Can Tho University Journal of Science
website: sj.ctu.edu.vn

BIODIESEL PRODUCTION AND USE FOR AGRICULTURAL PRODUCTION IN THE MEKONG DELTA: CURRENT STATUS AND POTENTIAL

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ARTICLE INFO

Received date: 25/01/2016
Accepted date: 08/07/2016

KEYWORDS

Renewable energy, biodiesel, Mekong Delta

ABSTRACT

Mekong Delta plays an important role in Vietnam agriculture and food security. It contributes more than 90% nation rice export quantity and 70% fishery and fruit tree products. Currently, a huge amount of fossil diesel has been consuming in farming activities such as land preparation, irrigation, harvesting, and product transportation. The use of fossil diesel can cause environmental pollution and farmers' health impacts. In the Mekong Delta, raw materials for biodiesel production are widely available, for example catfish fat (Pangasius) and coconut oils. Up to 2020, it is predicted that demands and potential use of biodiesel in agricultural production is very high, particular in rice, fruit trees production and aquaculture. Therefore, using biodiesel in the Mekong Delta's agriculture sector is an emerging trend in the future. This paper presents current status and potential of using biodiesel in agricultural production activities in the Mekong Delta, Vietnam. Participatory approach including Focus Group Discussion-FGD, Key Informant Panel-KIP and Households Interviews (484 samples) were employed to collect data. Descriptive statistics and binary logistics were applied to analyse collected data. Results showed that biodiesel was not popularly used yet due to many reasons such as high production costs, unavailability in the local area, and users' awareness on using it. Recently, there are many policies encouraging biodiesel use in agricultural production. More than 80% of farmers have agreed to use biodiesel in agricultural production activities with some required conditions such as information on biodiesel, quality, production costs, and use efficiency.

Cited as: Tin, N.H., Hue, B.T.B., Thuy, T.L.K., Phuong, T.L., Duyen, C.M., Thinh, H.C. and Phuc, H.N., 2016. Biodiesel production and use for agricultural production in the mekong delta: current status and potential. Can Tho University Journal of Science. Special issue: Renewable Energy: 80-91.

1 INTRODUCTION

Energy demands are always important to socio-economic development of a nation and locality. National security and economic security have a close relationship to energy security. In Vietnam and the Mekong Delta, energy demands in agricultural production systems are very huge especially fossil diesel demands. Fossil diesel could be used

in farming activities including land preparation, irrigation, harvesting, and products transportation. In recent years, fluctuation in prices of fossil fuels has made a tremendous impact on farmers' production costs. In long term, using fossil diesel in farming activities could face problems such as environmental pollution and farmers' health poisoning. This pushes pressure on alternating sustainable energy sources to partly replace traditional energy sources. In other words, looking for renewable energy sources such as biodiesel to use in agriculture sector is an emerging research topic. Producing and using biodiesel in agricultural production can utilize available and accessible raw materials e.g. catfish fat, coconut oils and others to increase added value of the agricultural value chain while reducing environmental pollution. In 2007, the Government issued the Decision 177/2007/QĐ-TTg on approving "Biofuels development program to 2015 vision 2020" that encourage public and private sectors and users to use biofuels in production and living. Besides, several Mekong Delta provinces such as An Giang, Ben Tre and Vinh Long have specifically supportive policies on producing and using biofuels (i.e. Decision No. 53/2012/QĐ-TTg; Circular 23/CT-TTg dated 31, August 2015; Decision 502/QĐ-UBND dated 03, March 2016 of An Giang People' Committee). However, there are not many consumers using biofuels, in general, and biodiesel, in particular. At the first International Workshop on Development of Renewable Energy for the Mekong Delta-DREMD-1 (Can Tho University, 2016), many authors reported that usage and production of renewable energy sources including biodiesel in the Mekong Delta has much potential. However, its current production costs associated with low price of fossil fuels can cause limiting consumers. Taking these into considerations, this study aimed to evaluate the existing potential use of biodiesel in agricultural production activities in the Mekong delta region focusing on its advantages and disadvantages. Moreover, factors affect on utilities of biodiesel and desirable solutions are described in this study.

2 STUDY METHODOLOGY

2.1 Approach

Participatory approach and systematic theory were applied in this study through survey and interviewing actors (data providers) related to supplying and using fossil fuel and biodiesel in agricultural production.

2.2 Study area and survey objects

Selected study areas were representative agro-ecological zones for agricultural systems and raw materials availability to produce bio-diesel (Table 1 and Figure 1). Rice, aquaculture, fruit trees and upland crops were key farming systems to be focused on. Three data provider groups were interviewed including policy makers and Key Informant Panel-KIP (enterprises produced materials for making biodiesel such as sea food companies, coconut oil processing companies, fast-food processing companies), services like gas stations, agricultural machine services (pumping, ploughing, and transportation), and fossil diesel users including farmers and others (Table 2).

