Group 5

DEVELOPMENT OF RURAL AREA BY OIL CROP

Small Scale and Diversified Agriculture of a Non-Profit Organization at Ibaraki : The Strategy and Challenges

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CONTENT

EXCECUTIVE SUMMARY

Our study aimed at identifying current issues face by a rural oil cropping project and tried to propose solutions that may solve them. The objectives are: (a) to identify the key success factors of this rural oil project consisting in a NPO, Biolife, producing cooking oil and make a comparison with Shizuoka's waste management companies, (b) to acknowledge the current issues faced by the NPO along the supply chain on production, marketing, as well as waste management, (c) to propose solutions to solve current problems faced by this NPO and adapting best practices from industry in Shizuoka prefecture when possible, also (d) to keep the values put forward by Biolife (rural development, social link, environmental concerns) in our solutions proposed to increase its profit.

This study was carried out by visiting the non-profit organization Biolife, a small-scale company producing vegetable cooking oil in Ryugasaki, Ibaraki prefecture, as well as companies recycling waste from larger agricultural and beverage industries in Shizuoka. All these companies were small-scale companies promoting sustainable activities related to agro-food business but facing different issues slowing down their growing. While Biolife's activity is mainly limited by the availability of raw material and human resources, the companies in Shizuoka face a lack of competitivity preventing them to reach a higher scale of waste recycling.

This report is focusing on the case of Biolife, providing some ideas based on a solid analysis of the NPO in its context. These ideas are listed in five major proportions which are facilitating cooperation among farmers and encouraging farmers to grow rapeseed, utilizing uncultivated farmlands, increasing machine capacity utilization, increasing participation of members, and improving the economic value of rapeseed oil waste.

It appears that Biolife should especially maximize its current capacity mainly consisting in the presence of many available lands, an underused processing machine, members and non-members that can get more involved in cropping activities, and regarding the strategy of Shizuoka's companies for a better waste management. This study ends with a final analysis that enlightens both advantages and drawbacks of the solution we humbly propose to Biolife.

INTRODUCTION

Having a long history in agricultural production, Japanese individuals have been adamant in preserving the physical, cultural, and traditional aspects of agriculture. Thus, as a result of protecting the local agricultural production, high tariffs have been set, which has caused the Japanese market to be extremely difficult for other countries to enter. With this, agriculture has rapidly become a minor sector of the Japanese economy, allowing manufacturing, technology, and exports to be the main influencers of the overall Japanese GDP. This decline in the number of employment shares, and GDP shares involved with agriculture has been seen from 1960, despite Japan being a developed industrial nation. 28% of the labour force had been employed to support the 9% agricultural production within the Japanese economy, of which 50% derived from the production of rice. However, over the course of 45 years, in 2005, the employment share decreased to 4.0%, causing the share of agriculture in GDP to fall to 2.0%, as well as the production of rice, decreasing to 23.1%, which was lower than the production of vegetables at 23.5% **(Figure 1).** This has a caused a shift within the value of production, where the value of rice has fallen almost half, whilst fruit and vegetable production has increased almost double.

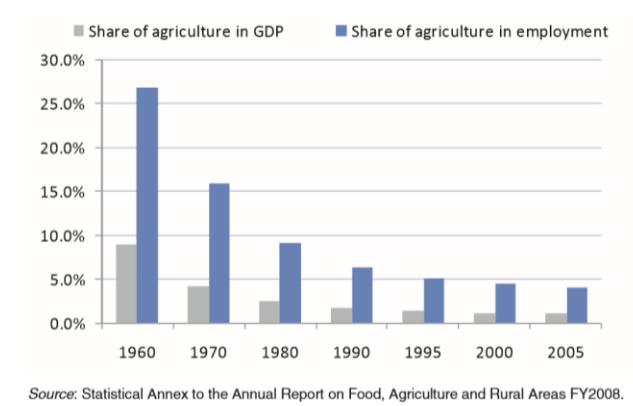
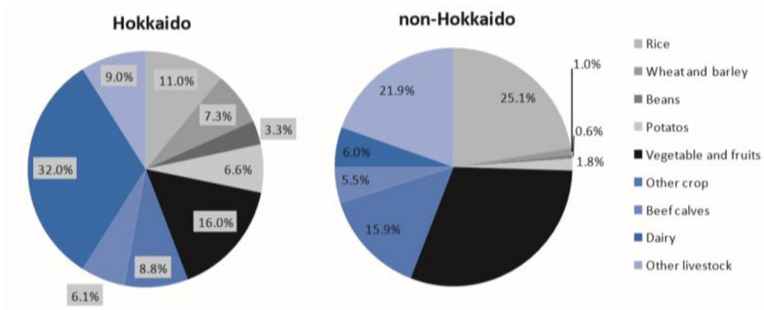


Figure 1. Contribution of agriculture to the economy, 1960-2005

With rice being the main staple in Japan, rice production has always been considered as being the core product of Japanese agriculture. However, with a shift in diet to westernised foods, beef production and vegetable production has grown substantially. Livestock has increased from 18.2% to 30.1% over a course of 50 years. As a result, when looking at the agricultural production within Japan, including Hokkaido, dairy, vegetable and fruits, and rice are the main factors respectively **(Figure 2).** Other agricultural production occurring within Japan mainly consists of;

rice, wheat and barley, beans, potato, vegetable and fruits, beef calves, dairy, and other livestock and crops. When comparing the agricultural development from 1960 to 2010, on one hand, the average size of farms that grow rice has increased to almost double, whilst on the other hand, the average size of dairy farms has increased up to over 30 times. This further supports the fact that the production in dairy has grown at an extremely fast rate due to the shift in demand (**Table 1).**



Source: MAFF.

Figure 2. Composition of agricultural production in Hokkaido and other regions in 2005

Table 1.

Table 4. Change of agricultural scale

		1960	1970	1980	1990	2000	2010
Rice planted area(a)		55.3	62.2	60.2	71.8	84.2	105.1
Number of dairy cattle		2.0	5.9	18.1	32.5	52.5	67.8
Management cultivated area	Whole Japan except for Hokkaido	0.77	0.81	0.82	1.10	1.21	1.42
(ha)	Hokkaido	3.54	5.36	8.10	10.8	14.3	21.5

Source: Ministry of Agriculture, Forestry and Fisheries "Agricultural census"

Note: A management cultivated area and the rice planted area after 1990 show numerical values of the sale farmhouse where a management cultivated area is more than 30 ares or farm products sale amount of money is more than 500,000 yen).

There is a high demand in vegetable oils, mainly palm oil, rapeseed oil, and soybean oil in Japan for consumption purposes, as of 2016 respectively **(Figure 3)**. Palm oil is usually used for processed products, such as; instant noodles, and chocolate, whilst due to its health benefits, and high oleic acid content, rapeseed oil is commonly used for at-home cooking purposes. Finally, soybean oil is commonly used in industrial or commercial settings, usually in combination with other oils, such as sesame oil. Though quantity is limited, vegetable oils are often recycled in Japan, and used for biodiesel fuel purposes **(Table 2)**. Therefore, within Asia, the supply of vegetable oils in Japan is relatively high, being the second largest consumer after South Korea since 2005.

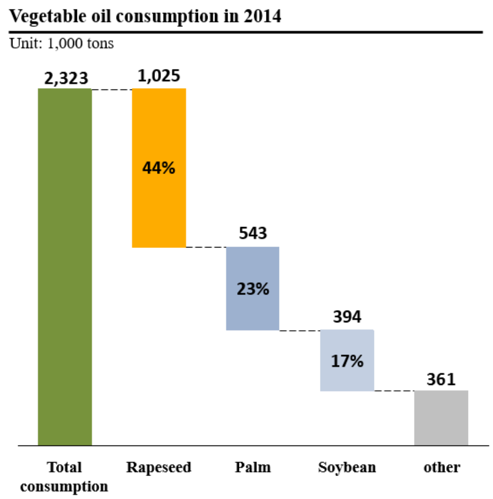


Figure 3. Vegetable oil consumption in 2014 (USDA)

Table 2.

Table 5. Vegetable oil consumption in current year 2014 (MT 1000)							
Oil	Home*	Professional*	Processed food	Total food use	%	Non-food use	Grand total
Soybean	30	169	195	394	17%	26	420
Rapeseed	307	64	371	1025	44%	56	1081
Palm	15	78	449	543	23%	92	635
Other	58	264	192	361	16%	143	504
Total	410	575	1207	2323	100%	317	2640
%	16%	22%	46%	88%	-	12%	100%
Source: MAFF oil and fat market annual report by in 2015 *: Post estimate							

In the case of rapeseed oil, despite consumption being high, oil production in Japan has been declining since 1989, due to the introduction of cheap rapeseed oil from Canada and Australia, as well as the general decline in individuals involved in agriculture **(Figure 4)**. Whilst national production has been decreasing drastically, importation of rapeseed has been increasing, of which, in 2007, 2.5 million tons of rapeseed was reported to have been imported to Japan from Canada and Australia **(Figure 5)**. As a result of this, the number of rapeseed farms have dropped to 108 hectares and 83 farms, only producing 996 tons of rapeseed, which means that Japan only produces 0.05 percent of the combined total amount of rapeseed. Although the amount of used oil may not be sufficient for the purpose of biofuel, there are alternate procedures in using the waste product.

