ระบบแนะนำการหมุนเวียนวัสดุเหลือใช้ทางการเกษตรโดยอ้างอ้างอิงความต้องการธาตุอาหารเพื่อรองรับการทำการเกษตรพอเพียง

A Recommendation of Side-Product Recycling for Sufficiency Farming Using Similarity of Nutrients

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บทคัดย่อ

ในการทำฟาร์มเศรษฐกิจพอเพียงนั้น การหมุนเวียนวัสดุเหลือใช้ทางการเกษตรเพื่อเป็นวัตถุดิบเพื่อใช้ภายในฟาร์มของเกษตรกรเอง ถือว่าเป็นแนวคิดหลักในการพึ่งพาตนเองและสร้างความยั่งยืนในการทำการเกษตรพอเพียงและถึงแม้จะมีเผยแพร่และแจกจ่ายแนวทางปฏิบัติจากภาครัฐในการใช้แนวคิดการทำเกษตรพอเพียงแต่ก็ปรากฏว่ามีเกษตรกรเพียงไม่กี่รายที่ประสบความสำเร็จจากการนำแนวคิดนี้ไปปฏิบัติ ประเด็นหนึ่งที่เป็นอุปสรรคสำคัญประการหนึ่งคือความซับซ้อนของการหมุนเวียนวัสดุเหลือใช้ทางการเกษตรมาใช้ให้เกิดประโยชน์ภายในฟาร์ม เนื่องจากมีวัสดุเหลือใช้หลากหลายชนิดที่เกิดจากกระบวนการในการทำเกษตรพอเพียง ซึ่งส่งผลให้เกษตรกรเองไม่สามารถตัดสินใจได้ว่าจะนำวัสดุเหลือใช้ทางการเกษตรใดมาใช้ร่วมกันเพื่อใช้เป็นธาตุอาหารที่เหมาะสมให้แก่พืชภายในฟาร์มได้อย่างเพียงพอ ทั้งนี้เราอาจต้องพิจารณาร่วมกับความต้องการธาตุอาหารที่จะแตกต่างตามพื้นที่ฟาร์มตลอดจนจำนวนของวัสดุเหลือใช้ทางการเกษตรที่ถูกนำมาใช้ภายในฟาร์ม งานวิจัยนี้ได้เสนอวิธีการในการเลือกใช้วัสดุเหลือใช้ทางการเกษตรที่มีความเหมาะสมกับวัตถุประสงค์ในแต่ละฟาร์มเกษตรพอเพียง โดยการออกแบบวิธีการนั้นผู้วิจัยได้ให้ความสำคัญกับปัจจัยที่มีผลกับความต้องการธาตุอาหาร เช่น ความแตกต่างของพื้นที่ฟาร์ม, ชนิดและจำนวนของพืชตลอดจนจำนวนของวัสดุเหลือใช้ทางการเกษตรที่เกษตรกรมีอยู่ วิธีการเริ่มต้นด้วยระบบจะคำนวณความต้องการธาตุอาหารของแต่ละฟาร์มเพื่อกำหนดความต้องการธาตุอาหารโดยอาศัยข้อมูลของเกษตรกรที่นำเข้ามาในระบบต่อจากนั้นในกระบวนการที่สองเริ่มต้นในการกำหนดชนิดและปริมาณวัสดุเหลือใช้ทางการเกษตรซึ่งเป็นตัวเริ่มต้นและเป็นตัวหลักโดยจะพิจารณาร่วมกับข้อมูลความต้องการธาตุของฟาร์มโดยมุ่งเน้นที่การเปรียบเทียบค่าความห่างที่น้อยที่สุดโดยพิจารณาระหว่างความต้องการธาตุอาหารของฟาร์มกับปริมาณสารอาหารในวัสดุเหลือใช้ที่ถูกเลือก สำหรับกระบวนที่สามเป็นขั้นตอนที่เน้นการเติมเต็มวัสดุเหลือทางการเกษตรชนิดอื่นๆ เพื่อให้ผลรวมของธาตุอาหารของกระบวนการข้างต้นได้ใกล้เคียงความต้องการธาตุอาหารของฟาร์มมากที่สุด โดยสามารถสรุปผลจากการทดสอบประสิทธิภาพภาพของวิธีการที่นำเสนอข้างต้นพบว่า 90% ของผลการทดสอบอยู่ในช่วงที่ยอมรับได้ โดยที่ประสิทธิภาพของคำแนะนำการใช้วัสดุเหลือใช้ทางการเกษตรจากวิธีการดังกล่าว ในมุมมองของการให้สารอาหารของวัสดุเหลือใช้ก็ได้ถูกปรับให้ค่าความห่างให้ใกล้เคียงกับความต้องการธาตุอาหารของแต่ละฟาร์มถึงแม้จะใช้วัสดุเหลือใช้ทางการเกษตรที่ผลิตเองในฟาร์มของเกษตรกรเองก็ตาม