2.3 Data collection

Secondary data were collected at the provincial level on issues related to fossil diesel and biodiesel. Similarly, primary data were collected through Key Informant Panel, In-depth Interviews, Household interviews, and Focus Group Discussion using Participatory Rural Appraisal approach.

Table 1: Study site distribution by agro-ecological zones (AEZ) in the study

No.	AEZ	Province/district	Materials to made Biodiesel	Crop systems that potentially use biodiesel
1	High flood	An Giang (Thoai Son, Chau Phu)	Catfish fat	Rice systems, upland crops and aquaculture (fresh water)
2	Middle	Vinh Long (Binh Tan, Mang Thit, Tra On)	Wastes such as used cooking oils	Fruit trees, upland crops
3	Coastal area	Ben Tre (GiongTrom)	Coconut oils	Rice and aquaculture (saline, brackish)

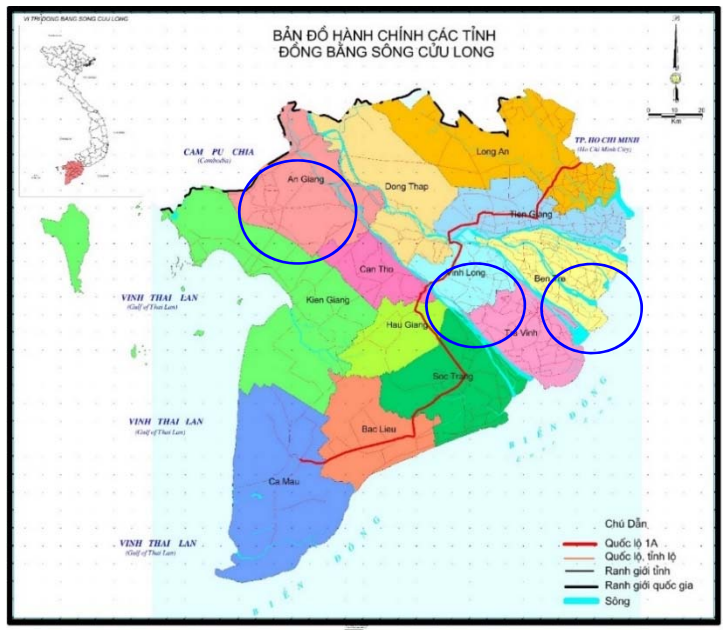

Fig. 1: Study site in the Mekong Delta (circle)

Table 2: Sampling and its distribution by locations and crop systems in the study areas

Respondents	Vinh Long	An Giang	Ben Tre	Total
Rice farmers + machines without services	-	47	10	57
Rice farmers + machine services	-	31	16	47
Rice servants	-	7	2	9
Catfish farmers (*Pangasius*)	22	16	-	38
Freshwater shrimp farmers	-	23	-	23
Black tiger and white-leg shrimp farmers	-	-	58	58
Upland crop farmers (sweet potato, water lemon)	72	-	-	72
Coconut farmers	-	-	76	76
Fruit tree farmers (citrus)	99	-	-	99
Gas station owners	-	5	-	5
Total	193	129	162	484

2.4 Data analysis

Collected data were checked, compiled and coded prior input into the Microsoft Excel software. Descriptive statistics, SWOT (Strengths, weaknesses, opportunities, and threats) analysis and ranking were employed for analysis. In order to predict acceptance probability of farmers in using biodiesel for agricultural production activities, binary logistics in SPSS software was used.

Binary logistics function as following (1)

$$Ln\left[\frac{P(Y=1)}{P(Y=0)}\right] = b_0 + b_1x_1 + b_2x_2 + b_3x_3 \ldots + b_ix_i \quad (1)$$

Where

P (Y=1) = P_0: probability of an event occurring (farmers use biodiesel in agricultural production)

P (Y=0) = 1 - P_0: probability of an event not occurring (farmers don't use biodiesel in agricultural production)

Xi: independent variables, Ln: log of e (e=2.714)

Odds constants

$$Odds = \left[\frac{P_0}{1-P_0}\right] = \frac{P\ (probability\ of\ farmers\ use\ biodiesel)}{P\ (probability\ of\ farmers\ don't\ use\ biodiesel)} \quad (2)$$

and (2) could be become Ln (Odd) = $b_0 + b_1x_1 + b_2x_2 + b_3x_3 \ldots b_ix_i$ (3)

(3) is a logarithmic function, then Ln (Odd) is linear regression function with independent variables

Xi. From (3), probability of using biodiesel in agricultural production could be estimated following.

$$E = \left(\frac{Y}{Xi}\right) = \left[\frac{\mathrm{P}}{1-\mathrm{P})}\right] = e^{b_0+b_1x_1+b_2x_2+b_3x_3\ldots+b_ix_i} \quad (4)$$

E (Y/Xi): probability to Y=1 occurs when independent variables Xi have specific values. Therefore, the function (4) could be rewritten as (5) below.

$$P = \left(\frac{e^{b_0+b_1x_1+b_2x_2+b_3x_3\ldots+b_ix_i}}{1+e^{b_0+b_1x_1+b_2x_2+b_3x_3\ldots+b_ix_i}}\right) \quad (5)$$

There are many tools, techniques and model could be used to estimate and determine factors impacting upon customers' decision on using and producing or non-using and non-producing biodiesel. It depends on collected data, sample size distribution as well as specific respondents. In this study, respondents are farmers who need and familiar with simple and easy interviewing questions and answers. Hence, the binary logistic model is employed to predict and explore factors influencing farmers' decision on using biodiesel. This is because the model uses dummy variables (yes, no), which seem to be easier to farmers.

