Market Development Feasibility Study

Biogas Slurry in Vientiane Capital Region, Lao PDR

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Executive Summary

This study was commissioned by to examine the possibility of marketing biogas slurry produced by small household biogas digesters in Vientiane Capital Region of Lao PDR. There are less than two hundred digesters operating in the study area and less than 0.045 digesters per square kilometer. Most digesters are fed with cow manure, and on average they operate at 70% of installed capacity.

The study area is an important agricultural zone producing rice, vegetables, fruits and other horticultural crops using organic and conventional farming methods. Chemical fertilizers are commonly available in the study area, and record high prices are expected to decrease over the short term. Other organic fertilizers such as manure, compost and crop residues are widely available, but markets for these products are localized and inefficient. Shortages of organic fertilizers exist in areas with intensive farming and few animals, while surpluses exist in other areas where there are large animal farms.

Liquid biogas slurry has a higher nutrient content than dried slurry and is an especially side dressing fertilizer for vegetables and fruits. Nutrients in biogas slurry are well balanced for many vegetables, and they can be rapidly absorbed and used by plants. Demand for slurry by vegetable farmers will be highest in the cool dry season, which is the time that many owners of digesters will have excess slurry because they are not growing rice.

Selling liquid slurry directly from the slurry pond requires little or no investment by sellers and minimal intervention by BPP. Farmers who come to purchase slurry will also see working biogas systems, making them more likely to build digesters of their own. Local trade in slurry also avoids exporting nutrients from local ecosystems and minimizes carbon emissions and other ecological effects of transporting slurry long distances.

The conclusion of this report is that BPP should focus on marketing liquid slurry as a specialty fertilizer for vegetable and fruit production in the study area. Organic vegetable farmers are organized into producer groups, and would be the best target market for slurry sales. Organic rice farmers and conventional vegetable farmers are also important target markets.

Because BPP has limited resources, promotion of slurry sales should not require large amounts of project time or resources. The most appropriate intervention is for BPP to bring together slurry sellers and potential slurry buyers to meet, learn about trading slurry and exchange contact information. This very simple value chain intervention should be easy to replicate in other parts of Lao PDR, and would fit well with the Ministry of Agriculture and Forestry policy to encourage development agricultural development through farmer groups.

Table of Contents

Executive Summary 2
Table of Contents 3
Glossary of Terms and Acronyms 4
1. Introduction 6
1.1 Purpose and Scope of Study 6
1.2 Using the report 6
2. Background information 7
2.1 Agricultural situation and trends in Lao PDR (“the place”) 7
2.2 Conventional and organic agriculture in the study area (“the place”) 8
2.3 Organic fertilizer availability and use (“the product- substitutes”) 9
2.3.1 Manure 9
2.3.2 Crop Residues 9
2.3.3 Bat Guano 10
3. Technical aspects of slurry use 10
3.1 Soil conditions and nutrient requirements (“the place”) 10
3.1.1 Soil texture and physical conditions 10
3.1.2 Fertility characteristics 11
3.2 Characteristics of biogas slurry (“the product”) 11
3.3 Comparison of fertilizer availability (“the place”) 12
3.3.1 Chemical fertilizers 12
3.3.2 Organic Fertilizers 13
3.4 Value of nutrients in slurry (“the price”) 13
3.4.1 Nutrient content of common fertilizers 14
3.4.2 Slurry price as equivalent value of inorganic fertilizers 15
3.4.3 Theoretical value of 1000 liters liquid slurry or 1 ton wet solids 16
3.4.4 Maximizing the effective value of biogas slurry 17
3.5 Price comparison with competing fertilizers (“substitute products”) 18
3.5.1 Semi-structured interviews with organic farmers 19
3.6 Regulatory environment for sales and trade of organic fertilizers in neighbouring countries (“the place”) 20
4. Analysis of marketing opportunities 21
4.1 Potential markets 21
4.2 Trading and market structures in the study area 22
4.3 Discussion of factors affecting biogas slurry marketing 24
4.3.1 Summary of Constraints 24
4.3.2 Opportunities for trading biogas slurry 25
5. Marketing Strategy 26
5.1 Large Scale Business Strategy 26
5.2 Small Scale Business Plan 26
6. Other recommendations and follow-up actions for BPP 29
6.1 Continued nutrient analysis of slurry 30
6.2 Digester sales to organic rice farmers 30
Appendix 1: Nutrient contents of on-farm residues 31
Appendix 2: Nutrient contents in rice 32
Appendix 3: Conventional fertility program for rice 33
Appendix 4: Applying slurry with green manure 35
Appendix 5: Liquid slurry as an input for vegetables 36
Appendix 6: Proposed Agenda 37

Glossary of Terms and Acronyms

BPP: Biogas Promotion Project, an international co-operation project between the Lao Department of Livestock and Fisheries and SNV, the Netherlands Development Organization

Clay: Soil with a very small particle size, usually considered to be less than 4 micrometers in diameter

Complete fertilizer: A fertilizer that contains all three of the main nutrients needed for plant growth (N/P/K) and which may also contain micro-nutrients

Conventional farming: A system of raising plants and animals that makes use of modern agricultural inputs such as chemical fertilizers and pesticides

DAFO: District Agriculture and Forestry Office, the district level government department that is responsible for managing agriculture, forests and fisheries

DLF: The Lao Department of Livestock and Fisheries, a department of the Ministry of Agriculture and Forestry responsible for animal rearing and fisheries.

DOA: The Lao Department of Agriculture, a department of the Ministry of Agriculture and Forestry responsible for plant agriculture.

Extensive farming: Farming systems that use large areas of land to produce crops with low amounts of capital, fertilizer, labour and other inputs

Intensive farming: Farming systems that use large amounts of capital, fertilizer, labour and other inputs to produce crops on a small area of land

Limiting factors: The main factor that limits a plant's growth, either because it is lacking or because it is over-abundant. This may include plant nutrients or other physical factors such as the availability of water or sunlight.

Loam: A soil that contains sand, silt and clay in relatively even concentrations. Loam soils are some of the most fertile and versatile soils for agriculture.

Macro-nutrients: The elements which plants use in large quantities for growth. The most important macro-nutrients are nitrogen, phosphorus and potassium, all of which are commonly used as fertilizers. Calcium, magnesium and sulfur are also macro-nutrients, but they are less important as fertilizers.

Micro-nutrients: Nutrients which are essential for plant growth, but which are only needed in small quantities. Examples of micro-nutrients are boron, copper, zinc, molybdenum, manganese and iron.

Organic farming: A system of raising plants and animals that attempts to recreate natural cycles, and which does not use chemical inputs such as fertilizer and pesticides

Organic fertilizer: A product derived from plant or animal sources rather than elements obtained from refined minerals or industrial processes. All of these inputs provide macronutrients (nitrogen-phosphorus-potassium), micronutrients and organic matter to soils, although some such as bio-fertilizer or sewage sludge cannot be used on certified organic crops.