คำสำคัญ: ระบบแนะนำ การหมุนเวียนวัสดุ เกษตรพอเพียง

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Abstract

In the Sufficiency Economy Farming, recycling side-product for feeding its own farm is the core concept of self-reliance and sustainability. Although practical guidelines to apply SEfarming concepts were published and distributed, few farm owners have adopted the concept and very few successfully achieve a result. One and the foremost issue is a complexity of material recycling. Since there are many waste types produced from the process, farmers cannot decide which waste or combination of wastes to be used. Based on the nutrition requirement differed from lands, it remains a puzzle on what and how many of wastes to be used that will be sufficient for plant to grow healthily. This work presents a method to assist in selection of appropriate wastes for farm objects. It is designed to dynamically support the difference in farm setting and available wastes in farm. The method starts with the determining a farm requirement based on user's input. The second is initial fertilizer assignment process, to start suggesting a waste and its amount, the output of nutrition requirement from the previous system plays an important role. The third is assignment of remaining nutrition process, The initial assignment is expected to fill majority of the nutritious requirement. From testing its potential, the results were outstanding as 90% of the test case were in an acceptable range. Quality of suggestion in terms of provided nutrients were closed to the requirement despite using wastes and side-products self-produced in the farm.

Keywords: Recommendation, Side-Product Recycling, Similarity of Nutrients

INTRODUCTION

The causes of the trouble are that the low price of the agriculture products are against the cost of required items in production such as seed, fertilizer, water, pesticide, storage and man-month wage. It is difficult to make profit with such heavy expenditures. The only viable and affectless option is to reduce the cost in production process so the farms can become sustainable.

To make a sustainable farming, several approaches have been invented. The most suitable for Thailand context is The Sufficiency Economy Farming (SEfarming) (Ministry of Foreign Affairs, Kingdom of Thailand., 2017), which is the application of the Philosophy of Sufficiency Economy to the agricultural sector initiated by His Majesty King Bhumibol (Office of the National Economic and Social Development Board, 2007). The major focus of the theory is for farmers to make sustainable cycle by optimizing the use of recyclable resources of their own and surrounding environment. The aim is to optimize farmland with a sense of reducing unnecessary cost by recycling waste within the agriculture process (The Chaipattana Foundation, 2007) so the farm can be self-sustained.

Although practical guidelines to apply SEfarming concepts were published and distributed, few farm owners have adopted the concept and very few successfully achieve a result. One and the foremost issue is a complexity of material recycling. The idea of waste recycle is to apply by products or wastes from production processes as a fertilizer or food within farmland. Since there are many waste types produced from the process, farmers cannot decide which waste or combination of wastes to be used. Based on the nutrition requirement differed from lands, it remains a puzzle on what and how many of wastes to be used that will be sufficient for plant and animal to grow healthily.

Objectives

1. To develop a method to suggest wastes and their amount based on nutrition standard and Sufficiency Economy Farming

2. To calculate a suggestion in side-product recycling based on individual settings including land area, farm size, farm part, and by product pool

3. To suggest appropriate amount of farm part that produces sufficient byproducts for sustainable recycling in case of lacking materials to recycle

Scope

This work applies the concept of Sufficiency Economy Farming; hence, the work focuses on four parts of farmland including rice farm, fruit farm, inland-fishery, and chicken farm. The natural side-products for recycling are those produced from the abovementioned farm parts. The nutrition requirement for plant is for soil of agriculture in Thailand.

SIDE-PRODUCT RECYCLING RECOMMENDATION FOR SUFFICIENCY ECONOMY FARMING

Overview and scope of this work

This work aims to solve a fertilization assignment problem about what side-product and how many of it to be used to feed the farms. The main objective is to select the side-product or combination of it that fits to nutrition requirement varied from individual settings (Chariyamakarn, Ruangrajitpakorn, Supnithi, & Boonbrahm, 2016). Since the existing suggestions are a suggestion served for general without specification, this work considers nutrition requirement based on standard requirement for chemical fertilizers. The main research question is to find the best combination of side-products, namely organic products self-gained in farming, to feed a farm in which can provide nutrition as much alike to chemical fertilizers (Sardi, 2009).

