REGIONAL FISHERIES LIVELIHOODS PROGRAMME FOR SOUTH AND SOUTHEAST ASIA (RFLP) – VIET NAM

FEASIBILITY ASSESSMENT ON SMALL-SCALE INTERGRATED SYSTEM OF AQUACULTURE, ANIMAL HUSBANDARY, AND BIOGAS IN COASTAL COMMUNITIES IN QUANG TRI PROVINCE

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Acronyms

CRRD	Center for Rural communities Research and Development
DARD	Department of Agriculture and Rural Development
GDP	Gross Domestic Products
PMU	Project Management Unit
PRA	Participatory Rural Appraisal
RFLP	The Regional Fishery Livelihood Program
VAC	Garden, Aquaculture Pond and Animal Husbandry
VACB	Garden, Aquaculture Pond, Animal Husbandry and Biogas
VACVINA	Vietnamese Gardening Association

Executive Summary

This report provides an evaluation and analysis of current status and potential of small scale integrated farming system in coastal areas of Quang Tri province under the Regional Fisheries Livelihoods Programme (RFLP). Methods of analysis include both qualitative and quantitative approaches focusing on household integrated farming activities. Results of data analyzed shows that while traditional fishing is diminishing in generating income, other activities like aquaculture, agriculture and animal raising have been chosen by local farmers as alternative income sources. However, rapid development of shrimp culture and animal raising has induced problem of disease outbreak and environmental pollution. Additionally, the integration between household's activities is still limited. The report finds the prospects of the integrated production systems of either VAC with addition of bio-digester or AC-earth worm raising are sustainable for coastal areas. Apart from reducing environmental pollution, local farmers can raise more income from improving production effects and saving energy expenses for daily cooking. It is recommended that the demonstration models should be conducted as a trial in regard to geography and household conditions.

Introduction

The growing population in recent decades has caused increasing demands of food and traditional fuels for family daily use leading to serious problems of resources exploitation, forest destruction and environmental pollution. Traditional fuels such as wood and coal for cooking are becoming increasingly scarce and expensive, and can contribute to deforestation. Large numbers of households engage in farming, and agricultural waste poses a threat to the environment due to fresh animal dung being discharged into open gutters and community waterways. An increasing population leads to intensive agricultural aquaculture practices, damaging the environment.

In the context of small scale agricultural aquaculture production, Vietnamese farmers, especially poor people have to seek for ways to more effectively use on-farm resources from their farming systems. The integrated farming system encompassing gardening, fish pond and livestock pen (called VAC from the Vietnamese words for garden, pond and animal pen, namely Vuon, Ao and Chuong) is the most popular practice in the rural communities. This farming system promotes the full use of all material produced on the farm for production of food for human consumption (Nhung 1997). Animals produce inorganic manure which can be used to fertilize of fishponds and crops. The crops and aquatic plants provide food for the fish, animals and man, and the pond humus which contains nutrients is put back on the cropland as fertilizer. Recycling is considered as the best way for waste treated because of it is economically efficiency. Vincke (1991) reported that it is possible to recycle organic waste manure and farm effluents in fish ponds. The end product is an improved production of animal protein, which is particularly needed in developing countries.

However, in the Central coastal areas of Vietnam, farming communities have very limited productive land, and marine aquatic resources are overexploited. Further, about 80% of the households in coastal communities rely heavily on income from fishing and aquaculture activities with quite low productivity (contributing up to 95% total family income). In recent times, natural marine resources have declined due to over fishing and destruction of mangroves for the construction of shrimp ponds leading to the loss of income and livelihood for already poor communities. Diversification of the income base for coastal communities is a major issue for both local and central Government. Therefore, the Government is strategically focusing effort on reducing coastal exploitation by identifying alternative livelihood options.

In order to contribute to this effort, under The Regional Fisheries Livelihoods Programme (RFLP) funded by Spain, the development of a modified integrated farming system with aquaculture, animal husbandry and biogas is being considered by Quang Tri provincial Department of Agriculture and Rural Development. The treatment of animal and human waste by bio-digestion is one method that increases the production and use of renewable energy, is a safe treatment for human and animal wastes, which reduces deforestation, increases the capacity of farmers to supply more food, and supports the livelihoods of farmers and vulnerable people.

Objectives

Overall objective

Strengthening and diversifying income opportunities for fisher families in coastal communities of Quang Tri province

Specific objective

- To investigate possibilities for development of the integrated farming system of aquaculture, animal husbandry and biogas in selected coastal communities.
- To propose potential sites for pilot development of the system with economic and technical recommendations.