3 STUDY RESULTS

3.1 Crop systems and farming activities using fossil diesel

Agricultural production systems in the Mekong Delta are much diversified depending on various natural conditions in locality. On top of that, KIP results indicated that rice, upland crops, fruit trees, catfish, and aquaculture (fresh and saline water zones) were the main systems. Table 1 presents that rice production system used fuel diesel in many farming activities compared to other systems. Irrigation, land preparation and harvesting and product transportation were key tasks which used 40%, 30%, and 30% fossil diesel respectively. To upland crops, fossil diesel was used mostly in land preparation while aquaculture systems used fossil diesel mainly in irrigation activity (80-100%).

Table 1: Crop systems and key farming activities using fossil diesel (%)

Production systems	Land/pond preparation	Irrigation	Pesticides application	Harvesting, transportation	Total
Rice	30.0	39.3	-	30.8	100
Upland crop	100	-	-	-	100
Fruit tree (citrus)	-	92.1	7.95	-	100
Catfish	22.5	77.5	-	-	100
Freshwater shrimp	-	80.7	-	19.4	100
Black tiger /white-leg shrimp	-	100	-		100

Note: -: not using fossil diesel. Farmers use other energies such as gasoline, electricity, human power due to specific tasks of farming activities. (Source: Survey data in 2015)

On average fossil diesel use per household depended on different planted areas and crop systems (Table 2). Generally, aquaculture systems used most fossil diesel than others, and rice was the system that used least fossil diesel. Black tiger/white-leg shrimp farmers who had agricultural machines (e.g. pumping machines) could use up to 1405 L of fossil diesel/ha/year, while farmers who did not have machines (they rent machines from servants) used approximately 794 L/ha/year. This proved that fossil diesel was used much in agricultural production activities in the Mekong Delta.

Table 2: Average fossil diesel quantity used in different crop systems

Production systems	Area	Farmers have agricultural machines		Farmers do not have machines
	(ha/HH*)	(L/HH/year)	(L/ha/year)	(L/ha/year)
Rice	2.8±0.26	356±49	122±8	248
Upland crop	1.0±0.07	145±16	166±20	158
Fruit tree (citrus)	0.7±0.05	229±24	328±25	327
Catfish	0.8±0.13	360±100	570±105	
Freshwater shrimp	2.2±0.28	945±142	457±44	794**
Black tiger/white-leg shrimp	0.2±0.03	145±19	1405±150	

*Note: Data were rounded; *: Household; **: Total average of aquaculture systems (catfish, fresh water shrimp and black/white shrimp)*

3.2 Accessibility to fossil diesel sources

Survey results showed that more than 80% farmers easily accessed to fossil diesel through providers in the local. Farmers could easily buy fossil diesel at gas stations at the commune level. KIP interview results also indicated that fossil diesel distribution network was very large and systematic; buyers could access anywhere in the local area. Unfortunately, there was not biodiesel product to be introduced based on this distribution system. Currently, most farmers satisfied with the quality of fossil diesel supplied by local servants. They only complained that the prices of fossil diesel have often been fluctuated overtimes that caused an unforeseen supply to farmers' demands.

3.3 Fossil diesel use trends in agricultural production

Figure 1 shows that about 60-70% farmers reported the trend of using fossil diesel for all upland crops, fruit trees and aquaculture systems has been increased between 2005 and 2015. Predicting fossil diesel will be used in the next time 2015-2025, farmers stated that it would continue to increase because using energy sources is compulsory in farming activities, and in their awareness there are no energy sources could be replaced fully fossil diesel. The increase mostly occurred in irrigation and water exchange activities where electric operating machines and others could not replace diesel operating ones (investment cost for diesel machines for irrigation was lower than for electricity pump stations and gasoline machines). For rice production system, 50% farmers report that fuel diesel use increased 40-50% in the years 2005-2015 and it is predicted to go up in the years 2015-2025. Of which, land preparation, irrigation and harvesting are core activities consuming much fuel diesel in so far. Nevertheless, the trend of diesel consuming for irrigation during the period of 2015-2025 seems to be decreased compared to the previous period. It could have been due to introducing new farming techniques such as AWD (Alternate Wetting and Drying), irrigation base on crop demands. In fact, land preparation and harvesting are two farming activities need much power (heavily) to do and no gasoline or other machines can replace fuel diesel machines. Therefore, definitely this needs much fuel diesel in the future for rice production system.