With the mentioned objectives, an overview of the system is designed as illustrated in Figure 1.

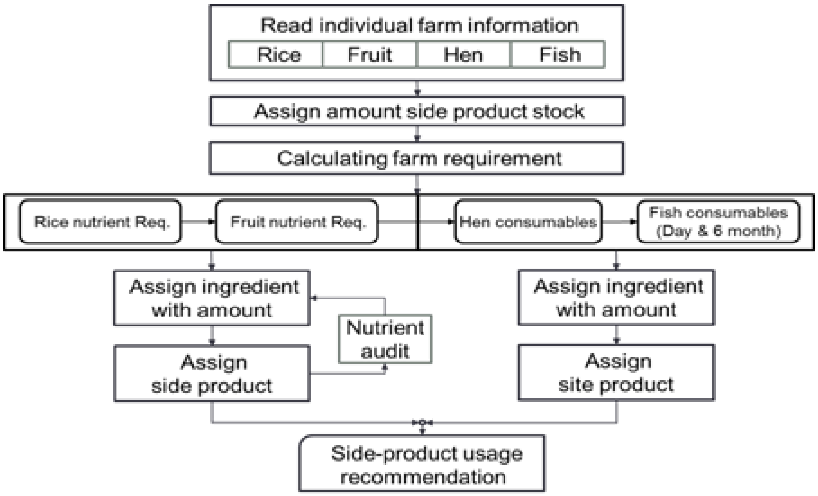

Figure 1 An overview of a system to suggestion a side-product recycling following chemical requirement standard

Requirement Finding

Nutrition requirement for Rice

Rice requires an efficient nutrition to grow and produce rice products. Generally, major nutritious substances for rice are nitrogen (N), potassium (P) and phosphorus (K) (Brady, Weil, (1999). These nutritious substances are normally collected in a soil; however, a volume of the substances is various from place to place. In cases of deficient nutritious substances, it is commonly appropriate fertilizers fitting to the lacking nutrition (McCauley, Jones, & Jacobsen, 2011) for improving farming result. Factors to calculate for nutrition requirement for rice are as follows.

• Nutrition in soil in range of high, medium and low:

1) organic matter (OM, which will be generated into nitrogen substance), 2) potassium (P) and 3) phosphorus (K) (Silva, & Uchida, 2000)

• Specie of rice based on classification of photoperiod sensitivity which only affects nitrogen requirement:

1) Photosensitive rice and 2) Non- photosensitive rice

The combination of these two factors can be summarized as shown in Table 1.

Table 1 Combination of factors for each rice-based nutrition requirement (Rice Department, 2009)

Nutrition in soil	Range of nutrition	Photoperiod sensitivity	Requirement per Rai (kg.)
OM	High	Yes	6
	Medium		12
	Low		18
	High	No	3
	Medium		6
	Low		9
P	High	-	0
	Medium		3
	Low		6
K	High	-	0
	Medium		3
	Low		6

UI for Requirement Calculation

Since each farm has different settings in nutrition in soil and other factors, the input from user is required for calculation. User Interface (UI) is designed to acquire the information from users. The design involves in dynamically asking only the information related to selected farm type (according to requirement calculation). Hence, those who have a rice farm will only need to input soil information, rice specie, area size of rice farm without bothering with information of other types of farm. Snapshot of the UI is given in Figure 2(A).

In this part, not only farm information is asked from users, a stock of side-product is also inquired. A stock of side-product plays an important role in later processes since it will limit an amount of possible uptakes for using in a farm as input. For example, we cannot ask farmers to use chicken dung for fertilizer if they do not have it, hence; other side-products will be suggested instead. The UI to ask for a stock of side-product is given in Figure 2(B). As default, all side-products are ticked with pre-set amount for ease of testing. Though a nutrition values used in a system are applied from reliable sources, we also aware that nutrition value produced from side-products can be varied and provide an option (right side option shown in the UI) for user to edit the value fit to actual value if they have their own information.