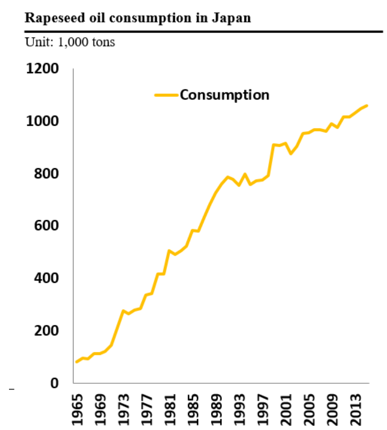


Figure 4. Increase in Rapeseed oil consumption in Japan from 1965 to 2013

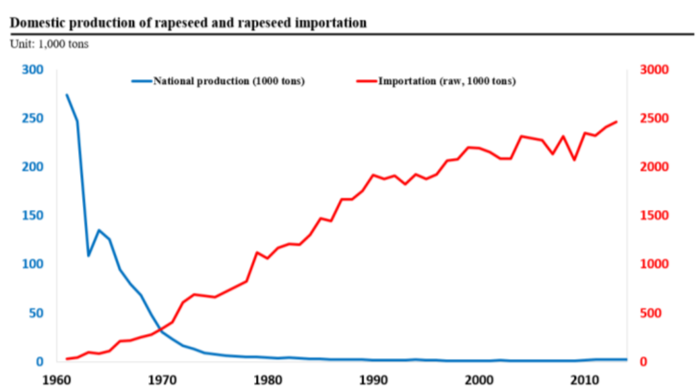


Figure 5. National production in Japan decreasing, whilst importation has been increasing from 1960 to 2010

Founded in 1988 in Aito-cho, Shiga prefecture, Nanohana Project was created as a mean to encourage individuals to become a recycle-based society. There are two main factors that are considered to be influential of the construction of this project, one of which occurred 11 years prior to this. In 1977, there was a breakout of red tide in Lake Biwa, in Shiga prefecture, causing a “Soap Movement” to come in place. In order to prevent the direct disposing of oils, individuals were encouraged to collected the used cooking oil and create soaps, resulting in a “recycling cycle”. The second factor was from the influence of a program that had been established in Germany. The "Rape Seed Oil Program", encouraged individuals in Germany to utilize and circulate the rape blossoms within the community. Rape Blossoms are commonly used as a rotational crop with wheat, rice, or peas in Europe. Therefore, after the extraction of oils from rape blossoms, the German program proposed that it was best to find alternate purposes in the waste product from the plant.

The Nanohana Project now consists in 129 organisations from all over Japan. It aims to have a larger participation and cooperation base, in order to construct a recycling-based society. In doing so, it is believed that it will not only allow communities to become more tight-knit by being a recycling-oriented society, but also, having a reductive effect on the CO_2 emission. The Nanohana Project is based on a resource recycling cycle, where after the rape flowers have been harvested, and oils have been extracted, the compost either is used as animal feed, fertilizer. The oils extracted are either directly sold to consumers or used for commercial purposes, and the used oils are then collected and reprocessed, leading to them being used as fuels or for agricultural purposes **(Figure 6)**.

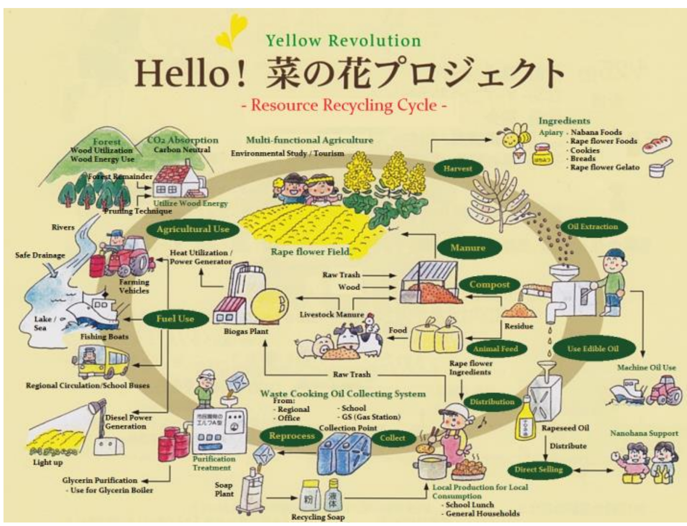


Figure 6. Scheme of Nanohana project as the agricultural-based society recycling model that has been implemented in Biolife

The outline of the project consists in five different points, those being the following. The rape blossoms are to be planted in crop-rotating rice fields, thus having an original purpose for the production. The cooking oil is to be manufactured from harvested rape blossoms, and the used oil is to be collected as an ingredient for soap or fuel for vehicles such as; fishing boats, farm tractors, automobiles, etc. The oil cakes, or the waste product from the rape blossoms that have undergone the oil extraction, is to be utilized as fertilizer or feed, and finally, the excrement from livestock is to be used as manure for agricultural production.

The Nanohana Project continues to expand with the growth in awareness of the aim of the project. The organisation also encourages this expansion by organising, for example, in April 28th 2001, a "Rape Seed Summit" in Shiga Prefecture, where 500 individuals from 27 different prefectures participated. Organisations involved in the project are only involved in certain aspects of the cycle, thus supporting the main aim being to create a recycling-based society with the influence of other individuals. An NPO named "Biolife" is one of the organisations involved in the Nanohana Project, and focuses mainly on the harvest of rape blossoms, the production of rapeseed oil, and the by-product used as feed for livestock.

After visiting the Biolife organisation located in Ibaraki prefecture, a proposal can be made for the expansion of the NPO and production.

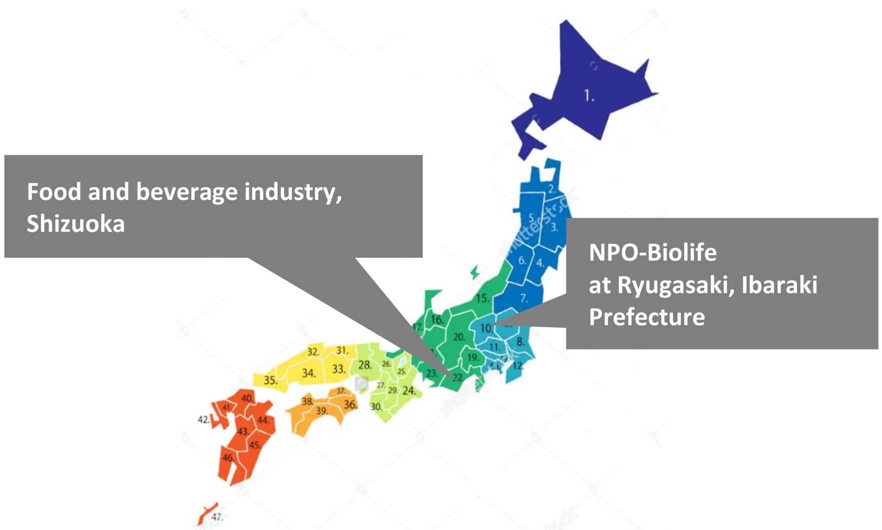


Figure 7. Location of study trip

BIOLIFE:
RURAL VEGETABLE OIL INDUSTRY

Bio-Life is a non-profit organization (NPO) that was established in April 2008 and led by Fujio Shiokawa. This NPO is located in Daedeok-cho, Ryugasaki City, and southern Ibaraki Prefecture. The NPO with the slogan **“wheel of bio-life"** is aiming at creating one model of a recycling-based society in this region. The project promotes food self-sufficiency by developing plant cultivation system in non-productive land. It is taking advantage of local resources (people, land, and facilities) in order to produce sustainable, valuable product and energy for local consumers, particularly by producing oil crop. All of those inter-relating activities among landlord and producer will stimulate economic advancement in this region. Thus, by establishing this model, this community’s life could become more independent from international companies or globalization, thus recreating social link.

Besides producing vegetable oil as a key activity, this NPO also work on environmental conservation. Those purposes are implemented through the utilization of idle, devastated or abandoned farmland in Tsuchiura region for more economical value by planting biomass crops and establishing vegetable oil industry. Maintaining land area for rapeseed cultivation as winter crop also provides soil protection from wind erosion during winter as it improves rural landscapes.

The overall oil crop production relies on the participation of community’s members. Recently, there are around 40 to 50 members from different background which is categorized as farmers and non-farmers. Farmers who join Biolife have to allocate some part of their land to grow oil crop, whereas other members who have no experience in agriculture give their unutilized land.

Oil crop production

Various crops are cultivated such as rapeseed, sunflower, and soy for oil production. Oil crops cultivation is conducted once a year in an organic way without using any chemical fertilizer and pesticide or herbicide. Chicken manure and magnesium lime are applied in combination as fertilizer during sowing in February/March. Harvesting time is carried out in June. Ripe rapeseed grain is harvested using combine, whereas sunflower grain is manually harvested to avoid possible losses up to 50% in comparison with mechanical harvesting. Currently, 5 ha are cultivated out of the total land in Toride region that is available for agriculture while the rest of 25 ha is unutilized.

The production cost of cultivating oil crops are particularly for buying organic fertilizer and mechanization. Moreover, there is no labor cost for sowing since farmers basically do themselves. The total of expenditures is described in details below.