Depending on specific production systems, trends of using fuel diesel could be increased or decreased. Table 3 summarises reasons rising by farmers and local authorities during the survey. Besides, abnormal weather, climate change and natural disasters will lead an increasing highly in energy use to deal and adapt with those challenges.

Table 3: Reasons increasing and decreasing fuel diesel demands in agricultural production

Increase reasons	Decrease reasons
- Increase crops a year - Apply mechanism in agricultural production - Enlarge planted areas and agricultural services - Abnormal weather, climate change and natural disasters - Agricultural products transportation	- Use electricity instead of fuel diesel - Decrease in planted areas (depending on specific production systems)

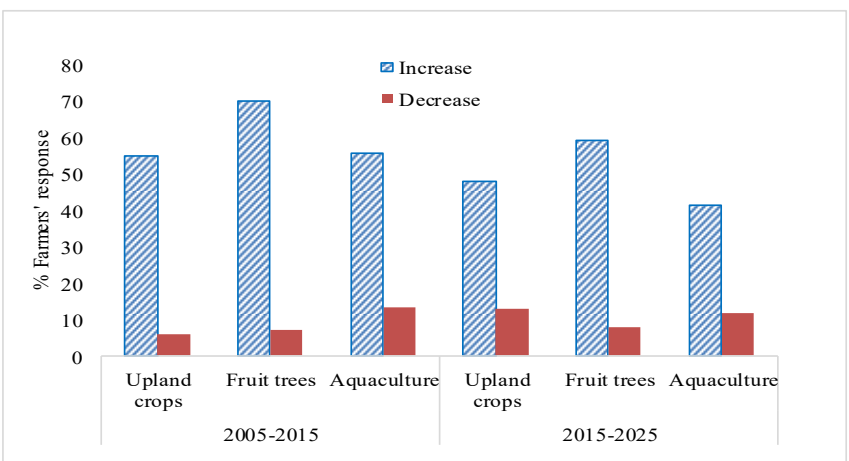

Fig. 1: Trends of using fuel diesel in key production systems between 2005 and 2025

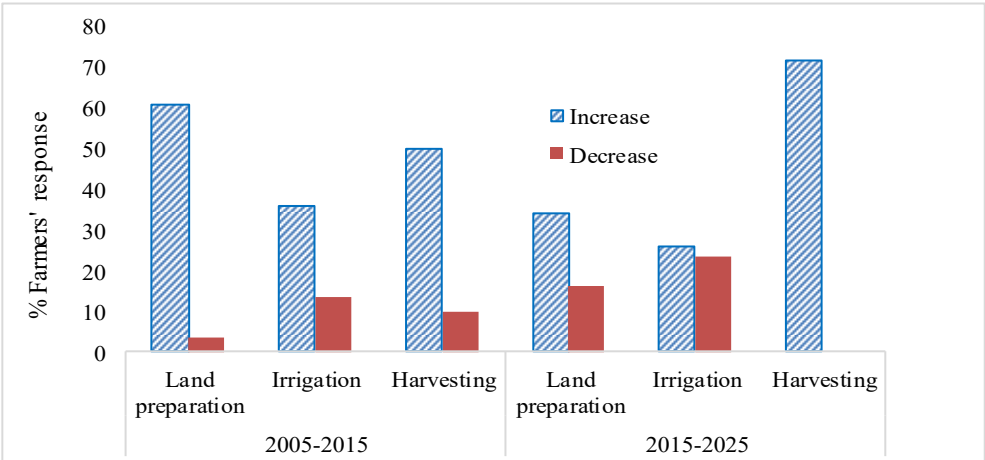

Fig. 2: Trends of using fuel diesel in rice production system between 2005 and 2025

3.4 Fuel diesel demands in agricultural production to 2020, vision 2030

Fuel diesel demands were estimated based on agricultural land use planning to 2020, vision 2030 under Decision 639/QĐ-BNN-KH dated 02/04/2014 of the Vietnamese Ministry of Agriculture and Rural Development (MARD) for main production systems associated with actual fuel diesel use in agricultural production. Accordingly, Mekong Delta currently needs 1 million ton of fuel diesel for key agricultural production systems, and this number increases to 1.1 million ton in 2020 (Table 4). This confirms that fuel diesel demands in agricultural production activities in the Mekong Delta are very large. In other words, biodiesel has good opportunities to partly replace fuel diesel solving pressure on energy and fuel sources in agricultural sector. However, the current competitive price of fossil fuel cannot promote and encourage customers to use biodiesel. Therefore, to enlarge number of farmers using biodiesel in agriculture sector, supportive policies such as price subsidy needs to be considered.