Figure 2 A screenshot of UI for inputting farm information (A) and inputting a stock of side-products (B)

Initial Fertilizer Assignment

To start suggesting a waste and its amount, the output of nutrition requirement from the previous system plays an important role. The nutrition requirement is the main input for this part along with a stock of available resources as another input. Please be reminded that an organic side product of the farm always yields more than one nutritious input as nitrogen (N), potassium (P) and phosphorus (K), and these three cannot be separated calculated.

To select the first waste fitting a requirement, a percentage proportion of N, P and K from a requirement is calculated using (1).

$$Nr = N/(N+P+K)$$
$$Pr = P/(N+P+K) \quad (1)$$
$$Kr = K/(N+P+K)$$

Let N, P and K refer to nitrogen, potassium and phosphorus value generated from requirement calculation respectively. Then, a percentage ration of N, P and K respectively can be formed. Moreover, a nutritious percentage proportion of wastes is also calculated using

(1) as a representative of how much nutrition is provided per kilogram. With the results of (1) to a list of organic wastes from Rice Department of Thailand (Food and agriculture organization of the united nations, 1991) a nutritious percentage ratio of each waste is obtained and shown in Table 2.

Table 2 Examples of nutritious percentage ratio of organic wastes available in SEfarming for recycling

Organic Waste	Provided N/100Kg.	Provided P/100Kg.	Provided K/100Kg.	Percentage Ratio (N:P:K)
Rice straws	0.59	0.08	1.72	24.69 :3.35 :71.97
Rice husk	0.46	0.26	0.70	32.39 :18.31 :49.30
Rice-dust	2.71	0.68	0.59	68.09 :17.09 :14.82
Rice-bran	1.22	0.91	1.09	37.89 :28.26 :33.85
Broken-rice	2.71	0.56	2.47	47.21 :9.76 :43.03
Chicken litter	2.12	2.63	2.81	28.04 :34.79 :37.17
Hen dung	2.42	6.29	2.11	22.37 :58.13 :19.50
Pond soil	1.80	1.32	1.28	40.91 :30.00 :29.09

Then, a comparison in each nutrition type of a requirement and each side product is conducted using (2) to find the gap.

$$G\_i=|(N_r-N_i)|+|(P_r-P_i)|+|(K_r-K_i)| \quad (2)$$

Where G represents a gap value and i indicates each of available side-products. A value in the Gi represents a different in a percentage ratio of a requirement and the side product. The higher the value is, the greater in the difference becomes. In this process, a side product that produces the minimum Gi value is considered as the best candidate for filling as a main ingredient. Thus, the system selects the side-product with the lowest Gi as an initial ingredient.

Another puzzle is an amount of the selected side-product. Though the selected side-product is the best to fertilize as it is nearest to a requirement, there is a gap; hence it cannot satisfy the requirement for solely filling it. The Gi value is then again exploited to calculate for the percentage amount of the selected side-product. Because the gap stands for the difference, a reverse of it can be used to how resembling they are. Thus, we apply (3) to gain the percentage amount for amount calculation.

$$S=100-G_i \quad (3)$$

The percentage amount is then used to assign an amount of the selected side-product in following steps.

1. Calculating S
2. Calculating amount from S from N, P and K value of the side-product
3. Selecting the LOWEST amount among three results of N P K value

For example, let's assume that S is 85, and the selected side-product for ingredient is pond soil. The requirement is 3:3:3 for N, P and K, respectively. So, for N to be filled, 3 will be divided by 1.80 and multiply with 100 (since the nutrition value is based on nutrition for 100 kg.) to obtain 166.67. The 166.67 will be set for 85% calculation (from S) for 141 (round down number). Hence, the amount of the ingredient based on N is set for 141 kg. With same method, P is 193 kg, and K is 199 kg. The lowest amount among these three is thus N, and the amount will be selected. The reason to select the lowest is because the lowest possible amount can provide significant space for more ingredients as much as possible and will not exceed the limit of other nutrition unless they are zero.

Assignment of remaining nutrition

The initial assignment is expected to fill majority of the nutritious requirement. However, the leftover requirement is still needed to be filled. This process is similarly designed to the previous process, but the difference is that this process will continue to add side-product(s) until fulfilling the requirement.

With the initial ingredient, the leftover requirement is again calculated to find a percentage proportion of N, P and K using (1). Since the requirement is not the same, a percentage proportion is therefore changed and is called as a 'remaining requirement'. In fact, a Remaining Requirement is updated every time if there is a change of ingredients in a feeding assignment including changing to another and adding a new side-product or adjusting amount of existing. The change will affect to the decision of selecting the most fitting side-product based on the difference in nutrition.