Table 3. The expenditure for cultivating oil crops on fertilizer and harvesting machine

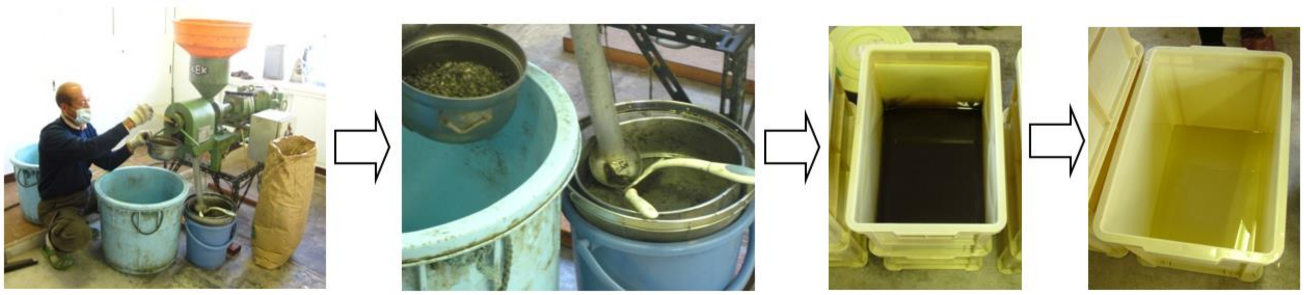
Expenditures	Volume	Price
Chicken manure	3 bag x 0,1 ha	200 yen/50 kg
Mg lime	5 bag x 0,1 ha	400yen/bag
Rental combine machine	0,1 ha < 30 min	5000 yen/hour

Vegetable oil production

Biolife produces high-quality unrefined vegetable oils in the form of extra virgin canola oil and sunflower oil. Rapeseed and sunflower grain from their own farm are used as raw material. Oil extraction process is conducted solely by mechanical cold-pressing method in several stages as follows: grinding rapeseed grains and pressing the oil content by a milling machine, storing oil at room temperature to precipitate impurities, filtering the oil seed using high-quality filter paper, and finally the oil will be stored $4^{o}C$ refrigerator for a week as second precipitation processes to allow impurities that can spoil the flavor to settle.

The milling machine that is used for those steps needs to be warmed up to $70^{o}C$ prior extraction in order to avoid the clogging problem. The grinding and pressing rapeseed grains have to be carried out twice to increase the oil recovery rate that remains after the first grinding operation. Pressed cake resulted from the oil production is collected below the perforated chamber. Filtration paper in the filtering process can be replaced up to six times to ensure producing pure clean oil. Quality assurance for the presence of impurities in the oil product is only depends on the human eye. Rapeseed and sunflower oil produced can be stored at room temperature for a years and a half without additional preservatives.

As the manager said that the production capacity of oil extraction is around 10 tons of rapeseed and sunflower ripe grain in the previous year. Extracted oil recovery of rapeseed and sunflower is about 30% and 25% relative to the grain weight, respectively. Based on this information, it can be assumed that the production rate of the factory is nearly up to 17.000 bottles of 175 ml oil volume per year for rapeseed and sunflower oil each. Currently, the market demand is higher than the current production rate. Those vegetable oil products are entirely marketed by the internet and direct selling in the supermarket. Besides doing oil extraction for their internal production activities, Biolife also acquiring additional profit by providing oil extraction service for other farmers.



(a) **(b)** **(c)** **(d)**

Figure 8. Oil extraction process. Grinding rapeseed grains and pressing the oil content (a,b), filtering the oil seed using high-quality filter paper (c), extra virgin oil product (d)

Waste management

The rapeseed oil extraction generates a large amount of by-product in the form of rapeseed pressed cake. Rapeseed oil extracted at 30% of recovery rate of the highest value while other remains are considered as waste. Recently, the total of rapeseed oil waste has been treated for further use as fertilizer. Other "go green" activities of Biolife consist in collecting and recycling cooking oil waste for the production of biodiesel fuel. This eco-fuel has been distributed to Ushiku city and other company and should be used for city cars or buses, bus, and/or truck.

Further development

Realizing the vast benefit of community-based economic activities that has been implemented in this NPO, there are more applicable ideas for further development. First is to expand the production of food from oil crop such as tofu and natto, also another product type of vegetable oil-based so-called environment-friendly detergent. The second is to establish solar panel system in combination with agriculture. Solar panels are a great energy supply for a small local community that can then produce and consume energy independently. This integrated solar panel system has been started since 5-6 years ago based on the experience of farmers in Ushiku city. This panel is designed to a higher level around 3 m height close to surface soil with some space between the rows of solar panels. Solar panels in higher position enable the cultivation of some vegetables by providing some shade but with enough sunlight. The reduction of solar light up to 50% is the suitable condition for planting less light-intake crops such as kabocha pumpkin. One panel is supposed to generate 12 KW of electricity.

UTILIZATION OF BY-PRODUCT DERIVED FROM BEVERAGE INDUSTRY IN SHIZUOKA

Shizuoka prefecture has the highest beverage production in Japan. For the companies there, disposal costs for the solid waste production are an important problem. Accordingly, an attempt on reusing and recycling that waste-product is carried out by some companies we visited.

Ryokusan: Composting coffee ground and tea husk waste

Located in Izunokuni city, Ryokusan is a private company that had been founded 40 years ago, and focusing on utilizing industrial beverage waste to produce composted soils as fertilizer. By-products are used particularly in the form of coffee ground and tea husk. Whilst other compositions include the use of rapeseed oil waste and rice bran in portion of tea husk (20%), rapeseed oil waste (15%), and rice bran (65%). Rapeseed oil waste, coffee ground, and tea husks as raw material for producing composted soils are obtained freely from rapeseed oil and beverage industry. Sometimes, they also get paid for composting. Whilst they still have to buy rice bran from rice storing shops.

The composting process is carried out by two sequential steps of fermentation involving natural microbiome activities. During the fermentation process and soil rotation, air is blown through the compost from underground pipes. The whole fermentation process takes around 3 months, producing dried composted soils. Through this process, the moisture content of husks will be reduced from about 80% to about 35%. This results from the decreasing of microbiome activities, not consuming nitrogen substances in the soil anymore.

There are 5 types of composts depending on the mixture of raw material that are [N] 4.0, C-G compost, T-G compost, BASE, and 343. Those five types of composted soils have different properties and usage as can be seen at the table below.

Table 4. Composition and application of composted soils product

Composition	Properties	Application
Coffee ground	- high N producing NH_4 (alkaline) - increasing the pH of soils - high density. - high C (carbon) content	- for soil quality improvement, can be applied to acidic fields e.g. in Hokkaido - for soil slippery prevention - producing humus up to 20% - enabling soil aggregation - enhancing aeration - water filtration and retention
Tea husks	- generating low rate of amine, made less smell - inhibits the growth of fungal/mushroom	- protecting fewer flies - as bio-fungicide - mulching
Mixed husk, coffee ground, and rice barn		for growing flower

Ryokusan produces around one thousand tons of composted soils per years, with production costs from 50 to 120 yen/kg. Compost with a higher Nitrogen content involves two steps fermentation process and is therefore costlier. The soil made by this company is not distributed to the real market, but is just being sold to the near farms around Shizuoka prefecture. All of the composted soils produced are sold to Japan Agriculture (JA) Cooperatives that will take part for selling that product to farmers.

Figure 9. Composting soils system in Ryokusan

<u>Ootomi :</u> Farm shop using compost by coffee ground

Ootomi farm's core business is the production of mango fruit. Around 1.100 mango trees are grown in full controlled environment in greenhouses which have been built for 50 million yen. Mango tree is grown using composted soils medium produced by Ryokusan Company that was specifically developed for the optimum growth of mango in 140 L pot. The mangoes were first grown at Ryokusan using the rhizosphere limiting method in coffee ground waste-based soils with additional nutrient. Though the root growth is limited, it does not affect the size of the mangoes, but the taste becomes denser. The growth rate and maintenance cost of mango trees grown using this rhizosphere limiting method can be four times more efficient than a tree grown on the ground. Composted soils medium price roughly 40.000 JPY / m^3 and can be used up to 15 years followed by adding soil volume regularly. Thus the two-time rotation of applying composted soils medium is much efficient to enable the growth of mango tree with a lifetime of approximately for 35 – 40 years. Additional fertilizer is applied 3 times a year.

Figure 10. Mango tree grown in composted soils of Ryokusan

<u>Nirayama Hansharo Brewery :</u> Composting soils system

Besides producing beer from malt, this beverage industry also developed waste composting system for 10 years. The compost uses various wastes derived from agriculture, restaurants and households and consists in 10 % by-product from beer industry, 20 % household waste (restaurants mainly), 30 % wood pulp (sawdust), and 40% bovine manure.

The composting process is conducted for two months, in two stages, by adding microbial agent and doing conventional mixing with an air circulation adjustment system. The first mixing step is held primarily for 14 to 20 days under 80°C or more, with air circulation provided by underground pipes. The mixed waste is kept two weeks, followed by moving it to another place in order to undergo the second mixing process for 30 days. There, the compost is gradually moved and dried in order to obtain a finer soil. Instead of selling the composted soil to JA, itis sold directly to farmers for 250 yen/m3. Some of the compost is used by the tea farm situated behind the beer factory.