PAFO: Provincial Agriculture and Forestry Office, the government organization responsible for agriculture, forestry and fisheries management at the provincial level.

Sand: Soil with a large particle size, often defined as 62 micrometers to 2 millimeters in size.

Silt: Soil with an intermediate particle size, often defined as being between 4 micrometers to 62 micrometers in diameter

Side dressing: This is the practice of adding fertilizer around a plant, usually without cultivating it into the soil. This practice is often used prior to irrigation in order to boost the growth of plants. Side dressing may also be referred to as top dressing.

Soil amendments: A product added to the soil to improve its physical properties such as porosity, water retention or drainage. Soil amendments may or may not add nutrients as well.

Soil structure: A physical characteristic of the soil that determines how individual soil particle bind together. Soil structure is influenced by the mix of sand, silt, clay and organic matter in the soil. Good soil structure helps keeps plants healthy and improves crop yields.

Soil organic matter: Non-mineral materials in soil that are derived from the decay of living plant and animal tissues. Adequate levels of organic matter are needed to maintain good soil structure and fertility.

Soil porosity: This is a measure of the empty spaces in the soil. This includes large spaces (macro-porosity) and small spaces (micro-porosity) that help hold air and water in the soil. Addition of organic matter can help improve porosity in many soils.

1. Introduction

This study was commissioned on behalf of SNV Lao PDR to examine the market potential for biogas slurry produced by single-family biogas digesters in Vientiane Capital Region. SNV Laos has been working with the Department of Livestock and Fisheries (DLF) to create a small-scale biogas digester industry, with initial operations taking place in Vientiane Capital region. While the project has since expanded to other provinces, Vientiane Capital has the largest concentration of biogas digesters in Lao PDR.

As the Biogas Promotion Project (BPP) has progressed, it became increasingly apparent that biogas slurry is an underappreciated resource. Biogas slurry is valuable, but it has advantages and disadvantages compared to substitute products available in the study area. An effective marketing plan should therefore find a niche where slurry's particular traits give it an advantage over competing products like chemical fertilizer, compost and farmyard manure.

1.1 Purpose and Scope of Study

The study was conducted in the Vientiane Capital region of Lao PDR from September to November 2008. The purpose of the study was to determine if slurry from small biogas digesters can be marketed as a value added product. Adoption of biogas digesters in the area has been slower than expected, and the BPP team feels that more people will build digesters if they know there is a market for the waste product (slurry).

The survey's conclusions are based on the following assumptions:

- All recommendations should be viable under existing conditions in the area, which has 175 digesters installed over an area of 3,920 km^2 (0.045/ km^2)
- BPP should be able to develop a slurry market with minimal human and financial resources
- That a free market for slurry will be more sustainable than one that depends on project or government intervention
- The proposed solution should maximize benefits to people who own digesters and people buying and using slurry
- It should be possible to replicate the slurry marketing plan in other parts of Lao PDR

1.2 Using the report

The information in this report includes mix of soil and agricultural science, social sciences and marketing concepts. Key concepts from *marketing mix* analysis are used to bring these concepts together in this report. The main concept of the marketing mix can be described using the "4 P's":

- <u>Product</u>: this is the thing that you are selling, with a focus on how it is better or different than competing or substitute products

- Place: this is where your product is going to be sold, and it can include the geographic area you will target or the type of place where your product will be sold such as retail stores, farm gate, or home delivery.
- Price: this factor considers how much money you charge for your product, and whether you position it as a cheap product, a mass market product or a premium priced product.
- Promotion: this is how you make potential customers aware of your product and its special characteristics and benefits.

The report will examine economic, social and technical issues as they relate to the four principles listed above. Section headings are labeled with these categories to help readers make the connection between technical information and its marketing implications. The report also provides specific recommendations about how to develop a self sustaining market that takes advantage of slurry's unique mix of benefits and limitations. This analysis revisits the "4 P's" of the marketing mix to explain why the selected approach is the most likely to succeed in the study area at this time.

2. Background information

2.1 Agricultural situation and trends in Lao PDR ("the place")

While Lao PDR has a reputation for low levels of chemical use and widespread use of traditional agricultural systems, government policy, increased openness to trade and economic development are causing rapid change. Market forces are driving increased production of many field crops, including grain corn (maize), sugar, rice, vegetables and job's tears. Tree crops and permanent crops such as rubber, coffee and agar wood are also expanding. Expanded production of these crops is replacing traditional low input, extensive systems with more intensive production, although traditional systems are still used in uplands, isolated areas and subsistence production[1].

Agricultural transformation is a major component of the Lao Government's *Sixth National Socio Economic Development Plan*[2]. Under this plan, the Department of Agriculture (DOA) is responsible for guiding agricultural development activities, a process that is guided by DOA's *Clean Agriculture Policy*[3]. This policy promotes agricultural transformation through the use of four types of modern agriculture: organic agriculture, pesticide free agriculture, Good Agricultural Practices (GAP agriculture) and conventional agriculture.

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1 Author, Luang Prabang Organic Vegetable Value Chain Feasibility Study, unpublished.

2 Lao PDR Sixth National Socio Economic Development Plan (2006-2010), Committee for Planning and Investment, Vientiane, Lao PDR, 2006.

3 Clean Agriculture Policy, Department of Agriculture, Ministry of Agriculture and Forestry, Vientiane, Lao PDR, 2007.

2.2 Conventional and organic agriculture in the study area ("the place")

Conventional agriculture is widespread in the study area, and the Vientiane Plain is one of Lao PDR's most important agricultural regions. Irrigated and rain fed paddy rice is the dominant crop in the study area, but vegetables, fruit, corn and other crops are also widely grown. While agriculture in the region is generally small scale and un-mechanized, many producers use chemical fertilizer on rice, corn, fruits and vegetables. Additional information about common fertilizers is given later in this report.

Organic fruit and vegetable growing in Vientiane Capital Region focuses on vegetable and fruit production in the districts of Xaithany, Saisetha, Hatxayfong, Sisattanak and Sikhottabong. Organic rice production takes place in the far west of the capital region in the district of Sangthong. Both the rice and vegetable farms are typically small, averaging less than 0.5 ha for vegetables and 2-3 ha for rice.

Currently, most organic farms rely on compost to meet soil fertility needs. Compost is made using a mix of rice straw, cow or buffalo manure, wood ash, molasses and a starter culture of micro-organisms. Organic vegetable farmers often have to buy manure and straw for making compost. Many do not apply enough manure or compost for optimum soil fertility and most organic vegetable fields could benefit from an additional source of nutrients and organic matter.

Conventional and organic vegetable farmers need to minimize the risk of contamination with pathogens such as bacteria, parasites and viruses. This type of contamination is much less likely with compost or biogas slurry than with substitutes such as manure or sewage sludge.