In this part, the system aims to select the side-product(s) that will mostly fill the requirement. A method does not limit a number of side-products. The method focuses on the difference in a gap in nutrition of requirement and filled-in ingredients. A method is to compare a set of selected ingredients with another as two different paths.

The first path is to select one side product as another ingredient for fertilizer. The selection determines the least gap calculated using (2). An amount of the selected side-product is calculated by following methods.

1. Finding the highest nutrition value among N, P and K as nutrition representative (R)

2. Calculating amount of R to fully fill the requirement of the same nutrition using following calculation: Amount of R = Remaining Requirement divided by R

3. Rounding down a decimal number

For example, if the selected side product is chicken dung, an Nr of chicken dung according to Table 2 is P (potassium) since nutrition value of P as 6.29 is highest among N, P and K. Assuming that the remaining requirement is 50, the calculated amount is 7.949 from 50 divided by 6.29. An amount for use is rounded down to 7.

Thus, the first path is to add up a new side product to fill the rest of a remaining requirement. An efficacy of the addition can be calculated by a gap value acquired by (4).

$$Gap=(|Nr-\sum_{i=1}(N_i \bullet A_i)|+(|Pr-\sum_{i=1}(P_i \bullet A_i)\ |+(|Kr-\sum_{i=1}K_i \bullet A_i)| \quad (4)$$

Where Ni indicates N nutrition value of i^{th} selected ingredient as so P_i and K_i • A stands for an amount of i^{th} selected ingredient. Gap is a total result of nutrition difference of their respective substances of all ingredients with their amount and the requirement. The gap value is in range of 0 to infinity. The lower is the better.

The second path is to reduce an amount of the added ingredient for one-quart as a room for another ingredient. Another ingredient is selected using Ingredient Selection method mentioned above with the updated requirement of reduced amount of the latest ingredient. The process to fill the space is same as the first path with a condition that cannot select the same ingredient as the first path. The GAP of first path and second path is then compared, and the lower value wins the comparison. If the first path wins, the process is done. Otherwise, the process is continued as the second path becomes first path in the next iteration, and the last ingredient will be reduced with the method for second path. The process is continued until the first path won or there is no side-product left for ingredient.

EXPERIMENT AND RESULTS

This section provides a testing of the proposed method to see how can it perform. It includes experiment settings and demonstrative results.

Experiment Settings

Since this work aims to support farming following Sufficiency Economy Farming, the selected test case must consist of at least 3 farm parts out of all 4 parts while the mandatory parts are rice farming and the fruit part is mango. The farm instances for testing were retrieved (in November 16th, 2017) from http://www.rid7.com/agriculture7/page/main.php that matched the aforementioned conditions. There are total of 20 farm instances that past the conditions. Inputs of the methods are farm settings including 1) available farm parts, 2) soil information, 3) rice specie and 4) farm stock. Since information of farm stock is not provided, an estimation of stocks was calculated following a production rate (Food and agriculture organization of the united nations, 1991) given in Table 3. Related details of 20 farm instances are given in Table 4.

Table 3 Examples of details of farm instances

Types	Stock Estimation
Rice product	Based on rice specie from RKB website
Rice-straw	630 kg. per rai
Rice-husks	24% of rice product
Rice-dust	7% of rice product
Rice-bran	3% of rice product
Broken-rice	20% of rice product

Table 4 Examples of details of farm instances

Farm ID	Soil Information			Rice Farm Information	
	OM	**P**	**K**	**Photoperiod Sensitivity**	**Paddy field size (Rai)**
1	Hight	Mid	Mid	Yes	2
2	Hight	Mid	Low	Yes	4
3	Mid	Low	Low	Yes	5
4	Hight	Mid	Low	Yes	3
5	Mid	Mid	Low	Yes	8

Suggestion Results

With 20 instances, methods were tested for suggestion. Results of each farm part are separately given for clarification. Even though all 4 parts were tested, the main focus of this work is plant-based farms, i.e. rice farming and mango farming since the proposed method involves mostly in fertilization. Hence, results of plant farming are given in more details.

For plant farm, an indicator of effectiveness is a gap value that indicates the difference in provided nutrients and requirement. The gap value is in range of 0 to infinity while the best is 0 meaning the same in value of provided nutrients and requirement. To normalize the gap value from difference in a rice farm size, a size of paddy field then is used to divide the gap value to represent a gap for the same standard. A category based on gap value is created to represent it into incomprehensible quality as given in Table 5.