Figure 11. Composting system of beer factory

<u>Oratche :</u> "Recycling-oriented" products and sales

The main business of Oratche farm is agricultural industry and eco-tourism covering horticultural farming, husbandry, and dairy home-industry. They produce wide range use of agricultural product as meat, fresh milk, yoghurt, cheese, and butter. They are also selling several recycle-based products such as cosmetics produced from citrus skin waste in the form of soap, aromatherapy oils, body lotion, etc **(Figure 12)**.

Figure 12. Cosmetic products derived from citrus skin waste that is sold by Oratche

CASE ANALYSIS

Overall, the main issue of Biolife is finding a solution to expand the rapeseed production to meet the demand concerning a healthy vegetable oil. For this purpose, there are two critical problems regarding low production scale and the lack of participation from members in farming activities. The availability of a large number of oil crop by-product also become a major concern regarding the community values.

1. **Oil crops production**
   a. **Low production scale of raw rapeseed grain for oil extraction**

   Rapeseed production is not enough to meet the demand, whereas the oil crop production is unstable and does not meet with oil processing capacity. Last year, Biolife processed about 10 tons of vegetable oil while only about 1,5 tons of oil crop have been harvested from their own fields, the rest has been bought from other farmers. The increase of vegetable oil production can be acquired by expanding the oil crop cultivation area. There would be enough land available for cropping since many fields in the region are uncultivated and many local farmers are offering lands without rent. However, those fields are quite scattered and, unfortunately, there is not enough manpower to care for them.

   b. **Low productivity and yield of oil crops**

   Experimental conditions showed a yield gap between the current yield of the fields and their real potential. Actual yields of both rapeseed and sunflower are quite low: about 1 ton/ha grain on average in comparison with the potential yield around 2-3 ton/ha. The reduced production is apparently due to unusual climate nowadays with continuous rainfall and unexpected typhoons. Moreover, insects and diseases are also affecting yield losses as no pesticides or chemicals are used to protect or fertilize the crops.

   c. **Lack knowledge of land suitability for ideal growing condition.**

   There are still issues for determining the quality of the soil before cropping, probably in term of soil pH and water content matter. The different conditions of the soil are unknown until rapeseed is grown and evaluating the soil performance.

d. There is a change on crop rotating system between summer-winter cultivation.

Rapeseed and rice can be cultivated on the same field rotationally within one year in terms of climate condition and technology. However, almost no farmers do double cropping due to their schedules. They do transplantations in May and want to avoid damage of typhoons around August and September. In spite of the fact that rice-rapeseed rotation system had been implemented in central Japan 40 years ago, it has been shifted recently into rice production that is transplanted in June and harvested in October. On the other hand, it is more and more common to perform transplanting rice as well in a week of May where there are more holidays such as the "Golden Week", while it is normally transplanted in the middle of June.

2. Vegetable oil production

a. Lack of extraction machine

The production capacity of one machine is about 30 kg seeds per hour. One machine seems not to be enough to expand the production. But since only 5 ha are currently cultivated, there is no need to buy another one regarding the own rapeseed production of fields managed by Biolife.

b. Waxy content impurities in oil production

The sunflower oil produced often contains such impurities noticed as waxy that reduce the quality of end product. These impurities happen because there is no refining step for quality improvement. These waxes cause visible turbidity or cloudy appearance during oil storing at lower temperature for long period that settle out as a crystalline precipitate. Cloudy (turbid) oils are not acceptable in the market. Moreover, such impurities has to be removed in order to produce the high quality product that suitable for market purposes and improve the stability of oil product that can be stored for prolonged periods of time.

Figure 13. Waxy content in vegetable oil product

3. **Lack participation of community member**

Biolife is still facing labor and other resources shortage to manage this available land. Even though 40-50 members are freely joining in, Biolife still does not have enough people to cultivate oil crop due to a lack of participation of some members in the activities. There are many possible causes: most of the members are busy with their main job and won't spend their weekend for these activities, lack of motivation to join in farming activities or the information about activities is unclear. Farmers are mainly offering land for oil production for the purpose of maintaining their property.

4. **Low economical value of vegetable oil cake waste**

Oil cake is a residual-product from oil production, mainly from rapeseed. Since Biolife use the cold pressing system for oil extraction, the recovery rate of extracted oil is quite low only about 30% for rapeseed and 25% for sunflowers relative to the total grain weight. Other 70 percent of solid residual substances (rapeseed cake) upon the extraction of rapeseed oil from seeds is considered as waste. Recently, around 7 tons of rapeseed cake is marketed as fertilizer which has low economical value.

5. **Uncompetitive market price.**

Both of rapeseed and sunflower oil are sold for about 750 yen in 175 gr packaging. Even though the actual price is reduced to 540 yen (discount), it is still higher compared to the selling price of commercial brands for about 300 yen/liter.

PROPOSED SOLUTIONS

The main goal of Biolife is to increase the level of oil self-sufficiency in Ryugasaki city. However, Biolife serves currently only 1% of cooking oil demand in Ryugasaki city (see appendix for calculation method). Therefore, we propose the following solution for Biolife to implement it in order to increase Ryugasaki city`s self-sufficiency for cooking oil to 20% by 2020 (see appendix for calculation method). Beside to promote the expanding of oil crop production, we also propose solutions to improve the quality of oil products and the use of by-product for more economical value.

1. Encouraging farmer to grow rapeseed as a second crop in paddy fields

In the past, farmers in Ryugasaki city commonly planted rice and winter rapeseed as part of a two- year crop rotation. However, this practice has been changed due to the rapid development of Japanese economy and price pressure from the imported rapeseed. According to the president of Biolife, if farmers grow rapeseed, they would have to harvest it in June. Since most of them are part time farmers, they prefer to transplant rice during the Golden week in May. As a result, they decided not to grow rapeseed anymore. In addition, individual famers alone cannot change rice transplanting date to June due to the irrigation system and other constraints, even though they know the benefit of growing rapeseed and want to change. This problem is called coordination failures in the economic literature. Therefore, if Biolife wants to increase rapeseed production in this area, this problem has to be solved, as well as farmers encouraged to grow more rapeseed.

Creating mechanism to solve coordination failures and facilitating cooperation among farmers

Coordination failures, in economy, happen when agents fail to coordinate to get a better outcome. For example, Palanpur farmers sow their winter crop several weeks after the date when yield would be maximized. All farmers know that earlier planting would give them more output, but no one is willing to be the first to plant since the seed on any lone plot would be quickly eaten by birds: There is no coordination between farmers and, in case of a coordination to sow earlier, all farmers would get higher productivity (Bowles, 2004). The same situation may happen in Ryugasaki city. Some farmers may want to change, but there is currently no possibility for them to coordinate. Therefore, Biolife could facilitate cooperation among farmers. For example, the NPO could organize an event for local farmers to meet with each other and discuss about the possibility of changing cropping pattern.

Promoting the benefit of growing rapeseed

One way to encourage farmers to grow more rapeseed is to show them the benefit brought by this crop, especially when cultivated as a winter crop in rotation with rice. A study by Kamoshita (2007) showed that the yield of rice cultivated after rapeseed tends to be 9% higher than after fallow and farmers also could get more profit from rapeseed selling. Our cost-benefit analysis also confirms the same conclusion. Farmers who grow rapeseed would get additional profit around 49,000 Yen per hectare (See **Table 5**). Note that the rapeseed cost data that we use for Biolife is quite low compare the average cost across Japan.

Table 5. Cost and benefit analysis of rice and rapeseed cultivation (2013 data)

Crop	Rice	Rapeseed	Rapeseed (Biolife)*	Rice+Rapeseed (Normal farmers)	Rice+ Rapeseed (Biolife)
Cost (Yen\0.1ha)					
Seeds	3,704	629	-	4,333	3,704
Fertilizer	9,500	10,220	2,600	19,720	12,100
Herbicide	7,555	269	-	7,824	7,555
Power	4,782	2,065	2,065	6,847	6,847
Soil improvement +water	4,442	641	641	5,083	5,083
Management	424	109	109	533	533
Rapeseed harvesting	1,820	2,500	2,500	4,320	4,320
Others material cost	47,265	664	664	47,929	47,929
Labor cost	35,884	9,801	-	45,685	35,884
Total cost	**115,376**	**26,898**	**8,579**	**142,274**	**123,955**
Revenue (Yen\0.1ha)				-	-
Yield	530	100	100	630	630
Price	233	100	100	333	333
Total revenue	**123,490**	**10,000**	**10,000**	**133,490**	**133,490**
Government subsidy	**7,500**	**15,000**	**15,000**	**35,000**	**35,000**
Profit (not include government subsidy)	**8,114**	**- 16,898**	**1,421**	**- 8,784**	**9,535**
Profit (include government subsidy)	**15,614**	**- 1,898**	**16,421**	**26,216**	**44,535**

Note: *doesn't include labor cost because of volunteering, seeds are from the previous year's harvest, Biolife don't use chemicals (herbicides,…)

Source: Author`s estimation based on MAFF and Biolife datas

Apart from showing benefit of rice-rapeseed system to farmers, we also suggest Biolife to create demonstration farm where farmers can come to learn about rice-rapeseed cropping.

2. Utilization of uncultivated farmlands

Another solution is utilizing uncultivated farmlands for rapeseed cultivation in the target region. According to its president, Biolife is thinking to expand its cultivation area for rapeseed to 30ha in 5 years to secure their own rapeseed production for more oil extraction. In the region, quite a few farmlands are not cultivated or used currently, though the government is encouraging utilization of them. Therefore, we would like to propose a plan to utilize abandoned farmlands for rapeseed production with economic insights.