Organic rice farmers also use manure and rice straw based compost at relatively low rates (2 tons per hectare or less.) These farmers tend to have more land and free roaming cattle and buffalo helps collect nutrients from grazing areas in their manure for use in growing rice. Many traditional varieties of rice will grow too tall and then fall down if they get too much nitrogen, so farmers apply less fertilizer and organic fertilizer to traditional varieties than the do to improved varieties.

Composting is considered hard work by organic farmers because labour is required to collect and prepare materials, build and turn compost heaps and to apply compost to the land. This problem is especially important for organic rice farmers who must devote large amounts of labour to preparing compost for their farms. Most farmers also consider buying manure and other inputs to be expensive, especially in areas closer to urban areas where demand for these inputs is highest and supplies are lowest. As these farmers become familiar with biogas slurry, they may want to install digesters as an easy way to make fertilizer.

2.3 Organic fertilizer availability and use ("the product-substitutes")

A variety of organic fertilizers are available in the study area, including crop residues, animal manure, compost, guano and "bio-fertilizers". Sewage sludge is used in at least one district, although this practice has declined sharply as chemical fertilizers have become more easily available. Green manure crops can also be grown in the study area, but efforts to promote them have not been well accepted in the past[4].

2.3.1 Manure

Animal manure is the main input for biogas and the closest substitute product for biogas slurry. Because animals such as buffalo and cattle graze freely, recovery rates for manure are low and many farmers have insufficient supplies on farm to ensure adequate fertility.

While manure shortages exist in some areas, surpluses are produced by large pig and poultry farms in other parts of the study area. According to farmers interviewed during the study, inadequate information and high transaction and transportation costs make the manure market inefficient. Most manure trading takes place within social and family groups at the village and *gum ban* (village cluster) level[5].

While manure is commonly used as an organic input, its disadvantages include bulkiness, the potential to spread weeds and pathogens, smell and the fact that the balance of nutrients in manure may not be appropriate for some crops. Manure must also be applied to the crop prior to planting, or very early in the season to ensure its nutrients are available to the plants and to minimize the risk of contaminating food with bacteria, parasites and viruses.

2.3.2 Crop Residues

Crop residues are an important source for organic fertilizer and soil amendments in the study area, particularly when they are made into compost. The most common crop residues available are rice straw and rice husk, both of which are high in potassium but low in phosphorus and nitrogen. Rice straw is often removed from fields to feed buffalo and cattle or it is collected to mix with manure, ash and molasses for compost. Rice husks are sometimes used in a similar way or are returned directly to fields but they are not preferred by farmers because their high silica and lignin content makes them slow to decompose.

In the past rice straw and husks were usually available for free, but promotion of

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[4] Linquist B, Sengxua P. 2001. Nutrient management of rainfed lowland rice in the Lao PDR. Los Banos (Philippines): International Rice Research Institute.

[5] The main exception appears to be poultry manure, which farmers consider to be more valuable and are willing to transport across longer distances.

composting in the area has started to give rice straw a market value in some villages. While compost made from rice straw and manure is reasonably common, it is primarily produced and used on-farm or traded on a very small scale between farmers within villages. Limited amounts of compost fortified with Effective Microorganisms ® are made and sold commercially by a Japanese supported project, and are sold at a retail price of 20,000 kip for a 20 kg bag.

2.3.3 Bat Guano

Bat guano is available in the study area at a cost of approximately $70 per ton with a minimum order of 10 tons. While the nutrient content of guano varies, most local bat guano is high in phosphorus, with lower levels of nitrogen, potassium and micronutrients. Compared to other organic inputs, guano is the most concentrated and easy to handle organic input available in the study area.

Despite its convenience and the high price of inorganic fertilizers recently, guano is not widely used or available in the study area. The main constraint to increased use of guano is the lack of bagging and distribution facilities, although at the time of the study bagged guano was temporarily available for 17,000 kip per 20kg bag through the PROFIL II project. Because guano must normally be bought in bulk, it is difficult for small farmers to purchase guano in the quantities needed on their farms. Development of guano processing, bagging and distribution in the future may make guano more competitive with other organic fertility products.

3. Technical aspects of slurry use

3.1 Soil conditions and nutrient requirements ("the place")

Biogas slurry has specific characteristics that give it advantages and disadvantages under different conditions. In order to determine how slurry should be marketed, a basic knowledge about soil types and conditions in the study area is important.

3.1.1 Soil texture and physical conditions

There are a great variety of soils in the study region, with light sandy soils in some areas and heavy loamy clays in others. Many of the soils that would benefit most from applications of biogas slurry have an intermediate to moderately heavy texture, with high levels of silt and moderate levels of sand and clay. These soils are moderately well drained to poorly drained, with many of the heavier textured soils devoted to rice production during the wet season.

Organic matter is generally low in local soils, with high rates of weathering due to the hot, seasonally moist climate. Soil macro and micro porosity in rice land is low due to low levels of organic matter and cultivation techniques that liquefy the soils prior to planting. Porosity in vegetable and fruit farms tends to be higher, especially where organic matter has been added regularly or where the soil is infrequently tilled.

3.1.2 Fertility characteristics

Nutrient requirements of fields in the study area vary dramatically due to soil conditions, previous fertility management practices and the needs of the crops being grown, but there are some shared characteristics. Soils experience heavy leaching during the rainy season, which reduces the amount of nitrogen and causes losses of nutrients into the environment. According to Linquist and Sengxua[6], rice fields in the study region naturally have adequate levels of potassium, are sometimes low in phosphorus, and usually have inadequate nitrogen.

Properly managed organic farms maintain soil fertility using natural means, but the soil on many organic farms in the study area have nutrient deficiencies because farmers do not apply enough compost or other sources of nutrients[7]. Of the soils tested, most had adequate levels of potassium, low to moderate levels of phosphorus and very low to moderate levels of nitrogen. Nutrient deficiencies have varying effects on different crops, ranging from slower growth and lower yields to problems with disease and to total crop loss in severe cases.

3.2 Characteristics of biogas slurry ("the product")

Biogas slurry has both benefits and drawbacks as an organic soil amendment and fertilizer.
On the positive side:

- Anaerobic digestion destroys most weed seeds and pathogens such as bacteria and parasites, making it safer to use than manure or sewage sludge
- Liquid slurry and slurry filtrate absorbs into the ground and can be used for side dressing growing plants, something that is not possible with solid organic fertilizers such as manure and compost
- Slurry contains a full range of plant nutrients and micro-nutrients
- The nitrogen content of slurry is more bio-available for plants than the nitrogen content of compost, making it a faster acting fertilizer
- Slurry has a lower carbon to nitrogen ratio than raw manure, a factor which makes it a more potent fertilizer
- As with other forms of organic fertilizer, biogas slurry adds organic matter to soils, improving soil structure, cation exchange capacity and soil micro-flora. This effect helps keep plants healthy and improves yields in conventional and organic farming systems.