Table 5 Conditions for suggestion quality based on an acquired gap value

Gap value	Suggestion Quality	Definition
<1	Perfect	Suggestion can provide nutrient very closely to requirement
≥1- <5	Excellent	Suggestion can provide nutrient closely to requirement
≥5 <10	Good	Suggestion can provide nutrient fairly close to requirement
≥10 - <15	Moderate	Suggestion can provide nutrient to middle requirement **(cut-off point)**
≥15- <20	Weak	Suggestion can provide nutrient slightly to requirement
≥20 - <100	Bad	Suggestion can provide nutrient far to requirement
≥100	Unacceptable	Suggestion can provide nutrient very far to requirement

Rice Farm

To indicate a difference and a value of processes, three experiments were conducted. The first is to process a suggestion without doing amount adjustment. This shows an ability of side-product selection with estimated amount. The second is a combination of side-product selection and amount adjustment. The last only used amount adjustment method to create a suggestion. This setting were set for all available side-products from 0 so it can choose to adjust an amount of any ingredient until stop criteria are met. For a result, a list of ingredients with amount and obtained nutrients are provided. The gap value and quality are used to indicate efficacy of the suggestion. Results without processing with amount adjustment of rice farms are given in Table 6.

Table 6 Examples of suggestion results of rice farming

Farm ID	Recycle Suggestion	Requirement (N-P-K)	Obtained nutrients (N-P-K)	Gap value	Quality
1	• Rice-dust (17 kg.) • Rice-bran (22 kg.) • Chicken dung (3 kg.) • Poultry litter (155 kg.) • Pond soil (106 kg.)	6-6-6	N=5.9957 P=5.9802 K= 6.1157	0.1398	Perfect
2	• Rice-straw (377 kg.) • Rice-husks (546 kg.) • Poultry litter (487 kg.)	12-12-24	N=15.0603 P= 14.5293 K= 23.9911	11.6635	Moderate
3	• Rice-bran (99 kg.) • Poultry litter (300 kg.) • Pond soil (1246 kg.)	30-30-30	N= 29.9958 P= 25.2381 K=25.4579	10.3424	Moderate
4	• Rice-husks (538 kg.) • Rice-bran (67 kg.) • Poultry litter (375 kg.)	9-9-18	N= 11.2422 P= 11.8710 K= 15.0338	8.9771	Bad
5	• Rice-bran (99 kg.) • Rice-husks (596 kg.) • Broken-rice (496 kg.) • Pond soil (1700 kg.)	48-24-48	N= 47.9910 P= 27.6681 K= 39.2623	10.3457	Moderate

DISCUSSION

In this section, results are discussed to explicate potential and limitation of the proposed methods.

Potentials of the proposed method

The proposed method produced recycling of side-products for feeding within farms as suggestions. In this work, the focused farm is rice farm since rice product is the major goods needed in domestic market and export market. The indicator of quality of the suggestion is the gap value calculated from nutrient requirement and provided nutrient of a suggestion, and it is graded into quality. The 20 farms in testing yielded the summary results shown in Figure 3.