Uncultivated farmland is defined as a farmland which has not been cultivated for more than one year and the owner has answered that he/she will not cultivate within three years, according to the Census of Agriculture and Forestry (CAF). Most of uncultivated farmlands will turn into wild fields or forests after a while, which require much cost and effort to start cultivation again.

Current situation of the land use in the region

The committee dealing with uncultivated farmlands of Ibaraki prefecture (CUI, 茨城県耕作放棄地対策協議会 in Japanese) found out the reasons of abandoning farmlands mainly are unfavorable conditions such as hilly and mountainous areas, a decrease in the number of farmers or aging farmers (CUI). Especially the south part of the prefecture (the main region of the NPO) is suffering from urbanization, causing a lack of labor for farming and a high competition of land use. Another analysis done by Lin et al. (1993) including the same region confirmed a significant contribution of conditions of road maintenance to the rate of abandoning farmlands. Although the growth rate of uncultivated/unused farmlands' area is becoming lower, the abandoned land area is still increasing **(Table 6).**

Table 6. Transition of area (ha) of uncultivated farmland (data from CUI)

Region/Year	2000	2005	2010
Ibaraki	16,205	20,357	21,121
Japan	342,789	382,791	396,088

Especially for the target region, CUI (2013) showed that the average farmland area per one management unit is 1.8ha in the south part of the prefecture, and paddy fields account for 63% of the cultivated area. Its ratio of uncultivated farmlands is 14.7%, similar to rate for the prefecture, and is especially due to urbanization of cities such as Ushiku-city, whose ratio is 33.9%.

Committee of Ryugasaki-city Local Agriculture Restoration (CRLAR, 龍ヶ崎市地域農業再生協議会 in Japanese) (2015) analyzed the soil characteristics of the region by dividing the region into North and South parts. The North part of the region is Inashiki-plateau which has accumulated Kanto loam layer, and the South part is an alluvial plain made by two rivers with a large granary, mainly consisting in paddy fields (60% of agricultural production in Ryugasaki-city is paddy rice).

Restoration methods of uncultivated farmlands

We would like to propose a method of restoration actually conducted in Ushiku-city by the Agricultural research center of Ibaraki Prefecture (Mori, 2013). The actual field experiment of this method includes cultivation of rapeseed as the crop chosen for maintenance of the restored field. Rapeseed is favorable for suppressing weeds as it is winter crop and can be cultivated soon after eliminating weeds during summer with relatively less efforts. Thus, adoption of this method is suitable for the target of the NPO. Also, extent of restoration matters in terms of applicability. Uncultivated farmlands turn into wild fields or forests and the necessary efforts to restore them vary depending on the extent of abandoning. The following method can be applied to uncultivated farmlands left for basically less than 10 years, with perennial weeds but no wood yet (There were actually some trees at the restored farmlands, but the costs to deal with them were not included in the analysis). From the past data of uncultivated farmlands, it is possible to assume there are enough farmlands in the region which can be restored with this method to achieve the target of 30 ha.

The basic procedures of restoration are shown in the following figure and description for each follows **(Figure 14)**.

1. **Weeding (1), (2), and (4)**: These parts of weeding were conducted by machine, flail mower.
2. **Weeding (3)**: This part of weeding was conducted by application of herbicide (Glyphosate), but this must be substituted with machine weeding again in order to apply the case of the NPO, which only allows organic farming. According to the paper, machine weeding can prevent recovery of pampas grasses, though herbicide is desirable to eliminate its rhizosphere.
3. **Plowing**: Plowing with a 100kW tractor with 22 inch in a row and with depth of 35 cm worked effectively to eliminate the rhizosphere of pampas grasses which had developed roots up to 30 cm depth.
4. **Harrowing**: Vertical harrowing was conducted.
5. **Applying composts**: Compost should be applied to decompose organic matters from the weeds turned over into the soil. Dried pork manure compost (T-C: 0.52%, T-N: 4.0%, C/N: 7.7) was applied (1t/10a) by auto-manure-spreader because of chemical condition of the deep soil, which is slightly acidic and lack phosphorous. Soil condition in deeper layers also should be considered because nitrogen content can be lower in the deeper soil. Since the compost has high content of phosphorous and potassium, the amount of it was reduced to half in the second year. In addition, chemical fertilizer was used for cultivation of rapeseed in the experiment because most of the nitrogen in the compost was supposed to be consumed for decomposition of organic matters. For application to the NPO, this part must be substituted with another organic fertilizer; otherwise the expected rapeseed yield may be lower.
6. **Mixing**: Rotary tiller was used for mixing the soil after compost application.

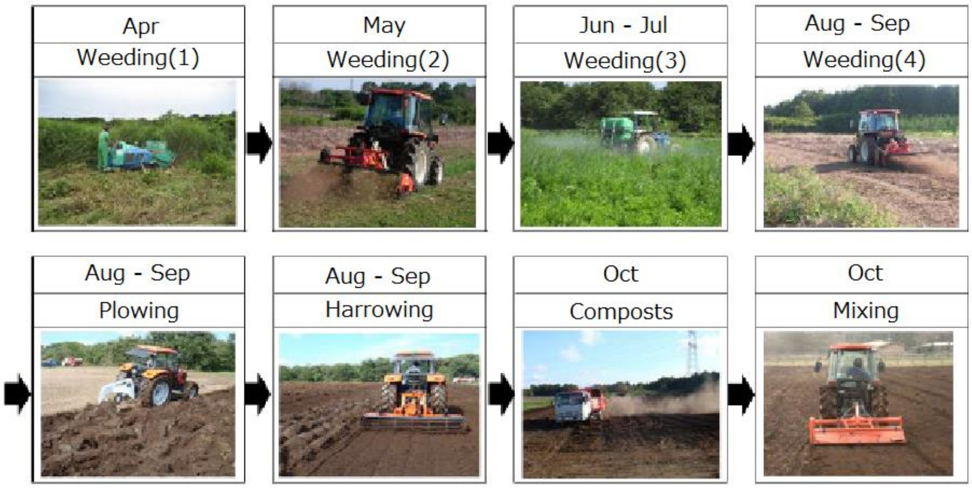


Figure 14. Procedures of restoration (source: Mori, 2013)

Obtained yield of rapeseed was 3.0 t/ha in the first year and 2.0 t/ha in the second year just by applying organic materials. In the third year, however, they observed severe reduction in yield due to diseases and damages of repeated cultivation. Therefore, it is recommended to avoid repeated cultivation more than three years in a row.

Economic feasibility

Table 7 shows the working hours and costs needed for the procedure in the experiment.

Table 7. Working hour and cost used for the restoration in the experiment (Mori, 2013)

Period	Procedure	Working hour (hour/ha)	Cost (yen/ha)	Equipment
Apr	Weeding (1) (Tree felling)	4	70,000	Flail mower
May	Weeding (2)	2.6	35,000	Flail mower
July	Weeding (3)	0.3	31,500 40,000	Herbicide spreader Herbicide (Glyphosate)
Aug-Sep	Weeding (4) Plowing Harrowing	2.6 3.6 2.2	35,000 100,000 35,000	Flail mower Plowing machine (20-22 inch) Vertical harrowing machine
Oct	Compost Mixing	1.6 3.2	50,000 100,000 50,000	Auto-manure-spreader Dried pig manure (10,000yen/2t/10a) Rotary
Total		20.1	546,500	

Therefore, the restoration method costs 546,500 yen/ha, but most of this cost can be balanced by the governmental subsidy to encourage restoration. In case of rapeseed cultivation, another subsidy can be applied. Subsidies related to this procedure are summarized below **(Table 8)**. From the candidates, the subsidy for restoration procedure can be obtain in many cases (see MAFF (2016) for detail criteria) and also that for the strategic crops (farmlands) in case of single cultivation of Kirariboshi, which is promoted in the region (Department of Agricultural Policy of Ryugasaki-city (DAPR) (龍ヶ崎市役所市民生活部農政課 in Japanese), 2012,). The former subsidy was actually given for the experiment in Ushiku-city beforehand (Mori, 2013) and the latter one was given for the NPO's rapeseed cultivation before revealed in our interview.

Table 8. Candidates of Subsidies

Subsidies	Price	Description
Restoration procedure	50,000 yen/10a	To support procedures as a whole (removing obstacles, plowing, soil improvement, and fertilizer, etc)
Support for machines	1/2 of the cost	Drainage system, machines, and houses, etc
Soil improvement	25,000 yen/10a	Only for second year if necessary
Management stabilization	25,000 yen/10a	Seeds and other items
Strategic crops (farmlands)	8680 yen/60kg	Only for specific cultivars (Kirariboshi, Nanashikibu, and Kizakinotane)
Strategic crops (paddy field)	20,000 yen/10a	Cultivation in paddy fields
Double cropping	15,000 yen/10a	Double cropping with rice

Application of this method followed by rapeseed cultivation to the region of NPO should be considering NPO's crop management specificities. Vegetable oil is sold as an organic product, chemical herbicide or fertilizer cannot be used for the farmlands. Second, the crop management of rapeseed seems much less intensive than that conducted in the research center for the cultivar (National Agriculture and Food Research Organization (NAFRO), 2010,). Therefore, expected yield is also assumed to be just 1.0 t/ha based on the interview, which is much lower than the result of the experiment (NAFRO, 2010). Also, some management procedures especially sowing, additional weeding and side dressing for rapeseed cultivation are assumed to be done manually, though the first fertilization together with lime application is made by machines, same as the restoration procedure. They are summarized as follows **(Table 9)**.