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[6] Linquist B, Sengxua P., ibid.

[7] Author's observation of organic farms in study area.

Biogas slurry also has some disadvantages:

- Fresh slurry is bulky, and difficult to store, transport and apply compared to competing products such as chemical fertilizers
- The nutrient content of slurry is not consistent, making it difficult for farmers to decide how much to use and what the appropriate value is
- Slurry from BPP digesters is available irregularly and in small quantities, making it difficult and expensive to test, label and certify.
- Dried slurry or making compost from slurry makes it easier to store and handle, but these processes require work and make slurry a less fast acting fertilizer.
- The cow manure based slurry tested from the study area has relatively low levels of potassium and moderate levels of nitrogen, making it inappropriate for crops like rice that require large quantities of these nutrients
- Slurry can be difficult to apply properly, depending on the system used

3.3 Comparison of fertilizer availability ("the place")

Despite its status as the largest urban area in Lao PDR, Vientiane capital is still largely rural and agricultural. Intensive agricultural production in the area supports some of the best developed agricultural supply chains in the country, including supply chains for agricultural inputs. In this section, trading, supply and availability of common chemical and organic fertilizers are briefly described.

3.3.1 Chemical fertilizers

Chemical fertilizer is widely available in the study area, and all supplies are imported from neighbouring countries. After entering the country, bagged fertilizer eventually ends up in one of the many small agricultural shops that are present in most villages in the area. These shops are easy for farmers to access with small hand tractors and carts, and because chemical fertilizers have standard formulations and packages it is easy for farmers to compare prices between shops.

The most common fertilizers in the study area are:

- 15-15-15 (sometimes with added MgO, CaO and S) which is often used for vegetable and fruit production and as a basal fertilizer for rice production. Prices during late September 2008 averaged 390 000 LAK per 50 kg bag.
- 46-0-0 (urea) which is mostly used to top-dress rice, but which can also be used as a top dressing for nitrogen loving vegetable crops such as cabbage, tomatoes and leafy vegetables. Prices in September 2009 averaged 420 000 kip per 50 kg bag.
- 16-20-0 (ammonium phosphate sulfate) which is the most common basal fertilizer for rice production, but which is also used for vegetables and fruits. Prices in September 2009 averaged 410 000 kip per 50 kg bag.

Chemical fertilizer prices were very high in the study area at the time of the survey, but manure (and slurry) prices have risen much less. The difference in prices for chemical and organic fertilizers is probably because a functioning market exists for chemical fertilizers, but there is no similar mechanism for manure or slurry produced by small farms. High fertilizer prices will likely decrease in the study area, as they have on world markets over recent weeks. This decline will reduce the value of slurry as a replacement for chemical fertilizer, but this may not drastically affect the actual cash value of slurry as an agricultural input in the study area which is already lower than equivalent amounts of chemical fertilizers.

The use of compound (multi-nutrient) fertilizers, a lack of soil tests and limited understanding of crop nutrient needs means that farmers using chemical fertilizers often apply nutrients inefficiently. This situation undermines one of the main advantages of chemical fertilizers over organic fertilizers, because chemical can more easily be applied to match crop requirements.

3.3.2 Organic Fertilizers

Farmyard manure is often used to build fertility in the study area, and many families collect cow and buffalo manure to fertilize fields and to make compost. In many cases, animals are allowed to graze in rice paddies during the dry season, ensuring that nutrients are directly recycled through animal droppings. While this system is sometimes practiced in organic vegetable gardens as well, it is not considered to be a good practice because it can transmit disease causing bacteria and parasites from animals to humans.

Poultry and pig manure is often available from large scale farms and farmers like chicken manure for its high nitrogen content. Both poultry and pig manure are traded in the area, although prices are inconsistent, and some pig farmers simply dump manure into treatment ponds, waterways and forested areas. Most manure traded is sold as dried or partly dried product packed into fertilizer or rice bags with a weight of 18-30 kg.

Over-all, manure availability is highly variable in the region, with very large quantities available near some large farms, and smaller quantities available in areas where intensive field cropping with rice and vegetables dominate. The high transaction costs (transportation, market information) and lack of an effective market mechanism make it difficult to determine the selling price for manure in the study area. The cost for cow and pig manure ranged from “free” to 6 000 kip per 20 kg bag of dry manure depending on the village visited.

3.4 Value of nutrients in slurry (“the price”)

The actual economic benefit of nutrients applied to agricultural land is difficult to calculate, and the value of organic inputs such as manure, slurry or compost is even more difficult to calculate. One simple method of calculating the value of biogas slurry is to find the value of an equivalent amount of inorganic nutrients such as N, P and K.

The main benefit of using equivalent values of N, P and K is its simplicity. Drawbacks to this approach include the fact that the price of chemical fertilizer changes rapidly, and an assumption that the organic matter added to the soil has zero value. Another difficulty in calculating the value is that some of the nutrients applied may not be used by the plants to increase yields.

3.4.1 Table 1: Nutrient content of common fertilizers

Fertilizer	Nitrogen	Phosphorus	Potassium	Other
Biogas slurry from cattle manure[8]	0.21%	0.22%	0.09%	Organic matter and micronutrients
Biogas slurry from pig manure[9]	0.39%	0.16%	0.13%	Organic matter and micronutrients
Biogas solids from cattle manure[10]	0.28%	0.27%	0.07%	Organic matter and micronutrients
Fresh cow manure	0.45%	0.25%	0.45%	Organic matter and micronutrients
Fresh pig manure	0.6%	0.5%	0.4%	Organic matter and micronutrients
Urea (46-0-0)	46	0	0	None
Ammonium Phosphate Sulfate (16-20-0)	16	20	0	Sulfur
15-15-15	15	15	15	Sulfur, some formulations contain micronutrients

<u>Special Note</u>: Biogas slurry tested by the PPC has lower than anticipated levels of K. This may be due to a loss during digestion, or it may be due to inadequate

[8] Average of samples tested from farms in study area during September 2008. Nutrient contents of samples varied widely, although relative nutrient balances were fairly constant, suggesting that dilution by rainwater has a major impact on nutrient levels. Low potassium levels may be due to loss of K.

[9] Based on single sample tested from a pig farm in the study area during September 2008.

[10] Based on single sample tested from a farm in the study area during September 20008. Note that this result suggests there was minimal loss of nitrogen from storage, but this needs to be replicated.

testing techniques at the center. This analysis will proceed under the assumption that K levels in slurry are as reported by the tests because K is seldom the limiting nutrient in Lao soils.