Methodology

Site selection

Based on the project logical framework, the RFLP target communes are Hai An and Hai Khe (Hai Lang), Trieu Van and Trieu Lang (Trieu Phong), and Vinh Thai (Vinh Linh). Among those communes, potential development of the system and proposed sites for a demonstration was identified through meetings with provincial project PMU, Quangtri's DARD and Agricultural and Fishery Extension Center. Hai An and Trieu Van were suggested as two representative sites where there exist the two distinct household production systems. A further investigation of the need and technical feasibility in those two communes will be conducted in order to develop the appropriate system.

Data collection and analysis

All relevant information, both quantitative and qualitative data to the system were collected focusing on integrated farming activities.

Secondary data

Secondary data, such as annual reports, development plans and statistical data were collected from relevant departments including provincial and district DARD, local extension center, and communal people's committee. These data were in hard copy format.

Primary data

Primary data was collected using interviews, observation, and participatory rural appraisal (PRA). This provides synergy effect for data collection and evaluation efforts, and collection of a comprehensive amount of information about household's production systems in a relatively short time period. Various tools and techniques of PRA were used with the help of checklists and semi-structured questionnaires, such as Seasonal calendar, Venn Diagrams, Matrix Ranking, to identify some key features of production activities of local households.

10 families were randomly selected in each selected commune for a household survey using a questionnaire to obtain information on household economic conditions and production activities.

Key informant interviews or in-depth interviews were also conducted with key informants from provincial and local authorities to get their opinions about the potential and development orientation of the integrated system.

Data analysis

Colleted primary data were coded and entered onto a computer. Thereafter statistical and economic analyses were done using Statistic Package for Social Sciences (SPSS) and excel programs. Descriptive statistics such as reports, frequency, mean, percentage were used to describe the household profile and existing production systems with their different components namely horticulture, animal husbandry and aquaculture.

Findings and Discussion

Located in the coastal central region, Quang Tri province borders Quang Binh province in the North, Thua Thien Hue province in the South, the People's Republic of Laos in the West, and the open sea in the East. The provincial terrain comprises three distinct parts including coastal, lowland and mountainous areas. The province is divided into 10 administrative divisions with one central city (Dong Ha) and 9 towns and districts (including Conco Island district). The coastline is approximately 75 km long with two river estuaries, namely Cua Tung and Cua Viet, and includes 12 coastal communes.

The area covers two climate regimes including the northern climate with a distint cold season and the southern climate which is hot and humid all year round. Quang Tri is affected by severe weather conditions including cyclones and floods. This brings advesersly affects the production systems of local people, and particularly farmers along the coastal belt coastal belt.

The rainy season runs from September to January of the next year. 75-80% of the annual total rainfall os concentrated between September and November. This period is considered most suitable for agricultural and aquaculture production. However, storms and typhoons at this time can negatively affect production activities.

Quang Tri has a total area of 474,699 hectares, of which agricultural land comprises 79,557 ha (16.7%), forested land 219,639 ha (46.3%) with 101,067 ha of natural forests, and timber reserves of about 11 million m^3, and 131,284.05 ha (27.7%) of unused land of which over 60% could be exploited..

A notable feature of the Quang Tri delta is sand dunes adjacent to the sea which is encroaching deeper inland. Quang Tri DARD estimates the area of dunes to be about 13,000 ha.

.Overall, GDP growth annually over the period 2005-2009 was 11%, with a per capita income in 2009 of VND 13.7 million (approximately U.S. $ 800 per person). The province's economic structure is improving and currently the construction, agriculture

(including forestry and fisheries) and the private sector account for 34.7%, 29.9% and 35.4% of GDP respectively.

Table 1. Key social-economic indicators

Indicators	2000	2005	2007	2009
Economic indicators				
Gross domestic product - billion Vietnamese Dong (price 1994)	1,195	1,813	2,251	2,712
GDP shares	100	100	100	100
Industry-Construction	14.64	25.76	33.01	34.7
Agriculture	44.77	37.23	31.48	29.9
Services	0.59	37.01	35.51	35.4
GDP growth rate - %	9	10.6	11.2	9.1
Import - export turnover (thousand US$)	21,851.1	12,343.6	27,048.8	38,000
Social indicators				
Trained workforce rate (%)	19	24	26,3	30
GDP per capita - million Vietnamese Dong (current price)	2,9	5,5	8.0	13.7

Source: The provincial statistical year book 2009

Land use and household production activities

As a common characteristic of all coastal communes, forest land occupies the largest proportion of land area. These areas are mostly protected forest which plays a very important role in preventing sand movement. Conversely agricultural land is usually only accounts for 13-15 % of total land area.

Although sand dune areas dominated in coastal communities, household production activities are usually quite diversified. Apart from fishing as a traditional occupation, aquaculture- agricultural production and household animal raising varies from commune to commune. The season for household production activities is described in the Table 2.

