: television, electric fans, electric pot, rice cooker, lightings, washing machine, electric cooker, refrigerator, water pump, radio, and video player. For intermediate/ higher user, 15 appliances were chosen including all of the appliances and four extra appliances: air conditioners, water heater/boiler, microwave oven, and a computer.

The capability of energy production in suburban areas is studied by testing the ability of electricity generation from immediate natural resources. The location of Thailand provides a good opportunity for exploiting solar radiation by using photovoltaic cells (PV) for electricity generation. The average number of solar radiation for the whole country is 18.2MJ/m^2-day (Serm Janjai, Jarungsaeng Laksanaboonsong, and Department of Alternative Energy Development and Efficiency (DEDE), 1999). Average global solar radiation for Phitsanulokis ranged between 15.8-22.3MJ/m^2-day or between the average insolation of 4.4-6.2kWh/m^2-day (Regional Office of Energy Development and Promotion 9, n.d.). Two systems of PV panels for electricity generation can be used: stand-alone and grid-connected. However, suburban areas are normally located where necessary facilities are already in place, so the stand-alone system would not be seen as necessary. A grid-connected system would be a better choice due to a smaller area requirement, less capital cost, as well as no need for battery. This paper chose to calculate the area needed for PV installation for the grid-connected system, which are likely to be the main choice of suburban people due to the support of MWA and PWA from the Very Small Power Producer program (VSPP). The grid will act as a backup system for the house as well as producing surpluses that can be put back into the grid.

The investigation for using a grid-connected system is calculated based on average insolation (5.2kWh/m^2-day). A project carried out by Electric Generating Authority of Thailand (EGAT) and DEDE, which introduced the use of several types of PV to general public. Phase one started in 1997 with 10 houses and later in 2002 with 50 houses. Experience from the project give a rough estimation of PV nominal power and installation area in square meters. It appears from the project that the average area for installing a nominal power of 1kW_p using mono-crystalline silicon or multi-crystalline silicon is around 9m^2, while an amorphous requires around 15m^2 (EGAT, 1998; 2004). According to the calculation, the suitable nominal power size of PV for low user household is 1.6kW_p, while 5kW_p is required for intermediate/higher user household.

The percentage of electricity generation capability from each housing types for the grid-connected systems are listed in Table 5. Note that the southern side of the roof is used for this investigation, since it is the most suitable for PV installation in Thailand. As mentioned earlier, the hipped roof seems to be the most popular style. However, this type of roof has only small area for PVs installation compared to its solar efficient area. With a gable roof, there will be more area for PVs installation. It can be seen that the selected house is still able to produce enough electricity for low user whatever types of PVs they use. The use of mono-crystalline silicon or polycrystalline silicon allows the intermediate/higher users to produce up to 82%. The amorphous type needs more area, so it is harder for the intermediate/ higher users to produce enough electricity with the current hipped roof structure. The use of a gable roof could give more roof area and therefore produce more electricity. However, in reality, the cost of PV panels in Thailand is still relatively high, at more than 200,000 Baht/1kW_p. Even though, electricity cost for low users can easily be up to 7,000 Baht/year or 24,000 Baht/year for intermediate/higher users, the pay back period of about 40-50 years may not interest consumers in the current situation. Therefore, installing PVs can be considered as a huge investment in typical suburban houses. Reduction in energy consumption would be a more appropriate and cheaper goal to aim for. Nevertheless, energy

prices are likely to continuously increase, especially in Thailand with more than 90% of electricity is made from nonrenewable resources, mainly natural gas. In addition, it is also possible that the price of PVs will be cheaper in the near future. If there is a reduction of pay back time, may be half or less, the use of PVs could be more convincing.

6. POSSIBILITY OF CHANGES OF ENVIRONMENTAL IMPACTS

It can be seen from the former sections that the potential for self-reliance of a small suburban house is quite high. Contribution from self-reliance to the natural environment can also be shown here using a sustainable indicator, Ecological Footprint (EF). In the study, a simple calculation based on a component-based EF analysis using the EF conversion factors provided by Chambers, Simmons, and Wackernagel (2000) is used. The footprint conversion factors suggested by Chambers *et al.* (2000) are based mainly on EU and UK data. So, the footprint calculated from this method or data set will give only a rough picture for the situation of suburban Thailand rather than an accurate one. Nonetheless, it provides a method for comparing possible changes in EF between practices.

6a. Ecological Footprint of Food

The analysis of EF shown in Table 7 compares a conventional family and the more productive ones. The analysis of the EF of food in this study is based on the Dietary Reference Intakes (DRIs) suggested by the Nutrition Division, Department of Health (2003). However, the study only accounts for food consumption and the estimated physical land area for different levels of productive garden, but it is enough to give a rough picture of the impact of a family of four on the environment. The energy and life cycle effect involved with household fruit and vegetable production is not included, however, these are understood to be small in comparison.

According to the table, the conventional family maintains a normal diet totally dependent on the outside supply of food. The productive family in the study ranged from 40%-100% self-reliance. The result of the EF is provided in hectare/year. It can be seen that the more a family can produce by themselves the more environmental impacts it can reduce. For example, the selected house in this study built on a 200m^2 land plot has a potential to produce up to 40% of the yearly consumption. Therefore, this family can actually reduce their environmental impacts by 1,000m^2/ year, which could already be considered as crucial improvement. When a family can produce up to 100% of their fruit and vegetables requirement, reduction of land can be up to 3,000m^2/year.