Image: A poorly built and maintained slurry pit with no lining and no protection from rainwater infiltration. Slurry from this pit had lower levels of nutrients, probably due to dilution with rainwater. Inconsistent nutrient levels and the small size of digesters make slurry less attractive for commercial producers of fertilizer and compost.

Additional information about the nutrient content of manures and crop residues are given in Appendix 1.

3.4.2 Slurry price as equivalent value of inorganic fertilizers

Local prices for three inorganic fertilizers were collected over a one month period in the study area, and average prices for 50 kg bags were calculated. The fertilizers studied were 46-0-0 (urea), 16-20-0 (plus sulfur), and 15-15-15. Prices for the nutrient content of each fertilizer were then calculated based on the long term average cost ratio of N= 33%, P_2O_5= 43% and K_2O= 24%.

The cost ratios for each nutrient in the study area were cross-checked with world prices for mineral fertilizers, and were found to be very similar (although a spike in the price of K has increased the ratio for this mineral). Further confirmation was obtained by cross checking the price of N from urea with the price of N in other fertilizer formulations and by assuming that the sulfur content in 16-20-0 had nominal value of 2000 kip per bag.

Based on these approximations, the value of inorganic nutrients in the study area during the first week of October 2008 was:

1 kg of elemental N is worth 18 400 kip

1 kg of P_2O_5 is worth 21 300 kip

1 kg of K_2O is worth 13 300 kip

While all calculations are based on these estimates, record high fertilizer prices have suffered a rapid decline on world markets since the survey took place. Although these price decreases have not filtered through to the Lao retail market yet, it is likely that prices will drop in the near future. Assuming that these price changes will be passed on to farmers, a 15% percent and 30% decline in fertilizer prices are also considered in this analysis.

3.4.3 Table 2: Theoretical value of slurry and slurry solids

Based on the fertilizer value calculations above, an equivalent value was assigned for biogas slurry and slurry solids.

Fertilizer	Nitrogen	Phosphorus	Potassium	Value kip/ton
Biogas slurry from cattle manure	0.0021* 1000 * 18 400 = 38 640	0.0022 * 1000 * 21 300 = 46 860	0.0009 * 1000 * 13 300 = 11 970	**97 470** kip -15%= **82 850** -30%= **68 229**
Biogas slurry from pig manure	0.0039 * 1000 * 18 400 = 71 760	0.0016 * 1000 * 21 300 = 34 080	0.0013 * 1000 * 13 300 = 17 290	**123 130** kip -15%=**104 660** -30%=**86 190**
Biogas solids from cattle manure	0.0028 * 1000 * 18 400 =51 520	0.0027 * 1000 * 21 300 =57 510	0.0007 * 1000 * 13 300 =9 310	**118 340** kip -15%= **100 590** -30%= **82 840**
Fresh cow manure	0.0045 * 1000 * 18 400 =82 800	0.0025 * 1000 * 21 300 =53 250	0.0045 * 1000 * 13 300 =59 850	**195 900** kip -15%= **166 520** -30%=**137 130**
Fresh pig manure	0.006 * 1000 * 18 400 =110 400	0.005 * 1000 * 21 300 =106 500	0.004 * 1000 * 13 300 =53 200	**323 300** kip -15%=**274 800** -30%= **226 300**

1000 liters liquid of assumed to weigh approximately 1 ton. A 4 cubic meter biogas digester running at full capacity is assumed to produce approximately 55 kg of liquid slurry per day based on feeding of 32 kg manure and 32 liters of water.


Image: Wet slurry solids from a digester fed with cow manure. These solids were being collected and stored for use on irrigated paddy rice grown during the dry season. Protection from the sun and rain helps to reduce nutrient loss.

3.4.4 Maximizing the effective value of biogas slurry

Calculating the value of manure or slurry as the equivalent amount of chemical fertilizer can sometimes be misleading. One of the main drawbacks to organic inputs is that their mineral contents do not always match the needs of specific crops. For example, the recommended N/P/K ratio for rainfed rice in the study area is about 6:2:3[11] for a well managed field, but cow manure slurry has a ratio of about 2:2:1. This means that slurry provides too much phosphorus (a potential water pollutant) relative to other nutrients needed by growing rice.

Fertilizer recommendations in the area suggest applying 60 kg of nitrogen per hectare. To get this amount using an average sample of cow manure slurry with 0.21% N would require 28.6 tons of liquid slurry, or approximately 16 months of production from a 4 m^2 digester. Since the average BPP household has about 3[12] hectares of rice land (almost all paddy) they are very unlikely to have enough slurry to meet all the fertility needs of their rice fields.

Even if farmers could get enough slurry for all their rice paddies, they would be applying almost 63 kg of phosphate, but their crop will only use 21 kg of this phosphate. While most soils can store a limited amount of P for following years,

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11 Linquist B, Sengxua P. 2001. Nutrient management of rainfed lowland rice in the Lao PDR. Los Banos (Philippines): International Rice Research Institute.

12 BPP 2008 Baseline Survey, as compiled by Digital Divide Data.

over the long term 42 kg of phosphate will be wasted every year. Excess phosphate wastes a valuable resource (making slurry less valuable than in theory) and could cause water quality problems such as eutrophication[13].

To maximize the value of slurry used on the farm, one approach is to make compost using other inputs available on farm such as rice straw or rice husks. While this produces a very useful fertilizer and soil amendment, it is also a lot of work. BPP owners should be encouraged to make compost, but they should also be aware that they can maximize the value of their slurry (on farm or for sale) in three other ways:

1. Many rice farmers should consider applying lower quantities of slurry to fields and adding urea to match the fertilizer needs of rice. A suggested fertility management scheme for rain fed paddy is described in Annex 3
2. Some farmers may be interested to apply slurry to a green manure crop such as stylo or sesbania. These crops actually make nitrogen fertilizer from the air which can be used by rice or other crops in the cropping season. More information about the potential for green manure crops are given in Annex 4
3. Applying slurry to crops with lower nitrogen and higher phosphorous requirements, especially vegetables and fruit. Applied properly to vegetables, the value of pig or cow manure based slurry can be maximized. Slurry's low levels of pathogens also make it safer to use on fruit and vegetable farms than substitutes like manure. This option has the highest potential to maximize the economic and environmental benefits of slurry use. More information about using slurry on vegetable crops is given in Annex 5

3.5 Price comparison with competing fertilizers ("substitute products")

While it is useful to estimate the value of slurry by comparison with the equivalent quantities of chemical fertilizer, this approach has several weaknesses. In the study area, the main problem is that this estimate does not reflect the erratic market price of organic amendments. This section of the report will look at manure, which is the closest substitute for biogas slurry in the study area.