Typically total land area of a coastal household varies from 2,000 to 10,000 m2. Household land holdings depend on the exploitation of unused land by the family in the past. 55-80% of household land is usually used for crops and gardening, with 18-20%of the total family land area typically being used for aquaculture. However, with only limited fertile agricultural land the land which is cultured is done so intensively and it generates the main source of income for families .

In most coastal communes, the integrated system of horticulture and animal raising is the most common. Households with a pond(s), garden and livestock are very typical in Trieu Van commune, accounting for about 50 % of the total.

Table 2. Seasonal production activities in surveyed areas

Month / HH's activities	1	2	3	4	5	6	7	8	9	10	11	12
			Low rain, water shortage					Water inundated				
Fishing			Main fishing crop									
Rice cultivation		One crop										
Shrimp culture		Crop 1			Crop 2			Crop 3				
Fresh fish culture	Harvesting							Stocking				
Pig raising	Raised around the year with every three months											
Crops	Sweet potato, melon, peanut…											

Fishing

In all coastal areas, fishing has been traditionally considered been the main household occupation. However, depending on geography fishing activities are also diverse. In-shore fishing still dominates and especially in shallow water areas, while off-shore fishing is more common in communes located around Cua Tung and Cua Viet (Cua Tung, Cua Viet, Trieu An, Gio Viet and Trung Giang). There are a total of 2,945 fishing vessels, of which 82.9% are small vessels below 20 Horse Power (HP) (DARD Quang Tri, 2010). Small vessels mainly operate in shallow inshore areas. Fishers from Trieu Van and Hai An communes, report that productivity and effectiveness of inshore fishing activity has declined in comparison with other activities. Reasons for this include: (1) A reported dramatic decline in aquatic resources due to destructive fishing methods with some species reportedly disappeared; and, (2) Limited capital resources as most of fishersin these areas are poor and are unable to upgrade their vessels and fishing gear.

As a result fishing is not very profitable and so many fishers have already shifted to other more profitable activities like pig rearing, crop cultivation and/or aquaculture production. Through time trend analysis done in Trieu Van commune, there is a sharp decrease in number of local fishing teams from 9 to 2 in the period of 2000-2009. Moreover many local people work seasonally as hired labour in southern provinces (coffee and rubber farms).

Agriculture/horticulture

As mentioned above, agricultural production is mainly vegetable cultivation. There are only few areas like Trieu Van where rice cultivation is possible. Even there only one crop can be cultivated per year with low productivity (less than 300 kg/500m^2.

In general, most of farmers cultivate agriculture crops in their garden land. A typical VAC garden is bordered by a row of Casuarina equisetifolia which acts as a windbreak, hindering drifting sand and filtering salt from the air and sea spray. Other trees and rattan are densely planted on mounds built up around the garden as protection. Within the garden, a variety of crops, vegetables are grown for family

consumption. Common crops recorded include sweet potato, peanuts and bitter melon. Some of fruits are also cultivated like water melon and casaba melon. However, there is little data on how much and which crops contribute to household income family income as no data on daily sales or consumption is recorded.

Aquaculture

Survey results showed that freshwater fish culture and shrimp culture were the major aquaculture systems.

Freshwater fish culture on sandy land has been practised for the last ten years. The provincial authorities report that the sand areas around most coastal communes are only slightly elevated and groundwater is usually available at a depth of 1.5-2.5 m. However, during the summer season where rainfall is low (40mm/month), freshwater sources are limited. Thus aquaculture is often seasonal with a growing season of 6-8 months. This type of aquaculture is usually semi-extensive, family scale and with low investment. It typically generates an income of VND 2 - 3 million per year.

Pond size varies from household to household, ranging from 250 to 3,000m^2. On average, the size is about 500 m^2, and pond depth ranges from 1.2-1.5 m.

The most common species for freshwater aquaculture are carp species including common carp, big-head carp, silver carp, and Indian carps. These species are available as they have been cultured for long time in the province and considered as “traditional species”. Recently, some species with high economic value have been cultured in either concrete tanks or in plastic lined ponds, such as giant snake head and catfish (Clarias batrachus), and these species are in communes where family land is limited. Feed for cultured fish is mainly trash-fish. However, in recent years, snake-head and catfish culture have been constrained by the limited availability of trash-fish.

Shrimp culture on sandy land in coastal areas of Quang Tri province has been practiced for almost ten years. The common culture species are tiger and white leg shrimp (*Penaeus vannamei*). Provincial authorities reported that white leg shrimp is being promoted for the economic development of coastal areas, particularly where in-shore aquatic marine resources have been exhausted. . From 2006 to 2010, the total culture area of shrimp rose from 55 ha to an estimated 600 or over 110% increase each year for 5 years. Intensive culture systems dominate with pond areas ranging from 2,000-6,000 m^2. Average productivity was about 12 tons/ha/year (DARD Quang Tri, 2010).