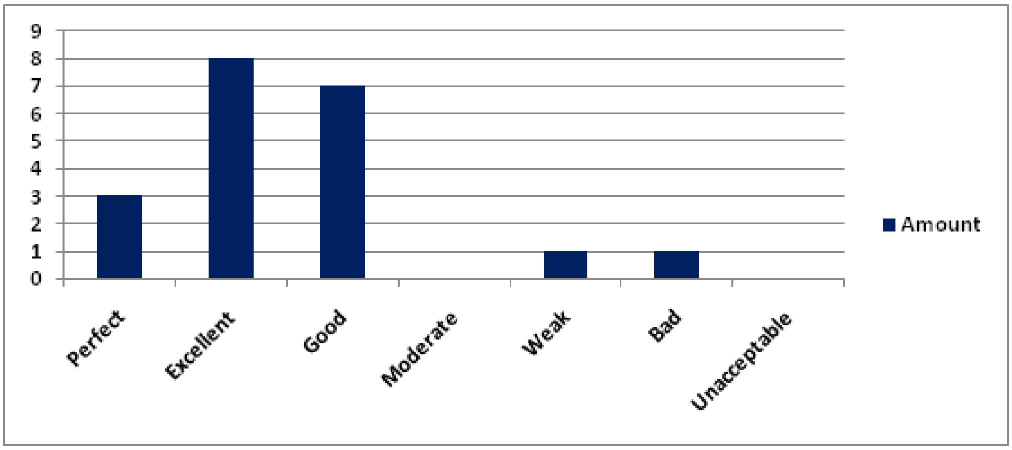

Figure 3 Result amount in quality grade

In the point of acceptable result, any grade beyond moderate is preferred. In the testing, 18 farm settings (90%) obtained an acceptable result based on expert's opinion. However, it is the best to acquire the perfect grade, but due to specification in settings it cannot be achieved. The obstruction from limitation includes the limit of ingredient stocks and difficulty of settings (will be discussed separately in later section). For the first issue, based on the SE farming theory, the input for feeding the farm should be the side-products acquired within the farms itself. However, it happens that the most suitable ingredient for some cases is insufficient for using; hence an optimal solution is yet produced. In that case, we rerun the system for all the cases with unlimited resource to find the optimal solution. Moreover, the result of rerun can be a good representative for the case of organic farming (farming without a chemical fertilization) since they do not care on recycling but have a certain specific input as natural product. The rerun results in quality grade comparing to the original settings are given in Table 7.

Table 7 Comparison results of original settings and unlimited resource settings for all test cases

		Original settings (stock limited to farm size)						
		P	E	G	M	W	B	U
Rerun (stock is unlimited)	P	0	2	0	0	0	0	0
	E	4	2	0	2	0	0	0
	G	1	2	2	0	0	0	0
	M	1	0	0	0	0	0	0
	W	0	0	0	0	1	0	0
	B	0	0	0	0	0	0	0
	U	0	0	0	0	0	0	0

The result shows that there are improved grades in 2 cases. The improvement signifies that the stock number is the cause of the issue. To make use of this finding, it is best to find the difference in required ingredients for optimal result and the suggestion, and a recommendation of stocking or increasing farm to produce sufficient stock can be done.

CONCLUSION AND FUTURE WORK

From intensive reviews, existing researches were focused on providing related knowledge and information to farmers to learn the best practice in farming for specific plants. Another type of researches is to apply automatic detection of essential features that may affect a production outcome of a farm. In addition, no research has been done for using IT to support Sufficiency Economy Farming beside our works. Hence, we decided to work on this task. After that, a review of nutrient for farms was studied along with Sufficiency Economy Farming practice. The obtained knowledge from the intensive study has been a core for designing the proposed methods ever since. The knowledge led us to realize the importance of major nutrition (nitrogen (N), potassium (P) and phosphorus (K)) required in growing plant and the effect of lacking the nutrient. Furthermore, the difference in settings such as base soil and plant specie of a farm was able to determine the requirement for a farm.

Design of the method is to consider the different settings and available ingredients based on the practice of Sufficiency Economy Farming. The method starts with the determining a farm requirement based on user's input. The requirement is nutrient values in which are used for deciding an ingredient most similarly provided nutrient values to the requirement. The process in selection and amount estimation are iterative until the lowest gap is achieved. Once, ingredients and their estimated amount were finalized. The amount of each ingredient is adjusted mathematically with three functions as adding, reducing and a combination of adding and reducing. The final result is a suggestion in recycling the available side-products for feeding the farm.

From testing its potential, the results were outstanding as 90% of the test case were in an acceptable range. Quality of suggestion in terms of provided nutrients were closed to the requirement despite using wastes and side-products self-produced in the farm. When comparing to the existing approaches of recycling designed by experts, the outcomes of the proposed method were all better.

The limitation of the proposed method was analyzed. We found that two discussed points. The first one comes from the issue of insufficient side-product stock. The amount in stock was a list of available ingredient for filling the suggestion. Since the practice is strict to allow using the thing produced within the farm for self-reliance, it affects in insufficient ingredients for most suitable one in failing case. Another test was conducted with unlimited resource settings and yielded the better and acceptable results for such cases, and signified that the lack of resource can be caused the fail in suggestion. The second is about the practical usage of the method. In testing, nutrient values of side-products were retrieved using the estimation provided by reliable source. However, the values are the core in calculation and the slight vary in the value can make a major difference of the suggestion results. Hence, the correctness of the suggestion heavily relies on the correctness of the nutrient values. Though we provide the option to edit the values for obtaining the actual values for correct outcome, the values are difficult to obtain and costly for users.

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