Pig manure has a high nutrient content, and theoretically should have a high value as an organic fertilizer in the study area. In reality, pig manure is often wasted, either by draining it into watercourses or by dumping or burning it. Pig manure from large farms is often available to farmers for free. This means that

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[13] Eutrophication happens when water contains too many nutrients such as phosphorus and nitrogen. These nutrients cause aquatic algae to grow and decay, reducing oxygen and making it difficult for some fish and aquatic animals to survive, while other weedy species may grow faster and start to dominate the new environment.

the cost of pig manure for farmers is zero, plus the cost of loading it and transporting it to the place it will be used.

Fresh cow manure is also sold locally for prices lower than the theoretical value of its nutrient contents. In one BPP village, small amounts of fresh cow manure are occasionally sold in 30 kg bags for 100 kip per kg. This price is equivalent to 100 000 kip per ton. Because the nutrient content of fresh cow dung should be worth approximately 200 000 kip per ton (see Table 2), manure is currently trading at a 50% discount to equivalent amounts of synthetic fertilizer.

The lower price offered for manure compared to the price of chemical fertilizers is probably due to a combination of the following factors:

1. The cost and inconvenience of transporting and applying adequate quantities of organic inputs is greater than the cost for chemical fertilizers. Farmers may therefore be willing to pay more for the convenience of chemical fertilizer.
2. The relatively high cost of transporting bulky, low value organic inputs means that it is not usually worth moving it long distances. As a result, some areas have surpluses of manure, while others have shortages.
3. There is a lack of information linking buyers and sellers of organic inputs. Without adequate information, the normal rules of supply and demand do not function and surpluses and shortages can co-exist. (In economic terms, *market clearing* is not taking place.)
4. Farmers do not have a good understanding about the fertility needs of their soils and crops, so some may not place a value on organic matter and micro-nutrients provided by organic fertilizers.
5. The rapid rise in fertilizer prices should have increased the price of manure, but this did not happen in the study area. The predicted rise in manure prices may not have taken place because farmers have not had time to adjust, or because farmers may believe that chemical fertilizer price increases are temporary.

While all of these factors specifically refer to trading and prices of manure, the *substitutability* of manure and biogas slurry means they will also affect the market for slurry. We can therefore predict that the market for biogas slurry will be very similar to that for manure.

3.5.1 Semi-structured interviews with organic farmers

Semi-structured interviews (a social science approach to data gathering) were held with a group of organic vegetable farmers from the study area to ask about their fertility management practices and needs. Responses obtained from the farmers were cross checked with DAFO and PAFO officers who work closely with the organic farmers and with staff from the PROFIL and PRORICE organic projects. Only information that could be confirmed by all three sources is included in this report.

Generally, organic farmers in the study area consider fertility management to be one of the most time-consuming and labour intensive aspects of their work. Less labour intensive ways of producing fertilizer would be very interesting for them, especially if the new techniques provided additional benefits such as a convenient source of energy. The organic vegetable farmers are also interested in a liquid fertilizer that can be used as a side dressing, but they would appreciate the opportunity to test slurry on their farms before they made any commitments.

Interviews with the farmers confirmed that organic fertility inputs are usually obtained on farm or from farms in neighbouring villages. While some farmers have access to manure from large farms, others lack information about sources of organic fertilizers such as manure or biogas slurry. Most farmers got information about manure from their family and friends and some got information from other farmers in their organic production groups or DAFO.

According to the vegetable farmers it would be impractical to transport manure, straw and compost long distances because they do not have trucks and must depend on hand-tractors and carts. This would make it difficult for them to buy inputs from distant villages, so they prefer to buy from other farmers in the local area or have fertilizer delivered to them.

3.6 Regulatory environment for sales and trade of organic fertilizers in neighbouring countries ("the place")

Given a large enough supply of product, it may be possible to develop markets for slurry in neighbouring countries. The export market with the highest potential for slurry exports is Thailand, which is located less than 20 km from the study area, and which shares many cultural, linguistic and economic links. Thailand also has a substantial agricultural sector which includes an organic sector which is growing at approximately 35% per year.

Fertilizers such as manure and bio-slurry are considered a "carrier" under the 2007 Thai plant quarantine laws. According to Notification number 5 under this law, organic fertilizer made from plant products or bat manure must "…complied [sic] with conditions specified by the Director-General of the Department of Agriculture before import"[14]

The department has not published regulations specific to bio-slurry, and it is likely that discussions would be needed to clarify the situation before shipping slurry products to Thailand. The Thai Department of Agriculture's "One Stop Service

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[14] Notification of Ministry of Agriculture and Cooperatives entitled "Specification of plant pests and carriers from certain sources as prohibited articles under the Plant Quarantine Act B.E. 2507(1964) (No 5) B.E. 2550 (2007);

Center" is the best source of additional information on border requirements.[15]

Vietnam is another possible market for biogas slurry. Manure, straw and other crop and animal residues are listed as "traditional organic fertilizers" under Vietnamese laws. These products require testing before being shipped to Vietnam, under Article 18 of the *Decree on the Management of Fertilizer Production and Trading*[16]. No other information about testing requirements or fees is given in the decree.

Raw manure imports enter Vietnam from southern Lao PDR through informal channels[17], and probably from other provinces as well. Cambodia also supplies manure to southern areas of Vietnam, although supplies are sometimes halted by outbreaks of food and mouth disease.

High transportation and transaction costs would make it very difficult for small producers to access international markets at a competitive price. Expansion of Thai and Vietnamese livestock production and installation of new biogas plants in these countries should ensure that both countries have ample supplies of slurry for domestic use without importing it from Lao PDR. However, while exports are inappropriate for small-holders, economies of scale may make it worthwhile for large biogas producers to export slurry products to these countries at some time in the future.

4. Analysis of marketing opportunities

4.1 Potential markets

For the purposes of this section of the report, markets for biogas slurry are divided into large scale markets and small scale markets. As this study will show, opportunities to develop smaller market niches are most appropriate at this early stage in the development of the BPP.

Large scale markets include commercial producers of compost or bio-fertilizers, large scale farmers and commercial marketing of slurry products as an agricultural input. The main large sale customers in the area are projects producing compost (the EM project at PAFO, Greenfield Rice Millers Group/PRORICE project), bio-fertilizer plants (Maliny Organic Soils and Maliny Bio-Fertilizer Companies, located between Vientiane and Phonhong) and large farms and plantations growing products such as rice, corn and cassava.

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[15] Contact information: 50 Phaholyothin Road, Ladyao Chaujark, Bankgok 10900. Telephone 662-579-6133.

[16] Decree on the Management of Fertilizer Production and Trading, No.113/2003/ND-CP, October 7, 2003; Pursuant to the Law on Organization of the Government, December 25, 2001.

[17] Author, personal interviews with smallholder coffee and vegetable growers in Champasak and Salavan provinces, 2007 and 2008.