6b. Ecological Footprint of Water

The analysis here accounts for the actual water consumption and estimated EF of a concrete rainwater tank including its embodied energy and

Table 7: Ecological Footprint of suburban basic needs

Ecological Footprint (hectare)	Conventional family	Productive family						
		40%	50%	60%	70%	80%	90%	100%
	ha/year	ha/year	ha/year	ha/year	ha/year	ha/year	ha/year	ha/year
Ecological Footprint of food								
Normal diet	2.7	2.6	2.6	2.5	2.5	2.5	2.5	2.4
Ecological Footprint of water								
Conventional fixtures	0.027	0.026	n/a	n/a	n/a	n/a	n/a	n/a
Water saving fixtures	0.020	0.020	0.019	0.018	0.017	n/a	n/a	n/a
Water saving fixtures and graywater reuse	0.013	0.012	0.012	0.012	0.012	0.012	0.011	0.011
Ecological Footprint of energy								
Low users (6kWh/day)	0.24	0.17	0.15	0.13	0.11	0.09	0.07	0.05
Intermediate/high user (18.5kWh/day)	0.75	0.51	0.46	0.40	0.34	0.28	0.22	0.16

land area needed for rainwater tank installation. Operating energy to supply water to any area within a house using a water pump will be calculated as part of electricity consumption. Treatment, if necessary, can be done by water passing through filters under gravity. So, operating energy will be excluded from this calculation to avoid double counting. For the footprint of water consumption calculation, two sources of water supply are considered as well as difference in conservation practices. For the first analysis it is assumed that water supply comes from one of the authorities. For the second, it is assumed that water comes from rainwater. This study also takes into account single and multiple water sources used by different households. This is because only a household with water conservation fixtures and gray water reuse can rely entirely on rainwater collection.

The life cycle effect involving energy use and CO_2 emissions during the production and maintenance of a rainwater tank is taken from related studies by Mithraratne and Vale (2007a, b) in Auckland, New Zealand. The study gives a life cycle comparison between conventional and alternative water supply systems, these being based on rainwater collection using concrete or plastic rain tanks. The studies show that life-cycle energy and CO_2 emissions of a concrete tank are much lower than a plastic rain tank the concrete tank has a longer life span as well. Even though the studies by Mithraratne and Vale (2007a, b) are in New Zealand, water tank technology and water systems in Thailand and other countries could be quite similar, and gives a rough picture for Thailand. As seen in Table 7, that water conservation practice with multiple water sources can contribute to lessening environmental impacts. Even though the size of reduction may not be as big as in the food category, a household with water conservation fixtures and 70% productive level can reduce as much as 100m^2 of EF per year. It is worth mentioning that even without being productive, a family can reduce their environmental impacts by reduction in consumption. The conventional family with water saving fixtures can reduce up to 70m^2 of EF/year, and 140m^2 of EF/year if having water saving fixtures with gray water reuse.

6c. Ecological Footprint of Energy

Two sets of EF factors are used in the energy analysis: a conversion factor for centrally supplied electricity and one for household generation using PV panels. An appropriate footprint conversion factor for centrally supplied electricity in Thailand is found by proportionally adjusting the footprint factors of its primary sources given by Chambers *et al.* (2000). As a result, 110 hectare-years/GWh is used as the footprint conversion factor for the central supply. The footprint conversion factor of PVs provided by Chambers *et al.* (2000) is derived from their direct land use (built land) and the land required for absorbing both direct and indirect emissions of CO_2 incurred during their construction, operation, and maintenance (energy land).

It can be seen from the table that a completely self-reliant low user family can have a footprint as low as 0.05ha/family/year compared to 0.24ha/family/year for a household with complete dependency on central supply. Like the low user family, the completely self-reliant intermediate/higher user family has only about one-fifth of the EF compared to the same family only using central supply of electricity. However, switching from being an intermediate/higher user family to a low user family is also giving significant reduction to the environmental impact. The reduction in Table 7 shows as high as 5,100m^2 of EF/year. Further reduction can then proceed toward higher productivity level.

7. CONCLUSION

The three areas of environmental impact presented in this study respond to the application of increasing self-reliance, self-sufficiency, and sustainable lifestyles in suburban areas, implemented from Sufficiency Economy and New Theory Agriculture. The results of the study show that the implementation of Sufficiency Economy by encouraging a more self-reliant lifestyle for suburban households is also beneficial in reducing human impact on the environment. The EF analysis, which is widely used as an indicator for sustainability, proves that development under the philosophy of Sufficiency Economy could help lower the rate of human impacts on the environment. While this paper promotes a higher rate of self-reliance, the process of achieving it can grow over time. The installation of kitchen gardens, water tanks or PVs can be done when a family is ready. This idea also follows the teaching of Sufficiency Economy and New Theory Agriculture, which recommend moderation, reasonableness, and self-immunity. Arising from the study, reduction in consumption also shows significant changes in environmental impacts. When a family can reduce the rate of consumption, it is more likely that they can produce to meet their needs.

The implementation of the philosophy of Sufficiency Economy is intended to encourage individuals to adjust their lifestyle and behavior. It also provides a rough idea of what households in Thailand with the same physical characteristics could achieve. This study selected only a single small house on a small plot to show what a family living in this type of house is able to achieve under the immediate circumstances. Becoming more self-reliant in suburban areas will not only help lessen the impacts on the environment in terms of energy and natural resources, but the better wellbeing of suburban people will also strengthen Thailand's national economic status.

Although the findings support the possibility of having a self-reliant lifestyle in suburbia, to achieve a completely self-reliant lifestyle should not be seen as necessary given the location and lifestyles of suburban people as compared to rural communities where access to infrastructure is limited. However, more achievements towards self-reliance are also important, because this can be used as a lesson for a better understanding of resource consumption and teach a family to be in control of their resource availability. Therefore, a family can be truly self-sufficient and content.

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