Table 9. Cost analysis for combination of restoration and rapeseed cultivation

Period	Procedure	Working hours (hour/ha)	Costs (yen/ha)	Equipments
Apr	Weeding (1) (Tree felling)	4	70,000	Flail mower
May	Weeding (2)	2.6	35,000	Flail mower
July	Weeding (3)	2.6	35,000	Flail mower
Aug-Sep	Weeding (4) Plowing Harrowing	2.6 3.6 2.2	35,000 100,000 35,000	Flail mower Plowing machine (20-22 inch) Vertical harrowing machine
Oct	Compost application	1.6	50,000	Auto-manure-spreader
			100,000	Dried pig manure (10,000 yen/2t/10a)
	Mixing	3.2	50,000	Rotary
	Sowing	20		Manual sowing machine (2h/10a)
	Fertilizer		6,000	Chicken manure (3bags/10a (1bag = 200 yen (50kg))
	Mg lime		20,000	Mg lime (5bags/10a, 1bag = 400 yen)
		1.6	50,000	Auto-manure-spreader
Dec	(Weeding)			
Mar	(Fertilizer)			
Jun	Harvest	5	25,000	Combine machine (Rental fee is 5000yen/hour and 10a needs about 0.5hour)
Total cost		49	611,000	

Finally, to consider the economic feasibility of the proposal, sales of rapeseed based on the statistics of MAFF are considered as possible source of benefits in addition to subsidies mentioned above. After calculation of benefits, profit is obtained by subtracting the costs above from the benefits as follows **(Table 10)**.

Table 10. Potential benefit and profit

Category	Benefit (yen/ha)	Description
Grain production		1 t/ha (Interview)
Sales of rapeseed	100,000	0.1 million yen/t (Japan)
Subsidy for restoration	500,000	50,000yen/10a
Subsidy for rapeseed	144666.7	8680yen/60kg
Total benefit	744,667	
Profit	133,667	Benefit – Cost (total)

In the end, this land restoration followed by rapeseed cultivation for the first year can be profitable as shown above, though the assumptions used in the analysis can be changed in practice, mainly due to availability of labor. Most importantly, the working hours are assumed to be accomplished by the voluntary work of the NPO's members but they might have to pay wage for part-time job if volunteering is not enough. It is assumed to apply manure by machines, but if this part can be done manually if enough workers, same as sowing (taking roughly 20 hours) reducing its cost by 50,000 yen/ha. In addition, the cost for Mg lime application can be omitted because the manure application in the restoration practice may be enough to adjust pH, which contributes to a reduction of costs by 20,000 yen/ha. Finally, the benefit of rapeseed sales should be substituted with the profit of the high added-value oil products. Thus, the profit can be estimated roughly between 130,000 to 200,000 yen/ha for the first year depending on how much labor can be involved in the plan.

Challenges and further steps for the realization of this plan

Even though the total amount of uncultivated farmlands is more than enough for the target of Biolife, the collection of uncultivated farmlands stands as a problematic concern. Those lands are scattered in the region and many of them can be smaller than 1 ha, but most importantly the restoration or cultivation of rapeseed is depending on subsidies. In addition, the soil improvement with manure and Mg lime application depends on the soil conditions. Therefore, determining candidate uncultivated farmlands through soil analysis can be useful for the realization of this plan.

It is even more important to secure labor force for achieving the target of 30ha. There is a trade-off between saving labor by machine and cost reduction, but introducing machines becomes more favorable in order to expand implementation of this restoration and cultivation methods. The total working hour is estimated as low as between 50-70 hours/ha annually but each procedure will require 15-100 hours just to expand 5 ha only for a very short period. Consequently, much more workers are needed only for the particular time to reach their goal. Hiring part-time workers using the profit of the method above as wage or inclusion of the local students to their crop management as events of agricultural experiences can be solutions to secure labor force. Further proposals to get more people involved follows in this project report.

As supplemental information, the waste of rapeseed after oil extraction can be utilized better than current use of liquid fertilizer by diluting. This possibility is also explored later in this project report, and that might be able to encourage more restoration and subsequent rapeseed cultivation.

Proposed solution for uncultivated farmlands

Utilizing uncultivated farmlands can be profitable in the range between 130,000 to 200,000 yen/ha though this estimation is very rough and highly depending on availability of labor force. Collecting uncultivated farmlands larger than 1ha is necessary and performing soil analysis is desirable especially for the soil improvement procedure. Also, acquisition of labor force for particular periods is the main task for realization of this plan. Finally, analysis of profits derived from sales of oil products and from utilization of wastes after extraction can be useful for a more comprehensive estimation of the profitability.

3. Increasing the machine capacity utilization for more profit

We conducted simple regression analysis to find the effect of grain processing volume (Grvo) on total cost (raw material cost + processing cost) of producing 1 liters of oil (TC). We postulate the simple model

$$TC = \beta_0 + \beta_1 Grvo + \mu$$

The slope parameter β_1 measures the change in total cost, in yen, when grain processing volume increase by one tons.

Using the data from Biolife annual report between 2012-2015, the OLS regression line relating *TC* to *Grvo* is

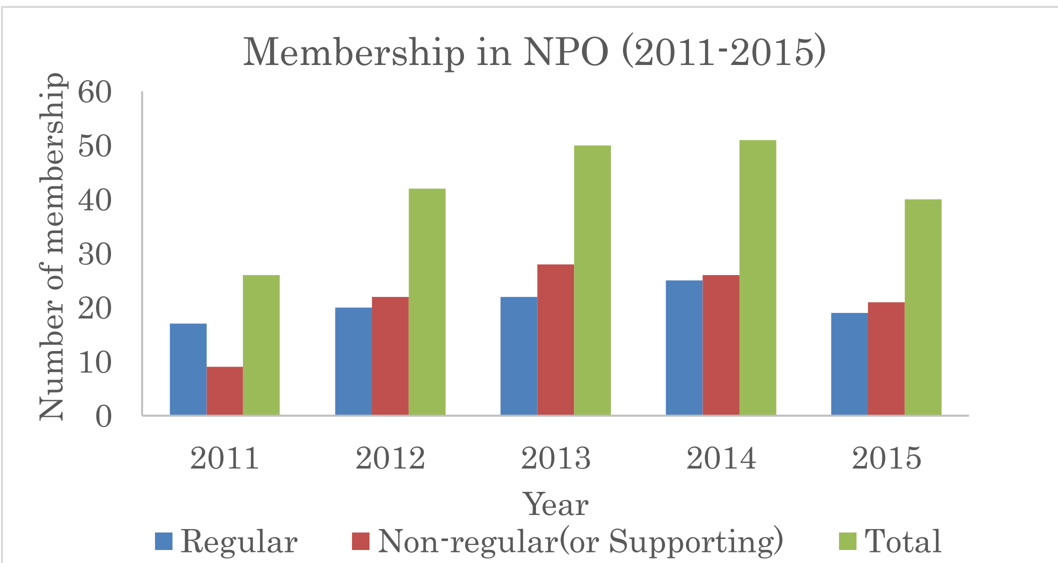
$$\widehat{TC} = \underset{(107.77)}{2292.46} - \underset{(12.77)}{44.87}Grvo$$

$$n = 4,\ R^2 = .86$$

B_1 is statically greater than zero at the 10% significance level. This coefficient means that another tons of grain processing lower predicted total cost of producing 1 liter of oil by about 44.87 Yen. Therefore, we suggest Biolife to increase the oil production to the maximum capacity of the processing machine and generate more profit for Biolife.

4. Increasing the participation of members

Although there are 40-45 members in total, Biolife is still facing the problem of labor shortage. Therefore, increasing member participation in NPO's activities is one of the possible solutions to increase the oil crop production.



Making schedule of the crop-related activities in advance:

Some people are willing to participate at least one activity in the NPO but they don't have time or sometimes the schedule is overlapped. Therefore, the schedule of rapeseed planting activities should be described clearly in advance so that all members or volunteers can participate by saving the date the earliest.

Table 11. The schedule of rapeseed planting activities annually

No.	Activities	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1	Soil preparation												
2	Sowing												
3	Fertilizer applying												
4	Weed control												
5	Harvesting												
6	Transporting to warehouse												
7	Cleaning												
8	Drying												
9	Oil processing												

Status: Family as members/ Inviting volunteers and students:

Member participation could also be increased by enabling family activities. It can take the form of a 1-day discovering of agriculture involving families. Currently, Biolife propose this kind of agricultural experience (mainly for sunflower) and usually more or less 10 people around Rugasaki city joined these events. Therefore, if the NPO can invite students to get experience in organic farming by participating in rapeseed planting, they can feel that the benefit came from their own efforts and get more interested in farming. These activities need people to teach and supervise those students.

Revising some regulations for membership:

NPO now have two types of memberships. Some of the members are regularly joining the activities. Usually, supporting members only provide financial participation and do not join the activities. So, the NPO could manage the participation of members by proposing them task, based on rotation system, so that members have a chance to participate occasionally to the growing of the NPO.

In a nutshell, Biolife could get widely open to people willing to bring help, but without being involved as member. Thus, more people would discover activities related to cropping and bring labor force to the NPO, through 1-day activities or as a regular non-member worker for instance. Young people, as students or children with their family, may get involved as the future of the Japanese society.