However, during the survey it was observed that the boom in shrimp culture on sandy ponds along the coastal commune has recently (since 2009) brought about several problems and is unsustainable.

Due to high economic returns from some successful models, many local farmers shifted to culture shrimp. Most of shrimp culture areas which developed were unplanned. In some communes like Trieu Lang, several farmers converted their garden into shrimp ponds, while some farmers occupied irrigation canal areas which had negative impacts on water flows and induced environmental pollution in culture areas.

Low technical know-how and lack of capital of all surveyed farmers lead to crop failures. According to Trieuvan's authority, most of shrimp farmers were fishermen without knowledge of shrimp culture techniques. They expected to get high production by stocking with very high density. It is recorded that average stocking density was about 200 PL per m^2. Particularly some farmers stocked up to 220 PL per m^2. As a result, problem of pollution and disease outbreak are seen very common recently.

In regard to investment, shrimp culture requires a large amount of capitals. Reported by one shrimp farmer, initial investment for 3,000m^2 of shrimp pond took about VND 300 million including pond construction and infrastructure (electricity, road, and well). Virtually all farmers reported borrowing up to 90 % of the investment capital from their relatives or banks. However, currently it is now difficult to obtain bank credit for shrimp culture as they perceive shrimp culture as risky. Often farmers must take loans from private informal money lenders at high interest rates. Therefore some farmers are now deeply indebted, and some have already abandoned shrimp farming.

Another important reason leading to unsuccessful shrimp culture is due to the low quality of post-larvae. With rapid development of shrimp culture, came a rapid development of shrimp hatcheries which produced PL's of variable quality. As a result, when farmers buy seed, they are unsure of the PL quality.

Case 1: Mr. Nguyen Quoc Danh, vice-chairman of Hai An commune

Like other coastal communes, white leg shrimp culture in Hai An developed rapidly since 2008. To date 36.9 ha of ponds culture shrimp, of which 6 ha belongs to a private company. The rapid expansion of shrimp ponds and low technical knowledge of farmers, plus poor PL quality caused environmental pollution and disease outbreaks. Mr. Danh estimates that 45% of local shrimp farmers lost money while 30% breakeven. The other 25% who were making a profit were usually better-off farmers. Currently commune authorities are not encouraging farmers to expand culture area until detailed planning is conducted for shrimp.

Livestock

The livestock subsystem in most coastal communities plays an important role in total production activities. The common livestock species raised in the local area are pigs, cow and poultry, of which pigs and chicken are the most popular. In recent years, grassland areas have decreased due to an expansion of afforestation and this has reduced the number of cattle raised. The survey showed that pigs are the main source of cash income for rural households. Chicken were reared primarily for family consumption.

Pig fattening was common in every sampled household. Four pig fattening cycles are conducted each year. Depending on household labour and economic condition, the number of pigs raised ranges from 5 to 15 per cycle. Exceptionally some families conduct almost commercial scale pig rearing with more than 50 pigs per cycle. On average, each household produces 200 kg of pig a year with a market size of 50 kg per pig.

Feed accounted for 70% of the cost of pig rearing. Most households use commercial pellet feed. On farm by-products including rice bran and vegetable wastes were also provided as supplementary feeds. Gross return for the pig fattening pig subsystem is about VND 8 million per year. i.e., VND 200,000 per pig).

The major risk for pig rearing is blue ear disease which was reported in the survey areas. This disease has a high mortality rate and also seriously decrease market price. In 2009, the price of live pigs was as low as VND 20,000/kg.

Socio-economic and environmental issues

As mentioned above, the depletion of aquatic resources has affected coastal communities who rely on fishing activities, particularly in-shore fishers. With growing population pressure coastal people must seek alternative livelihoods to survive.

The rapid expansion of shrimp farming on sandy soils caused several negative impacts. The cutting of protective forest areas accelerated the pace of sand encroachment inland. Intensive and industrial shrimp farming produced untreated waste waters, environmental pollution and shrimp disease outbreaks. Shrimp culture on sandy land also needs large quantities of fresh water, which can lead to over-exploitation of underground water aquifers, tectonic subsidence, increased salinization of groundwater and conflict between different water user groups.

Survey results showed that some rural households are rearing more animals without appropriate treatment of wastes. Discharge of untreated animal wastes into environment was found to have caused serious pollution problems. The two main causes recorded were (1) pig systems without waste treatment tanks where animal wastes were discharged directly into fish ponds, garden and/or the ground; (2) pig systems with too small storage capacity and no-cover, which resulted in wastes over-flowing especially during heavy rain events. Discharging animal dung over the ground leads to formation of a squalid bad smelling and fly-ridden mud which is unpleasant for local residents.