Table 4: Estimated fuel diesel demands in key agricultural production systems to 2020

Systems	Current		Planned/Predicted to 2020	
	Planted area (thousd. ha)	Fuel diesel use (thousd. litter)	Planted area (thousd. ha)	Fuel diesel use (thousd. litter)
Rice system	1562	387376	1700	421600
Upland crop	23	3634	333	52614
Fruit trees	242.4	79265	185	60495
Aquaculture	756.2	600422	812	644728
Total		1070697		1179437

Assumption is that existing farming activities and fuel diesel use are similar to that in 2020

Sources: GSO, 2015; QĐ 639/QĐ-BNN-KH dated 02/04/2014; authors complied and estimated.

3.5 Potential to produce biodiesel in the Mekong Delta

3.5.1 Policies on biodiesel use

In 2007, the Government issued the Decision 177/2007/QĐ-TTg on approving "Biofuels development program to 2015 vision 2020" that encourage public and private sectors and users to use biofuels in production and living. Besides, several Mekong Delta provinces such as An Giang, Ben Tre and Vinh Long have specifically supportive policies on producing and using biofuels. Unfortunately, up to now there are limited consumers use biofuels in general and bio-diesel in particular as well as lack of projects and programs on producing and using bio-diesel in agricultural production activities. Through KIP interviews, most policy conductors and influencers in An Giang, Ben Tre and Vinh Long (Department of Agriculture and Rural Development, Department of Industry and Trading, Department of Natural Resources and Environment) appropriated usefulness and benefits of using

biodiesel. Policy executors and stakeholders (private sector, companies) are willing to collaborate and participate in producing and using biodiesel if there are projects on biodiesel undertake in their locality. It is because common policies and trends of the government and local authorities. However, experiences on catfish oil production and use in the past years reflected that biodiesel need to be improved production costs and use efficiency to meet users' requirements (Dai and Tuan, 2007; Tuan, 2007).

3.5.2 Raw material sources

In the Mekong Delta, raw materials to produce biodiesel are very rich and much diversified. They are available in rural areas that allow farmers to access easily. Of which, used cooking oils (from fast-food processing factories), catfish fat and coconut oils are key sources. However, survey results show that used cooking oil sources were limited and scattered distribution. It is very difficult to collect. Moreover, use efficiency of cooking oil is very high that means by products and used cooking oil sources after processing are not much quantity. Therefore, this is not suitable source to produce biodiesel.

For catfish fat source, it is produced with a huge amount depending on production scale and processing technologies of different processing companies. Table 5 states that there is about 200 thousand ton of catfish fat provided to the market per year as an available source to produce biodiesel. Presently, most processing companies have closed their production chains to produce catfish fat for exporting and selling to other partners with large scale amount. Annually, Thuan An and Nam Viet companies (An Giang) produce about 30 million litter and 9000 ton of catfish fat, respectively. Those catfish fat were processed into catfish oils for exporting to Singapore (13.000VND/litter for low quality catfish oils and 16.000VND/litter for high quality catfish oils), and some catfish fat was sold in domestic markets with price is 12.500 VND/litter. Selling raw catfish fat in domestic markets is much lesser than export it after processing. Most catfish processing companies have factories to process raw catfish fat to export. Currently, some processing companies are studying on producing cooking oils from catfish fat, this improves added values in the catfish value chain while makes more pressure on production costs of biodiesel.

Table 5: Area, yield, production and fat quantity of catfish in the Mekong Delta in 2010-2015

Items	2010	2011	2012	2013	2014	2015*
Area (ha)**	5420	5430	5910	5668	5500	2204
Yield (ton/ha)***	210	220	216	279	277	280
Production (1000 ton)	1141	1195	1280	1125	1047	
Fat quantity (1000 ton)****	199.7	209.1	224.0	196.9	183.2	

*Notes *: calculated up to July, 2015, **: Planted/raised area, ***: average harvested yield; ****: fat content shared 16-17,5% total raw weight of catfish and it is dependent on various processing technologies*

Sources: Complied and synthesised from the Vietnam Directorate of Fisheries, Vietnam Catfish Association and KIP interviews, 2015

Table 6: Coconut area, production and estimated coconut oils in the Mekong Delta

Items	2010	2011	2012	2013	2014	2020*
Area (1000 ha)	93.64	109.35	113.91	121.31	127.37	127.58
Production (1000 ton)	834.53	889.68	954.64	994.38	1052.68	1178.97
Oil quantity (1000 ton)	103.48	110.32	118.38	123.30	130.53	146.19

*Notes: 5kg of dried coconuts give 1kg of coconut meat; 1kg of coconut meat gives 0,62kg of coconut oils (assumption that specific weight of coconut is 1); * planned to 2020; The production calculated only dried coconut, excluding fresh coconut*

Sources: GSO, 2015; KIP, 2015 and authors complied and estimated

For coconut oil source, it is very popular and always available anywhere in the Mekong Delta because coconut trees could be suitable and planted in most agro-ecological zones of the Mekong Delta. Of which, it is planted much in Ben Tre, TraVinh, Tien Giang and Vinh Long provinces. Data in the Table 6 indicate that planted areas, production and estimated coconut oils that released to markets has been increased steadily between 2011 and 2014 and vision to 2020. Similar to catfish fat,

coconut oils have high selling price, ranging from 20000-25000 VND/litter depending on specific selling time and quality of oils. This price can lead biodiesel has very high production costs. Besides, coconut oils are extracted effectively by companies, which have well processing technologies rather than households.