5. Improving quality of oil product

The high content of waxes, fatty acids and lipids are commonly originated from the complex cellulose of sunflower hull which is pass to the oil in the process of pressing. Those impurity of waxes are high melting esters of fatty alcohols and fatty acid which having a low solubility in oils. The quantity of waxes in crude oils varies from several hundred ppm to several thousand ppm. Generally in industrial scale, a clear oil product is obtained by a dewaxing step for removing components with high melting point (waxes) from vegetable oil called "winterization". Winterizing mainly consist of fractional crystallization of the wax esters oils and fats by cooling the oils gradually and filtering them at low temperature in special filtersor by centrifugal separators (Martini and Añón, 2000). This process can remove the components of edible oils which have may negative effects on taste, stability, appearance or nutritional value. Thus, this process can be applied by Biolife in order to improve the oil quality. However, if the construction of such dewaxing system is quite expensive, conventional precipitation process is adequate enough for small scale production.

6. Improving economic value of rapeseed oil waste

a. Direct use for animal feed (Short-term solution)

From the view point of vegetable oil technology, the oil cake is as valuable as the oil itself. Rapeseed press cake contain the high amount of crude protein (32 – 36%) and can be used for animal feed, i.e. dairy cattle, pigs, poultry, and farmed fish, thus that waste can be sold directly to farms for more economical value.

In China, for instance, rapeseed meal has been widely used in feed formulation for poultry, swine and cattle in amount of 3% to 20% (Feng et al., 2007). While in Japan, rapeseed meal consumption is forecasted to be stable at 1.15 MT by 2016/2017 with a proportion for compound feed around 40% for poultry (layers and broilers), 30% for swine, 20% for beef cattle, and 10% for dairy cows (Hahyashi, 2016).

However, after Fukushima earthquake generating nuclear radiation in 2011, a radioactivity suspicious added to a fear for bioaccumulation has forced biolife to stop this way of using co-products. Even though a previous experiment in Chernobyl showed that a high number of radioactive content such as Cesium was only absorbed into plant shoot and leaves, and that no radioactive content was detected in rapeseed grains. So as the oil produced from rapeseed and sunflower are safe for human consumption.

In order to encounter those cautious, we suggest Biolife to analyze radioactivity content of rapeseed oil cake waste to convinced the farmers that rapeseed grain does not absorb radioactive substances, complying to Standard limits for Radionuclides in General Food for about 50 – 100 Bq/kg for Cesium (Cs-134 and Cs-137, respectively) and 20 Bq/kg for Stronsium (Sr-90) (FAO, 2016).

As reviewed by Carré and Pouzet (2014) in Europe, rapeseed meal prices ranged between 150 and 300 €/ton in 2010–2012. On the basis of this review, the feed price of rapeseed press cake is estimated around 200€/tor equal to 25 JPY/kg by using conversion rate of 125 JPY/€. This price corresponding to approximately 30–60% of the seed price and 55% of soybean meal price. By using this estimation, it can be forecast that, if Biolife can sell that waste for 25 JPY/kg, they can make more profit: about 25.000 JPY per ton rapeseed cake produced.

b. The production of high value added product (Long-term solution)

Although rapeseed meal has only a slightly lower energy value than soybean meal and is also cheaper, it is considered as a secondary feed due to its phenolic content and higher fiber. This particular content contributes to less desirable features for feed production, such as dark color, bitter taste, coarse-grained texture, and limitation of digestibility and nutrient availability.

In order to overcome disadvantages of oil cake for direct feed, we also propose solution for the production of functional food and non-food product based rapeseed oil cake by utilizing its high nutritional protein content to ensure an increased economic revenue in the production of rapeseed oil.

Traditionally, oil extraction is carried out by adding hot water, boiling, or adding the high concentration of salt. While in industrial scale, oil production involving the use of high temperature (120^{o}C) or organic solvent for oil extraction followed by a series of refining process using alkaline chemical substances or physical steam distillation in up to 250°C to produces an edible oil with characteristics that consumers desire. However, cakes from this water/solvent extracted oil are usually depleted of nutrients.

In Biolife, the oil production uses cold pressing method to produce a high quality extra virgin vegetable oil. A major advantage of cold pressing, without using high temperatures and chemical compound, is that protein solubility in the residual seed mass (i.e. press cake) is better retained indicating its potential as nutritionally valuable protein resources.

Nutritional quality

Rapeseed cold-press cakes typically contain 32–36% proteins, 44% crude carbohydrates, 11–18% residual oil, 9% moisture content, and 6% ash on a dry matter basis. The protein and amino acid content of rapeseed cake is equal to that of soybean cake, provides all essential amino acids of about >400 mg/g protein with a balanced profile. In addition, rapeseed proteins contain adequate amounts of lysine and are rich in sulfur-containing amino acids in the range 40 – 49mg/g protein to meet the recommendations for daily amino acid intake. Nutritional quality of rapeseed proteins, based on the protein digestibility corrected amino acid score (PDCAAS), was reported to be 0.86 for a rapeseed protein isolate and 1.00 for rapeseed protein hydrolysate corresponding to that of egg and milk proteins. Rapeseed cake also rich in phenolic compounds with antioxidative activity and B vitamins (Romii, 2016). The well-balanced amino acid composition and high rate digestibility of rapeseed protein makes them an interesting plant-based protein source for human nutrition.

Production method

The suitability of rapeseed fractions for foodstuffs can be improved by eliminating the bitter flavor caused by plant phenols and enhancing the digestibility of canola fibers. Protein concentrate and isolate can be produced following sub-sequential procedures by removing the remaining fat in oil cake, reducing the carbohydrate content to increase protein extractability, and hydrolyzing the protein content for more nutritional values as depicted at **Figure 15**.

At first, the remaining oil can be removed using SC-CO2 (Supercritical carbondioxide) organic solvent. The defatted material after solvent extraction contained 46% protein, 29% of water soluble carbohydrates and 3% oil. The resulting defatted and low-phenol press cake could potentially be applied as a fiber- and protein-rich ingredient in food and feed, or it could be gently processed to improve its digestibility and functional properties.

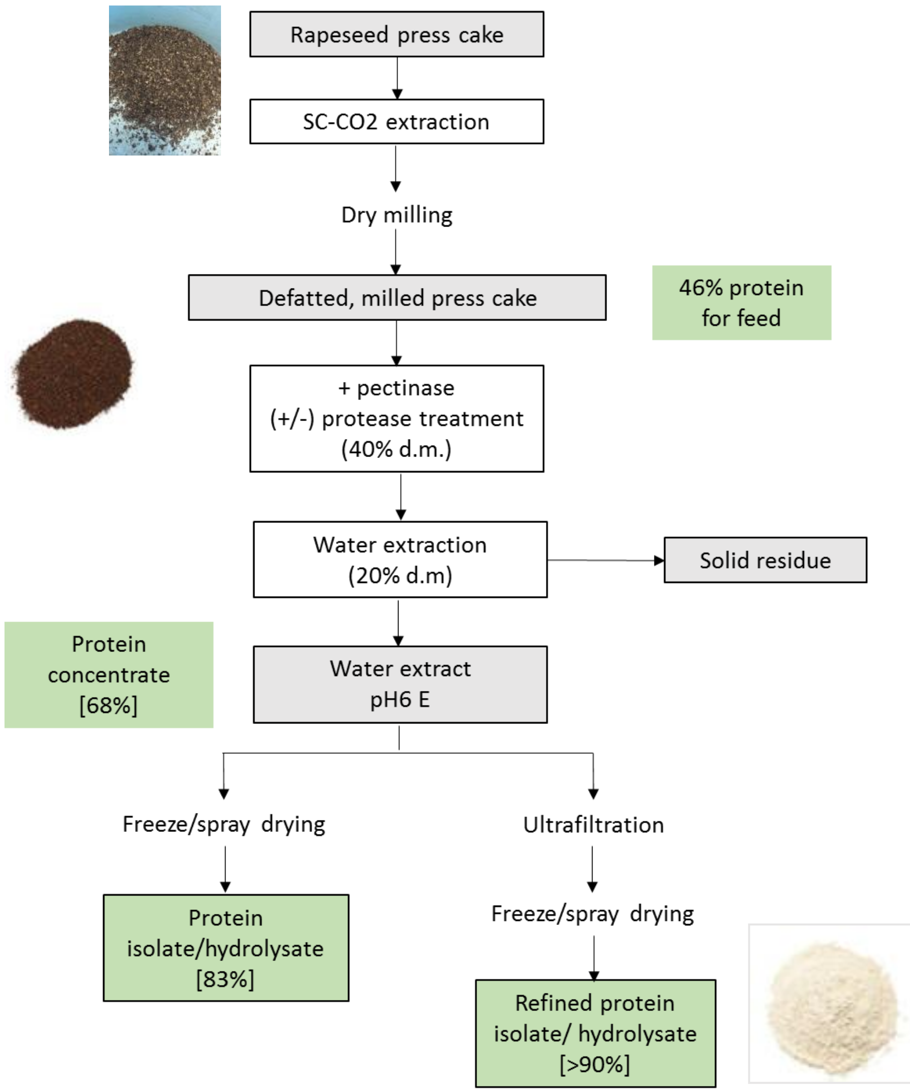


Figure 15. Scheme for the production of protein concentrate, protein isolate, and protein hydrolysates from rapeseed press cake by using enzyme-aided water extraction methods

Rapeseed protein can be enriched by saline, alkaline, or enzymatic extraction. In this case, we proposed to use enzyme-assisted methods for the enrichment of protein from rapeseed cold-press cake that have been developed by Katariina Rommi (2016), a doctoral student in University of Helsinki, Finland. This method showed more efficient in term of the production costs. The extraction process can be carried out in two step at 20% in Milli-Q water, enzyme concentration 10 mg total protein / g dry substrate at 30^{o}C in the natural pH of the substrates (pH 6.3–7.3). She reported the two-step extraction process by using pectinase solubilized 68% of the total protein and recovered 58% from defatted, non-dehulled rapeseed press cake. Water extractions gave product yields of about 20-40% dry extract per kg press cake. The study conducted by Niu et al. (2012) showed up to 83% of the total protein has been extracted from dehulled, cold-pressed rapeseed press cake using hemicellulases, pectinases and cellulases in combination with protease (Alcalase 2.4L) treatment at 50^{o}C, pH 8. Protein extraction followed by further ultrafiltration using suitable membrane produced rapeseed refined protein which has higher protein content of more than 90%.