Left unsolved, it may potentially create social conflicts among local people. A study of animal waste treatment conducted in Thai Binh province found that pig dung pollution resulted in bitter conflicts between pig raising farmers and their neighbours.

Environmental pollution caused by household's pig raising

It should be noted that in most coastal communes where agricultural activities are relatively under -developed due to infertile soils, the demand for use of animal manures is very limited. The recent expansion of both shrimp and pig rearing in

coastal communities is causing serious environmental pollution problems that need resolving.

Recognizing this problem local authorities have requested provincial support to pilot household biogas systems in communes. Some local authorities like Hai An commune are encouraging farmers to intensively rear pigs, but are allocating them land to do so distant from residential areas.

Case 2: Mr. Nguyen Van Tuan, 9th village, Trieu Van commune

Mr. Tuan has a family of 6 including his wife and 4 children who live inside the community. Their main income sources are pig raising and sale of pig feeds. The family has 5,000 m^2 of land including 400 m^2 of house, 120 m^2 of pig pen, and the remainder is forested. The family rears 120 pigs each three month cycle i.e. 4 crops per year. Vincent (CIRAD, 2001), estimated that each pig produces 7 % of its weight in wastes daily. Thus, if Mr. Tuan's pigs weigh an average 30 kg they would produce 252 kg of wastes daily; 54% of which would be solid and 46% liquids. The wastes were partly discharged into a small biogas tank ($7m^3$), but most overflowed into an uncovered small storage tank adjacent to the pigpen. When full, the wastes overflow across the ground. Despite giving some manure away to other farmers, the wastes are building up and smell especially in summer. Neighbours have complained to the authorities, but the situation is still unresolved.

VAC-Biogas and sustainability

The survey found both integrated VAC and VC systems in coastal areas. Among 19 sample households, 78.9 % were practising the VAC model. However, the level of integration between components of the system was inefficient. Most local farmers had developed their integrated systems based on their own experience. Thus, the production efficiency was still limited.

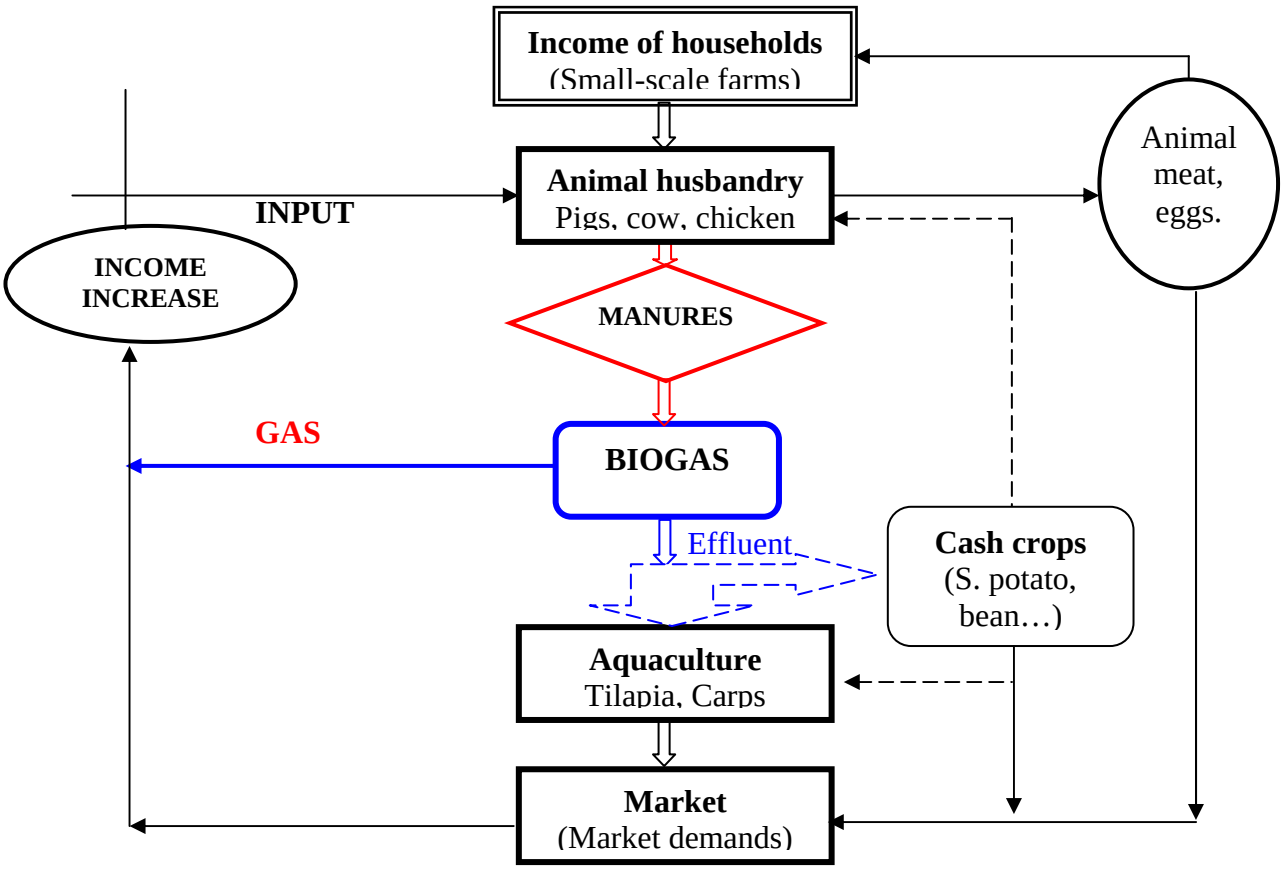
Table 3. Common species are currently practised in the integrated system by coastal households.