Small and very small- scale markets also exist for slurry. Small scale customers range from village agriculture groups containing 15-20 people, to individual farmers with small garden plots. Most small farmers in the study area produce at least some rice, and many get a large part of their family income from rice and animal rearing. While some rice farmers in the study area do not use chemical inputs, certified organic rice production is limited to Sangthong district in the far west of the capital region.

Vegetable production is also a very important activity in the study area, especially in fertile areas along the Mekong and Nam Ngum rivers. Most vegetable production uses conventional techniques, often mixed with traditional and organic techniques such as applying manure to improve soil fertility or using rice husks as mulch[18]. While vegetables are grown throughout the study area, the most important vegetable growing districts are Hadsaiphong, Xaythani and Nasaithong districts[19].

Organic vegetable farming is much less common than conventional production, but it is growing rapidly. Organic vegetable and fruit production is found in five districts surrounding Vientiane, with the largest number of farmers located in Xaythani and Hadsaiphong districts. Despite their small numbers, organic farmers are an attractive market niche for biogas slurry because they have fewer options for managing fertility and because they are especially likely to purchase inputs like compost and manure.

4.2 Trading and market structures in the study area

Markets and marketing systems serve many functions, and the relative importance of these functions will depend on the attributes of the product and the needs of buyers and sellers. One of the most important success factors for biogas slurry marketing in the study area is to select an appropriate marketing system. To aid this discussion, three types of agricultural marketing systems used in the study area are briefly described below.

<u>Formal markets based on a key central actor</u>

Markets for many important agricultural products organized around one or more strong players who can coordinate supply chains, guide the planning process and sell the product into national or export markets. These market chains are usually large scale, tend to be export oriented, and often involve foreign investment.

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18 Unconfirmed reports also state that the human sewage sludge is being used as a fertilizer

19 Personal correspondence, Ms. Phonthip Somany, Vegetable Value Chain Officer, PROFIL project, Vientiane, Lao PDR.

Common characteristics of this type of production and marketing system include predictable demand, high levels of production planning, and often the use of sales contracts. While these characteristics can allow for efficient value chains, they may also lead to an imbalance of market power between large companies and small farmers. Examples of formal market systems based on a key actor in the study area include animal feed, sweet corn grown for a canning factory and cassava grown to produce starch for export.

Markets based on many small actors

Other agricultural product markets in the study area are based on complex networks of small traders, wholesalers, processors, retailers and others. Many small firms operate in these markets and their collective contributions allows for specialization of roles, flexibility of supply and efficient information flow and price discovery.

This type of marketing system is appropriate for many common products produced in the study area, such as rice, vegetables, fruit, poultry, and fish. All of these products are available in large quantities, with reliable and relatively predictable demand. Most of these products can also be traded at one or more well known locations, where a "spot market" price can be set.

Informal trade of low volume or low value products

Some products in the study area are either too low value or not produced in sufficient quantities to support either of the marketing systems described above. These products are usually traded informally, often through family connections, social networks, farmer groups or other networks. The network structure of this system is especially well suited to products which are rare, difficult to find, or are available on an occasional basis. Examples of products traded in this way in the study area include seeds for specialty crops, botanical pesticides and small scale trade in manure.

The informal links used in this system (mostly mobile phones) provide a low cost way for buyers and sellers to find each other, to set prices and to exchange information about the product itself. These interactions also encourage new partnerships and local trading relationships that may grow into larger rural businesses, trading networks and more formal markets over time.

Lessons for Biogas Slurry

Because biogas slurry is available in small, irregular quantities[20] scattered over a very large area, it is a poor candidate for commercial marketing though a company, or for trading through a traditional system of traders and retailers. While it may be possible to attract project support for a more complex trading

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[20] This is based on 2008 data collected by the BPP and DAFOs from participating districts. While this data has not been formally analyzed yet, preliminary numbers show that most farmers use slurry on-farm, and a only a small percentage that do not use their slurry can be assumed to have a regular supply for sale.

system, this type of project supported market for slurry is unlikely to be sustainable in the long term.

Ministry of Agriculture and Forestry policy encourages the formation of farmer groups to help speed rural and agricultural development.[21] Strong, organized local groups are considered one of the strongest tools for improving the lives of small farmers in Lao PDR. Farmer groups complement the strong social, family and project networks that exist in the study area. The BPP should therefore take advantage of existing farmer groups and informal networks to create simple, robust and self sustaining markets for biogas slurry.

The most appropriate intervention in this type of decentralized marketing system is to bring digester owners together with groups of potential customers in a structured but informal situation. [22] Village meetings are an appropriate forum for marketing slurry (and biogas digesters), and they should be designed to allow existing digester owners to interact socially with potential customers. Meetings should not be excessively formal and should not be dominated by presentations from BPP or DAFO staff. The most important output from these meetings is an exchange of contact and other information between potential buyers and sellers that they can follow up on themselves. A suggested agenda for a pilot promotion meeting is contained in Appendix 6

As slurry supplies and local demand for slurry grows over time, new market opportunities should encourage local entrepreneurs to take slurry marketing to the next level. This may happen spontaneously as entrepreneurial biogas plant owners take advantage of developing opportunities for large scale marketing, making compost for sale or for packaging and selling slurry as a mass-market product.

4.3 Discussion of factors affecting biogas slurry marketing

Based on the information and analysis gathered by this study, the market for biogas slurry faces constraints, but can also benefit from some unique opportunities. A successful marketing strategy will minimize or avoid the constraints, while taking maximum advantage of opportunities.

4.3.1 Summary of Constraints

Marketing opportunities for small farmers wishing to sell biogas slurry are limited by the following constraints:

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[21] The most recent example is the Ministry of Agriculture and Forestry meeting held on Friday, November 29th, 2008 in Vientiane to share experiences and successes from farmer group formation. At this meeting, examples of successful and unsuccessful development through farmer groups by international projects and Lao government were shared.

[22] In essence, the BPP would be working with a very simple type of "value chain approach". More information about value chains is available on LaoFAB: http://groups.google.com/group/laofab?hl=en or at in Lao language at LaoLINK: http://groups.google.la/group/laolink?hl=en

- The selling price of slurry is limited by the availability of large quantities of very inexpensive or free manure (especially pig manure) from farms in the study area. This will limit the price of slurry unless a special use can be found where biogas slurry is more valuable than substitute products.[23]
- Small quantities of slurry being sold at irregular intervals by a large number of small producers would create very high transaction costs for a business venture. For an efficient market to operate the minimum information needed by buyers and sellers is:
  - when slurry is available
  - when will buyers need slurry
  - what quantities of slurry buyers will want
  - what form is the slurry in (liquid, wet solids or dried).