Potential use

The growing need for sustainable and plant-based protein sources opens wide potential for rapeseed protein concentrates, isolates and hydrolysates in food and non-food applications.

1. **Food and beverage**

   Food protein products classification is based on their protein content, as concentrate (65% protein) or isolates (90% protein). Protein concentrates and isolates are available as intact proteins, while protein in hydrolysates have been partially broken down in the form of di- or tri-peptide that allows to be absorbed more rapidly in human digestive system.

   Certain rapeseed proteins can act as effective emulsifiers and have foaming properties (Mansour et al., 1999). Currently, there are several protein products derived from rapeseed pressed cake that have been approved under the novel food category for food use and already available in the market. Two rapeseed protein isolates developed by BurconNutra Science, Canada (Supertein™ and Puratein) have been recognized as safe (GRAS) status from the US Food and Drug Administration (FDA), while other product from TeuTexx Proteins (Isolexx™ and Vitalexx) was already approved by European Food Safety Authority (EFSA) in 2014.

   The above proteins products contain around 90-percent protein isolate that has excellent nutritional and functional characteristics. Thus, it can be used in a wide range to replace soy or whey proteins, such as:

   - As egg-white substitutes in mayonnaises and bakery products, such as bread, cereals, rolls, cakes, cake mixtures, cookies, biscuits, crackers, pancakes, sweet pastry, snacks, doughnuts, and pasta. In this application, rapeseed proteins act as effective emulsifiers and have foaming properties.
   - Processed meat products such as baked meat, hot dogs, and sausage.

- Vegetarian food products and meat analogues a replacement for dairy, soy, or animal proteins.
- Nutritional and high protein bars and drinks.

2. Healthy food supplement

A number of studies have recognized bioactivity of rapeseed protein hydrolysates in particular as antihypertensive and antioxidative activities (Romii, 2016). Certain rapeseed peptides (such as the di- and tripeptides phenylalanine-leucine and valine-serine-valine) have been found to exhibit antihypertensive properties by inhibiting the activity of angiotensin converting enzyme (ACE), an enzyme with a central role in blood pressure regulation (Wu et al., 2008). All those studies suggest that there is a potential benefit of rapeseed protein hydrolysates as healthy food supplement.

3. Cosmetics for anti-aging skin care product

The study conducted by scientist from Universitat Politecnica de Catalunya, Spain and 2VTT Technical Research Centre of Finland in 2015, have reported the use of fractions of bioactive rapeseed peptide fragments that were extracted from rapeseed press cake by proteolytic enzyme treatment showed new application potentials as an active ingredients or natural preservatives in cosmeceuticals and skin care products. The hydrolysates showed antioxidant activity for radical scavenging by inhibiting ACE activities. The hydrolysates were also able to inhibit the myeloperoxidase and elastase enzymes that involved in inflammation and skin aging (Romii, 2016). A French cosmetic active ingredients supplier, Sederma, markets a face care ingredient (Eyeliss) containing rapeseed dipeptide 2 (valine-tryptophan).

4. Other non-food application

Several research also proposed the application of rapeseed protein for other non-food use such as edible films that was produced in combination with gelatin, emulsifiers and plasticizers for food packaging, surfactants, plastics, wood adhesives、paper additives, also as nutrient source in fermentative processes (Romii, 2016).

Estimation of the production cost and market price

Based on the study conducted by Romii (2016), overall production costs of protein-enriched fractions by enzyme-aided water extraction (around 4100–4500 €/ton protein produced). Estimated production cost of rapeseed protein fraction, obtained with conversion rate 1 € = 122 JPY, is of about 500 – 560 JPY/kg protein produced. Production cost include labor, capital charge, energy, water, chemical, and pressed cake as raw material.

According to a price analysis in comparison between soy and dairy protein products by Frost and Sullivan (2013), the prices of soy protein products represent about 60-80% of whey protein prices. Having similar characteristics in terms of amino acid composition and techno-functional properties, standard rapeseed protein isolates could reach a price level comparable to that of the current soy and pea protein products on the market **(Table 12).**

Table 12. Estimation of production cost and market price of rapeseed protein product

Indicator	Protein content (%)	Production cost	Market price	
		Rapeseed protein (JPY/kg)	Rapeseed protein (JPY/kg)[a)]	Whey protein (JPY/kg)[b)]
- Pressed cake (raw material for feed)	32 - 36	0	25	
- Protein concentrate	65 - 80	500 - 560	1,200 – 1,600	2,000
- Protein isolate	> 90		2,000 – 3,200	3,500 – 4,000
- Protein hydrolysate	> 90		2,500 – 5,000	4,000 – 6,000

[a)]Rapeseed protein price is 60-80% relative to whey protein price

[b)]http://jp.bodybuilding.com/store/hydrolyzed-whey-protein.html

5. Higher market price

Traditional processing used by rural vegetable oil production has positive features for high quality products. The oil is produced without heating in high temperature as usually being performed in industrial scale, has highly nutritional value and a special. The oil product from the cold pressing method is rich of tocopherols, sterols, and carotenoid that is good for health, while highly refined oils are linked to induce degenerative diseases and cancer. There were also environmental concerns since no chemical solvent is used for the oil extraction process.

Compared to vegetable oil from the large industry that often using the organic solvent, i.e. hexane, for oil extraction which still remains in the end product that harmful for human health.

CONCLUSION

All these projects located either in Ibaraki or in Shizuoka prefectures show that many small companies in Japan try to find original solutions to enable rural development in a sustainable way. Those companies, still young, are confronted to many problems that make their growing to a larger scale difficult. About Biolife, we have proposed different solutions to face this type of issue, but our proposition may be unrealistic or may have forgotten some aspects of the local context. They have advantages we have presented, but many drawbacks may be raised as well.

PROPOSITIONS		+	−
1	Farmers growing rapeseed	-Helps self-sufficiency -Enables **rural development**	-Do not suit the current **calendar** -relying on subsidies
2	Use abandoned lands	-Financially viable thanks to subsidies for **rural development** -Improves landscapes	-Find the **labor force** to maintain these lands
3	Maximize the utilization of the machine	-Maximizes the **profit** and the sales -**Expansion** of the project	-Dependent on **labor force** and rapeseed supply
4	Family or 1-day activities	-More labor force -deals with the **NPO's values** (people gathering)	-**Hard to manage** -Needs some counterparty
5	Waste management	-More **profits** -Better use of high protein content from the rapeseed cake	-Needs procedures to be fulfilled -A whole network to create for food (**management**)

Though, our propositions, besides giving solution to Biolife to increase production and profits, also highlight different values the NPO puts forward, such as rural development, landscapes preservation or agriculture as a social facilitator. Yet, these projects may need a lot of time, labor and management to give results that may be disappointing.

Though, we hope that Biolife will find helpful ideas in our suggestions: the main point is indeed to maximize current possibilities without needing to start with a big project. That's why trying to use the machine at its maximal capacity or cultivating lands already available seems the first thing to do. Finding solutions to improve the communication with people to get them interested in agriculture and in the project of Biolife is crucial as well. More people, even from Tokyo, or students, would probably like to get involved and to participate in this type of experience. At last, Biolife should find a better use to its high quality waste in order to improve the sustainability of the company and reach the goal of Nanohana's project. Thus, Biolife and the companies visited in Shizuoka can achieve the challenge of sustainability in food industry and help improving the Japanese agriculture.

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APPENDIX

1. Calculation method for cooking oil demand in Ryugasaki city
   We calculate consumption of cooking oil in Ryugasaki city by timing the population of Ryugasaki city (78,666) with per capita consumption of cooking oil in Japan (3.25 liter per person per year)
2. Calculation method for cooking oil provided by Biolife in Ryugasaki city
   We calculate cooking oil demand in Ryugasaki city that was served by Biolife by dividing Biolife oil production in 2015 (2,313) by total cooking oil consumption in Ryugasaki city (255,619 liters)
3. Calculation method for the amount of production that biolife have to increase in order to reach Ryugasaki city`s self-sufficiency in oil to 20% by 2020
   We calculate by assuming that Biolife needs to increase the percentage of cooking oil that they serve Ryugasaki city from 1% to 8% by 2020. Another 12% is assumed to come from other regions in Japan.