There are many raw material sources to produce biodiesel. However, the problems are that those sources have high selling price and therefore biodiesel has production costs compared to fuel diesel (Table 7). This is a key limitation in convincing farmers to use biodiesel in their agricultural production activities.

Table 7: Estimated production costs of biodiesel produced from different sources

Material sources	Price (VND/litter)	Production costs of biodiesel (VND/litter)*	Fuel diesel's price (VND/litter)**
Used cooking oils	10000-15000	14286-21429	15740-15790
Catfish fat	12500-16000	17857-22857	
Coconut oils	20000-25000	28571-35714	

*Notes: *: excluding fixed costs such as facilities, machines etc.; **: fuel diesel's price was recorded on July, 2015 for Fuel diesel 0.25 and 0.5S (Source: Petrolimex 2015); processing efficiency of biodiesel from used cooking oils, catfish and coconut oils is approximately 70%*

3.6 Acceptance ability to produce and use biodiesel

3.6.1 Farmers

There are more than 80% farmers responded that they agree to use biodiesel in their farming activities if the selling price of biodiesel is lower than fuel diesel. Besides, 36% surveyed farmers want to do pilot of biodiesel production at household level if they are trained and supported on techniques to produce biodiesel. Survey results confirm that 100% farmers concern on production costs of biodiesel, 94% and 90% farmers concern on engine life when using biodiesel and quality of biodiesel respectively. Additionally, use efficiency, operation safety, conditions for storage and suppliers in the local are key requirements that ensure farmers accept to use biodiesel (Table 8). Associated with required conditions to be used, farmers accept to produce biodiesel with conditions are low production costs (86%), markets' acceptance (69%) and availability of materials in the local (60%). Moreover, producing techniques, administrative registration procedure and market demands also considered by farmers when they agree to produce biodiesel at household level.

Table 8: Required conditions farmers need to use biodiesel

TT	Biodiesel users requirements	Ratio (%)
1	Low production costs compared to fuel diesel	**100**
2	Ensure engines' life when using biodiesel	**94**
3	Information on biodiesel is fully provided	**91**
4	Biodiesel has to be certified in term of quality	**90**
5	High efficiency use compared to fuel diesel	85
6	Safety in use	79
7	Safety for environment	79
8	Safe conditions for storage and transportation	72
9	Available suppliers in the local	60
	Biodiesel producers	
1	Low production costs compared to fuel diesel	**86**
2	Accepted by markets (market demands)	69
3	Raw materials are available in the local	60
4	Subsidized by the government	59
5	Easily to access to raw materials to produce biodiesel	51
6	Techniques, production process is easily and safe	46
7	Stable materials (quantity and price)	45
8	Simple administration and paper works	43
9	Suitable and acceptable trading taxes	41

To be accepted, farmers suggest that demonstration (pilot), training course and workshop on topic "biodiesel" need to be organised frequently and large scale to change awareness of users on benefits of

biodiesel. It is because biodiesel now is not familiar to farmers and fuel diesel users in the rural areas. So they need time to access and observe before deciding to use biodiesel. In summary, KIP and FGD results concluded that in short term biodiesel could not be accepted commonly to produce and use in agricultural production activities because its key benefits (economic, social and environmental) are higher than traditional fuel diesel.

Evaluation on availability and accessibility to material sources to produce biodiesel, coconut farmers have well available and accessible sources compared to other farmer groups (Figure 3 and 4). It is due to coconuts planted anywhere and farmers can access to coconut oils easily, while catfish planted mainly in some provinces such as An Giang, Dong Thap, Can Tho, Vinh Long and catfish fat only provided by big food processing companies in industrial zones with large amount. It means farmers can face difficulties to access to catfish as a material source to produce biodiesel.