Garden	Pond	Livestock
Sweet potato	Tilapia	Pigs
Corn	Carps (common carp, grass carp, mrigal)	Poultry (chicken, ducks)
Beans, peanuts	Clarias catfish	Cattle (cow, buffalo)
Vegetables	Snakehead	

Source: The survey result, 2010.

The proposed integrated system of VAC-Biogas system is actually based on the traditional VAC system. This has been modified and tested since 1998, by VACVINA with an additional of biogas component (see the diagram 1). The model of biogas was also recognized by MARD who decreed that it could be installed nationwide.

Diagram 1: The integrated system of VAC-biogas



The biogas technology should appeal to the rural people because it can raise household income, produce gas for cooking and light, and positively impact on pollution. A bio-digester can produce enough daily fuel for household cooking and lighting through releasing methane (CH_4). The study of VACVINA in 21 family scale biogas systems in Vinh Phuc province (1998) showed that an average volume of biogas received per pig (50kg) is about 0.27m^3/day, and average demand of biogas for cooking is 0.3m^3/day/person. If a family has 6 members, a total volume of biogas needed is 1.8m^3/day. Thus, to ensure a volume of biogas enough for daily cooking, the family must raise at least 6-7 pigs.

According to the survey, in coastal communes where there is an availability of firewood, most of local households use this firewood as a main source of their daily cooking energy. Reported by local authority in Trieu Van, there are only 20 percent of households in the commune using gas for their daily cooking. However, this case is often seen for medium and better off families.

With average number of pigs are 10 per household, the biogas installation in the study sites can provide enough biogas volume for daily cooking demand of the family. As a result, spending for fuel and/or time for collecting firewood can be saved. In the small scale bioenergy initiatives research program (FAO & PISCES 2009), VACVINA estimated that the installation of the biogas at family scale could induce a saving of $80-$200 per year or 50-90 days/person/year if the family has to gather firewood.

Wastes produced by biogas systems are odourless and the burning of methane produces less harmful effects than burning firewood or charcoal. This not only improves household heath, but also reduces conflicts between households

The use of the bio-digester also promotes sustainable agriculture practice. Biogas slurry or bio-fertilisers generated by the bio-digestion process still have high nutrient value, and can safe be used on fruit trees, fishpond, rice paddies and vegetable gardens and is preferable to chemical fertilizers (Table 4). The availability of an inexpensive, but rich organic fertiliser reduces the costs and risks associated with chemical fertilisers.

Table 4. Effective treatment of parasites by the biogas technology

Amount of parasites before treatment (eggs/l)	Amount of parasites after treatment (eggs/l)	Notes
458,000	176,000 (of which 70% are incapable of developing)	disintegrating efficiency reached 98 %

Source: CRRD, 2007.

Moreover FAO (2006) report stated that the global livestock sector was “one of the top three most significant contributors to the most serious environmental problems at every scale”. Livestock rearing was responsible for 18% of global greenhouse gas emissions, it states, putting it easily ahead of the transportation sector in the list of environmental threats (the latter producing around 13% of global emissions). Therefore, the application of VAC biogas system, in the long term, will also contribute significantly to the reduction of greenhouse gas emissions.

The main obstacle which has limited the development of the biogas application in rural areas is insufficient money to invest. The main obstacle which has limited the development of the biogas application in rural areas is insufficient money to invest. According to an investigation of VACVINA in Thanh Hoa province (2008) under the Enabling Access to Sustainable Energy Project, the shortage of capital was identified as one factor that limits biogas development in the community. Biogas use requires farmers to pay even more if they wish to incorporate a hygienic latrine. Currently, there are insufficient finance mechanisms through which farmers can access credit for building biogas plants. The demand is still immense as Vietnam has nearly 10 million households involved in various forms of animal husbandry.