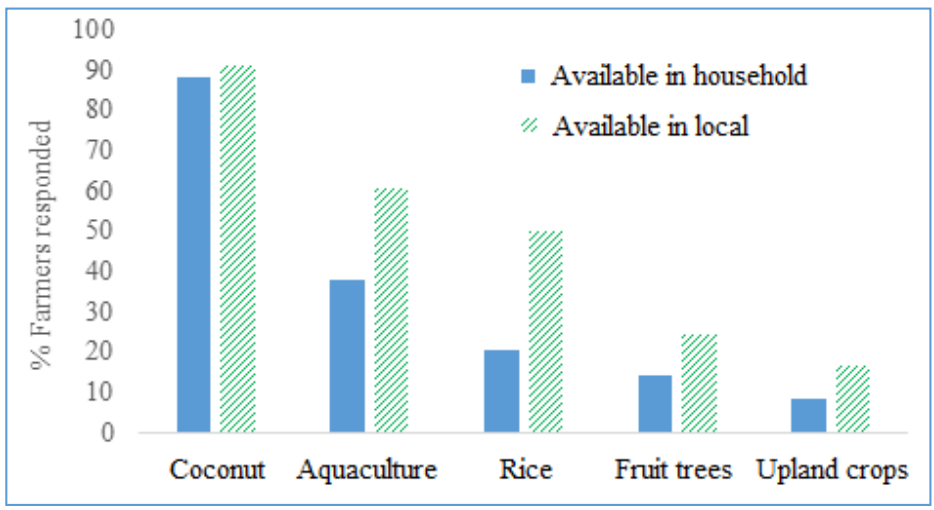

Fig. 3: Evaluation on availability of materials to produce biodiesel

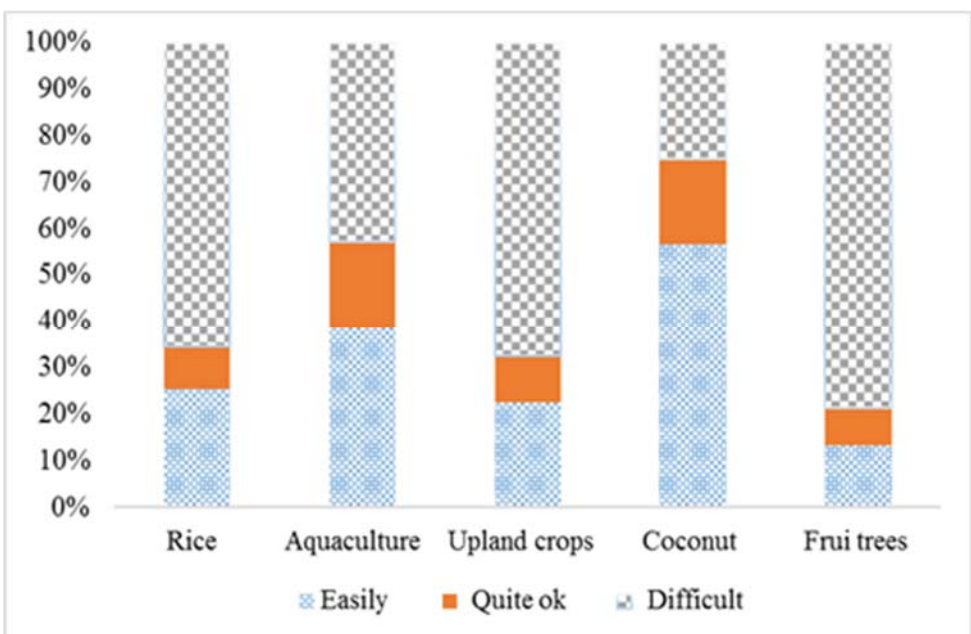

Fig. 4: Evaluation on accessibility to existing materials to produce biodiesel in the local

3.6.2 Factors impact on using biodiesel

Binary logistics analysis results show that there are 5 key factors impact on decision of farmers to use biodiesel including education level, poverty, family wellbeing, electricity use, in cooperative zone (Table 9). Accordingly, farmers have good education level and wellbeing agree to use biodiesel in their farming activities. It is because good education and wellbeing farmers have clear awareness on biodiesel benefits as well as community benefits when using biodiesel. In contrast, poor farmers, farmers use electricity for farming and farmers have planted areas in planning zones disagree to use biodiesel. This could be because poor farmers don't have much land area for farming therefore their demands on using biodiesel is not much. Meanwhile, farmers in the cooperative zones disagree to use biodiesel because their farming activities are undertaken by the cooperative, so they really don't have demands on using biodiesel. The perdition is correct 34% for cases of farmers disagree to use biodiesel, and it is correct 97% for cases of farmers agree to use biodiesel. The overall percentage correct of the prediction model is 87% (Table 10).

Table 9: Factors impact upon farmers' decision on using biodiesel

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Education level	.110	.047	5.364	1	.021	1.116
	Poverty	-.510	.250	4.153	1	.042	.601
	Family wellbeing	.507	.254	3.991	1	.046	1.660
	Electricity use	-2.362	.310	57.955	1	.000	.094
	In cooperative zone	-.481	.220	4.789	1	.029	.618
	Constant	3.835	.710	29.197	1	.000	46.313

a. Variable(s) entered on step 1: Education level, Poverty, Family wellbeing, Electricity use, In cooperative zone

Table 10: Percentage correct of the prediction model

Observed		Predicted		
		Biodiesel use		Percentage Correct
		No	Yes	
Biodiesel use	No	24	47	33.8
	Yes	14	393	96.6
Overall Percentage				87.2

3.6.3 Companies and services

In last years, some Fishery Processing Companies (Thuan An and Nam Viet in An Giang province) had studied on using catfish to produce biodiesel and oils to increase added values in the catfish value chain. However, now that activity is stopped because of very high selling price of catfish fat. Investment in biodiesel production doesn't give high benefits compared to other investments, so the companies just studied on biodiesel as social responsibility, they really don't want to enlarge production scale. Similar to companies, agricultural machine servants don't agree to produce and use biodiesel because its economic efficiency is lower than fuel diesel while they still worry about technical efficiencies of biodiesel.

3.6.4 Gasoline stations

Interviewed gasoline stations respond that current biodiesel trading is facing many problems below.

– High production costs and therefore users hardly accept to use;

– Unclear use demands particularly farmers and other objects' demands;

– Worry about biodiesel quality (engines' life expectancy);

– Trading benefits (efficiency) can be lower than fuel diesel;

– Signed contract with Petrolimex to sell only fuel diesel;

– Energy trading requires many paper works under state regulations, rules. Biodiesel trading may be more complicated than traditional fuel diesel trading.

3.7 Advantages and disadvantages in biodiesel production and use

It is clear that the Vietnamese government has policies to support and to encourage produce and use biodiesel in particular and renewable energy in general. However, up to now the application of any policies on using biodiesel in actual conditions is not popular. Demands and material sources to produce biodiesel are available, accessible and very

rich. However, producing and using biodiesel is limited, not familiar to users in the Mekong Delta. It is due to besides opportunities, producing and using biodiesel also has some challenges. Table 9 below summarised strengths, weaknesses, opportunities and threats of producing and using biodiesel in agricultural production activities.

Table 9: SWOT analysis results on producing and using biodiesel

Strengths Less dependency on fuel diesel; Suitable to international trends; Mitigation to climate change; Could be increase added values (green, clean production).	**Weaknesses** Unknown technical process to produce biodiesel; Processing efficiency from catfish fat, coconut oils to biodiesel is low (70%)[1]; Lack of information on biodiesel; Farmers are quite difficult to access to catfish fat and coconut oils with small scale; Awareness on biodiesel benefits of users are very poor;
Opportunities Rich, diversified and available material sources in the local to produce biodiesel (catfish fat and coconut oils); Policies on producing and using biodiesel (central and local governments); Improvement on environmental pollution (air pollution); Be accessible to catfish fat and coconut oils with large amount; Biodiesel could be safe to environment; Agreement of farmers, and other users to test and conduct pilot and demonstration.	**Threats** Production costs are higher than fuel diesel; Farmers use electricity and gasoline in farming activities, don't use biodiesel; High beginning investment costs to set up a system for biodiesel production; Price of catfish fat and coconut oils higher than petro-fuels; Inspection, certification and management on producing and using biodiesel is complicated; No subsidy to support biodiesel producers and users.

[1] *College of Natural sciences Lab (tested)*

4 SOLUTIONS AND RECOMMENDATION TO CHANGE AWARENESS ON USING BIODIESEL IN AGRICULTURAL PRODUCTION

Following solutions and recommendations based on current status analysis, demands evaluation and local farmers and stakeholders' needs on production and use of biodiesel.

– Introducing, propagating, advertising and providing information on benefits of biodiesel in general and in agricultural sector in particular to farmers, local stakeholders, users and servants who can use biodiesel;

– Organizing workshops, training courses, demonstration, pilot study on producing and using biodiesel at local and community levels. This allows farmers, users to participate in and evaluate advantages and disadvantages of biodiesel;

– Planning material zones for producing biodiesel associated with study on other materials such as sugarcane waste, rice straw and so on;

– Calling and linking with enterprises, fishery/coconut processing companies in producing and using biodiesel;

– Specifying policies supporting biodiesel production and use;

– Studying on improving production efficiency of biodiesel from catfish fat and coconut oils.

5 CONCLUSION

Fuel diesel is among key energies in agricultural production activities, its current and vision demands to 2020 are very huge and there are less opportunities for other products to be replaceable. Rice, upland crops, fruit trees and aquaculture are key production systems will use much fuel diesel in farming activities such as land/ponds preparation, irrigation, harvesting and transportation. Presently, biodiesel is not produced and used popular in the Mekong Delta because biodiesel is not familiar to users. However, potential to produce and use biodiesel in agricultural production is very ideal because the Vietnamese government has many policies supporting production and use of biodiesel as well as farmers, local authorities and stakeholders are willing to use biodiesel in the future. In addition, raw materials to produce biodiesel in the Mekong Delta are so rich, diversified and available

including catfish fat, coconut oils and other sources.

The big existing challenges in producing and using biodiesel are production costs, unclear use efficiencies and information on it. The study identifies key factors impact upon decision of farmers on using biodiesel such as farmers' education level, poverty status and wellbeing of farmers, electricity energy use and production organisation style in the local. So far, production and use of biodiesel in agricultural sector is among suitable pathways heading to agricultural green. Nevertheless, process of transforming biodiesel to users needs a specific road. Of which, introduction, propagation, information providing on biodiesel as well as workshops organisation, demonstration and pilots are very necessary to convince biodiesel users.

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