All surveyed farmers have heard about the biogas technology. However, only a few biogas systems have been installed, and had been installed primarily to treat animal wastes. Households that did not have biogas reported that limited capital for investment was the main cause.

Table 5. SWOT analysis of the VAC-biogas system

STRENGTHS	WEAKNESSES
• Improved environmental conditions and reduced the family energy costs. • Increased production efficiency via better integration. • Improved quality of agro-products • Foul smelling animal wastes processed into safe, odourless but useful organic fertilizer	• Requires appropriate investment costs for (costs for biogas installation and appropriate numbers of raised animal to maintain operation of the biogas system)
OPPORTUNITIES	**THREATS**
• Government policies and program for promoting biogas development. • Increasing of industrial energy costs (gas, electricity)	• Livestock disease outbreaks such as blue ear pig, bird flu. • Inappropriate installation of biogas system can cause explosions.

Conclusions

In summary, although fishing is traditionally considered as main production activity of coastal households, reduction in income due to diminishing aquatic resources has recently resulted in a shift from fishing to other activities. The alternative livelihoods that coastal households have been taken up include aquaculture, livestock raising, agricultural crops and/or hired labor work. However, among these activities, shrimp culture and animal raising were recorded as being unsustainable because of environmental pollution. This led can lead to potential social conflicts among local farmers.

Although integrated VAC and VC has been practiced by some households in surveyed communes, the recorded production was still limited mainly because of inefficient integration. Additionally, the direct use of animal dung to feed fish or as fertilizer for agricultural crops may result in the transmission of harmful bacteria to humans.

The improved integration of VAC with a bio-digester is seen as a good alternative sustainable livelihood for coastal households. Biogas complements sustainable agricultural production in the animal husbandry sector, generating additional income, protecting the local environment and enabling access to sustainable energy for the poor. This also meets with the objectives of the National Target Program (NTP) on climate change and the MARD program for expansion of biogas aiming to reach sustainable development of animal husbandry sector.

Recommendations

The type of integrated production systems required is site specific and depends on the geography. For all coastal communes, except Trieu Van, where productive land is

limited and the soil too infertile for agricultural production, the best model would be an aquaculture pond integrated with livestock and worm raising.

Production model of VAC-Biogas

This integrated model, which is appropriate for the Trieu Van area, comprises garden, aquaculture pond, livestock and biogas. It should be noted that to make use of wastes from the bio-digesters, recommended aquaculture species are carps, tilapia and *Clarias* catfish which feed on zooplankton, phytoplankton and zoobenthos respectively.

The survey found significant variation in household socio-economic conditions and production scales. In this case, it is assumed that animal wastes will form the center of household farm integration. The requirement for organic fertilizers was calculated based on the technical recommendations for aquaculture and agricultural crops given in annex 1. Also, the biogas volume was calculated based on the animal production scale and the energy demand of an average rural household.

For the pilot demonstration model it is recommended that a biogas system should be installed which can process wastes from 10-15 pigs. The effluent from the biogas will be used as organic fertilizer for the aquaculture and agriculture crop components.

For the biogas component, it is suggested that the VACVINA's model should be applied. This biogas technology has been improved by learning from experiences of different models from China, India and Colombia which have been piloted in Vietnam. This model is being promoted by MARD for its expansion program.

Production model of VAC-Worm raising

The model consists of a garden, aquaculture tanks/plastic lined ponds, livestock and worm raising. This model was not initially considered by the survey, but from data gathered the consultant recommends that this system is given due consideration by RFLP and DARD Quang Tri. This model works well where households with limited land, and high nutrients discharged from animal production systems. Recommended aquaculture species for this system are eels, *Clarias* catfish, and snakeheads. This model is not reliant on trash fish which have become scarce and expensive.

Earth worm culture has been adopted widely by farmers in northern rural areas in the last five years. The discharge of wastes from raising household animals like pigs, cows, buffaloes and poultry is used in the production of earth worms, which in turn can be fed to fish or poultry in the households. The production scale of each worm system will be designed depending on the scale of animal raising or the volume of animal dung can be collected by the household. For an average household with 10 pigs a worm area of approximately 20 – 25m^2 is required per household.

Apart from supplying a feed source for livestock and/or aquaculture, worm raising is also considered as a suitable treatment method for wastes releasing produced by animal rearing and agricultural activities. The effluent from worm production can also be used as bio-fertilizer for agriculture activities.

Combined VAC-biogas and worm rearing

For households rearing over 120 pigs/year or with more 5-6 cows/buffaloes, the amount of wastes discharged is large. Thus a combined VAC-biogas and worm rearing system can make use of the animal wastes while producing gas and earth worms for aquaculture or poultry.

However, with intensive animal raising (over 200 pigs/year), some households cannot invest in other production activities due to limitation of their resources (capital, labor, time). Thus, animal dung can become pose serious pollution problems. Local authorities however have an obligation to either limit the size of animal production units or to enforce animal production owners to treat animal wastes produced effectively, through the promotion of biogas and worm systems.

Specific suggestion for demonstration models under the project

In regard to specific demonstration models, the study has proposed two distinct integrated production systems in Trieu Van and Hai An. Set criteria for selecting households to develop the demonstration models as follows:

(1) VAC-Biogas model

a) Suitable for households with a pond >200m^2 with polyculture of freshwater species such as carps, and tilapia;

b) Practicing animal raising of approximately ten pigs or 2 cattle; and,

c) Willingness to participate.

It is proposed that Mr. Hoang Anh Dung's family, No.9 village, Trieu Van, Trieu Phong, is selected as his household already has a VAC system (Annex 2). A biogas component with a 7.5 m^3 capacity should be supported. The family toilet should also be combined into the system.

(2) VAC-Worm raising model

a) Suitable households should either have no pond or have a small pond and only a very limited land (less than 200m2), and particularly areas with limited access to water;

b) Practicing animal rearing with approximately ten pigs or 2 cattle; and,

c) Willingness to participate

It is proposed that Mr. Phan Thanh Tinh's household is selected as the pilot, My Thuy village, Hai An, Hai Lang (Annex 2), as the household rears pigs and is culturing fish. However, there is no integration between the two production systems. A 20-25 m^2 worm culture system should be constructed. Additionally a bio-filter system should be applied for reuse the water from the aquaculture system.

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Annex 1. Technical suggestions for the integrated production system

Table 6. Number of animals to stock over pond area

Type of animals	Animals number per ha of pond	Reference sources
Duck	300	
Chicken	300-500	Porphyre (CIRAD) & Coi (NIAH), 2006
Pig	60	
Cow/Buffalo	6	

Table 7. Recommended crop organic fertilizer rates

Type of crops	Kg/360m^2 "Sao"	Tons/ha	Reference sources
Spring rice	500	14	
Summer rice	500	14	
Vegetable	1,080	30	
Maize	600	17	
Soybean	360	10	Porphyre (CIRAD) & Coi (NIAH), 2006
Sweet potato	700	19	
Potato	700	19	
Peanut	700	19	
Bean	720	20	
Pumpkin	2,161	60	

- Biogas installation

The volume of the bio-digester will be calculated basing on the formula which has been developed by VACVINA:

$$V = V_{ck} + 6nLT$$

Of which: V_{ck} : the volume of gas contained in the biogas tank

$V_{ck} = h \times S$

S: a surface area of the biogas tank in square meter (m^2)

h: a distance from the bottom of the tank to the water surface in the tank (35-40 cm)

n: numbers of pigs raised frequently in household

L: an average amount of animal dung discharged a day from 1 pig (around 2 litres daily)

T: time the animal dung is in the tank (about 40 days)

It is suggested by VACVINA for an optimal performance of T = 40 days and h = 0.4m, thus the volume of the bio-digester is:

$$V = 0.4 \times S + 260 \times n \times L$$

Annex 2. Suggested households for developing demonstration models

Background information	VAC-Biogas Mr. Hoang Anh Dung No.9 village, Trieu Van, Trieu Phong	VAC-Worm raising Mr. Phan Thanh Tinh, My Thuy village, Hai An, Hai Lang
Family size and labors	6 (4 children)	5(1 children, 2 elders)
Total land (m2) including family house.	4,000	1,800
Main occupation	Carpenter, animal raising, aquaculture and agriculture	Construction, aquaculture and animal raising, and fish sauce selling.
Average income (monthly)	VND 4 million.	VND 3 million
Rice cultivation	2000m^2,1crop, productivity of 300 kg/500m^2	No
Horticulture	770 m^2 ; sweet potato, cassava, peanut, vegetable	1,300; sweet potato (now not cultivated)
Animal husbandry	30m^2 , pigs, 4 cycles, 15 pigs/cycle	45m^2, pigs, 3 cycles, 10 pigs/cycle
Aquaculture ponds/tanks	700m^2 divided in 2 ponds; Common carp, silver carp, tilapia, Clarias catfish	36m^2 divided in 2 tanks (cement tank with plastic cover bed); snake-head fish
Use of pig manure	80 % for rice cultivation and crops. 20% for fish culture	Not used. Discharging freely into the garden
Toilet	Temporary settled	Temporary settled
Main constraints	Lack of capital investment Limited technical knowledge of fish cultured, and integrated production Animal diseases	Lack of capital investment Limited technical knowledge of fish cultured, and integrated production Animal diseases Trash fish is very scarce