  Getting this information from a large number of small sellers would be difficult for a large company, but could be manageable within local social, family and business networks.
- Most commercial scale customers would need technical information such as the nutrient and water content of the slurry, levels of organic matter and levels of contaminants. Each of these factors will push up transaction prices (nutrient analysis by $5 per load, OM analysis by $1 per load, moisture analysis by $1 per load).
- The inconsistent fertilizer value of slurry makes it difficult for buyers to know what they are getting. This is important for commercial buyers, or large scale modern farmers but small farmers consider this less important because they do not have detailed scientific knowledge about the fertility requirements of their crops.
- Liquid slurry and semi-dry slurry is bulky and difficult to transport, especially compared to chemical fertilizer. Slurry trade will therefore be limited by the form of the slurry and the transport capacity of the buyers and/or sellers.

4.3.2 Opportunities for trading biogas slurry

Despite the many constraints to trading slurry, this product also has significant advantages:

- The nutrients in liquid slurry are available to plants much faster than they are from other organic inputs. This advantage is especially important for farmers who cannot apply fast acting chemical fertilizers.
- The anaerobic digestion process helps to eliminate pathogens, making slurry safer to use on vegetables and fruits than manure.
- The digestion process also helps to destroy weed seeds, reducing the amount of labour required to maintain fields.
- While slurry is bulky and difficult to transport, it is produced in many places by many small holder farmers. This makes it an appropriate product for

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[23] Potential advantages of slurry include lower levels of pathogens, availability near vegetable growing areas, low odor, ease of application and an appropriate balance of N-P-K for many vegetable crops.

the small, flexible, informal trading networks that thrive in rural Lao PDR.
- Liquid slurry is especially suited for adding to irrigation water in flood irrigation systems and for top dressing growing plants. This niche is especially important for organic producers who currently depend on slow acting compost and manure which must be incorporated into the soil prior to planting crops.
- Increasing amounts of slurry should become available in the future as biogas digesters become more common. This will allow for more economies of scale, and should help create a self-sustaining market for biogas slurry.

5. Marketing Strategy

5.1 Large Scale Business Strategy

Under the current conditions in the study area, it is unlikely that a business plan based on a large commercial buyer or trading system would be economically sustainable or competitive. Expected declines in fertilizer prices, the availability of manure from large farms and the option of buying guano cheaply all make slurry less competitive as a commercial organic input.

The small number and size of biogas plant owners willing to sell slurry and their wide dispersal over a large area also make slurry less attractive than other nutrient sources for large scale businesses. The organizational and financial costs of collecting slurry (especially when slurry is not consistently available) make slurry much less attractive for large scale operators compared to manure or guano.

Over the long-term, increased penetration of biogas digesters may reduce transaction costs for slurry trading, particularly for semi-dried or dried slurry that could be used as an input into bio-fertilizers or compost. When this takes place, it may be worthwhile to re-examine the potential for large scale trade in biogas slurry.

5.2 Small Scale Business Plan

Small scale trade in slurry is a much more attractive option, because it avoids many of the transaction costs that a large scale plan requires. Trade within villages and between individual farmers happens at an "appropriate scale" where demand from small vegetable farmers (mostly in the dry season) matches the supply from slurry producers (who use their slurry to grow rice in the wet season). This allows small farmers to deal directly with each other, benefiting both buyers and sellers without requiring high overhead and operating costs.

Trading slurry locally also has important environmental benefits which could contribute to meeting the BPP's goals. Most importantly, local trading keeps nutrients in the local ecosystem, minimizing the need to bring in replacement nutrients from outside sources. Small, local markets for slurry also reduce the environmental impact and carbon emissions from transporting slurry long distances to a central facility for processing, bagging, testing or large scale composting.

Shorter distances and personal networks in villages and village clusters should reduce transaction costs related to transportation and information requirements, making slurry competitive with other inputs. Local trading should also be possible to reproduce in many other parts of Lao PDR where poor roads and a lack of trucks will limit the potential for long distance trade.

In order to bring the various elements discussed above back together into a marketing plan, the discussion will use the concepts from the *marketing mix* to describe how a small scale trading system would work.

PRODUCT:

Organic vegetable farmers are especially likely to value liquid biogas slurry made from cow manure (see sections 3.4.4. and 3.5.1 and Appendix 5 for more information.) For the owners of digesters, selling liquid slurry minimizes costs and labour, and investment compared to other options such as making compost. Most importantly from a marketing perspective, liquid slurry is a distinctive product that can be promoted for a special niche in the market for organic fertilizers.

For organic farmers, liquid slurry is a new and valuable fertilizer that requires less labour than making more compost and has less risk of contaminating crops with pathogens than manure. Most importantly liquid slurry allows farmers to ***quickly treat crops that are showing signs of nutrient deficiency***. Conventional vegetable farmers should also be interested in liquid slurry as a fertility input, especially for relatively long-lived crops such as gourds, cucumbers, pumpkins, chilies, broccoli and cabbage.

PLACE:

The selection of an appropriate area to pilot slurry marketing will greatly improve the chances of creating a self-sustaining market. The most important factors for success include:

- Large concentrations of biogas digesters, with a significant number of people who want to sell slurry occasionally and at least some who want to sell slurry regularly
- Potential customers who are interested in buying slurry as an input for their farms. Ideally, these customers should be organized into groups that can be easily contacted for initial meetings and follow-up.
- Farms that grow crops with nutrient requirements similar to the nutrient profile of cow/buffalo manure based slurry.

- Organic farmers depend on non-chemical inputs for all of their fertility needs, and they should be especially interested in buying slurry. Organic farmers may eventually be interested to install digesters if they like using slurry as a fertilizer.

Based on the factors listed above, it makes sense for the BPP to do pilot slurry marketing work with the PROFIL organic farming project. PROFIL farmers are organized into groups that can easily be reached for marketing purposes, and most PROFIL farmers are buying at least some fertility inputs for their crops.

Like the BPP customers, PROFIL farmers are concentrated in Vientiane Capital region, with the largest number in Xaythany district. PROFIL farmer groups in Nonthea and Kengkhai are located in an area with many digesters, and both groups focus on crops that would respond well to slurry. The first attempts to market slurry should therefore take place in these villages, with expansion to other villages, districts and provinces possible in the future.

PRICE:

Recommended prices in the table below are based on the theoretical values of each product relative to commercial fertilizer and the observed price of manure traded on a small scale within villages. Because bagged manure trades at approximately ½ if the current theoretical value, the estimated value of delivered liquid slurry is about 65% of its current theoretical value for slurry. This price accounts for slurry's advantages as a niche product for producing fruits and vegetables, but also allows for expected declines in fertilizer prices. The recommended price of slurry sold "as is" from the pond is calculated as the delivered price minus 15 000 kip for delivery costs and handling.

Type of Slurry	Recommended Slurry Pond Price	Recommended Delivered Price (2 km radius)
Liquid slurry from cow manure	45,000 kip per 1000 liters	60,000 kip per 1000 liters
Slurry solids (wet) from cow manure	55,000 kip per 1000 kg	70,000 kip per 1000 kg
Liquid slurry from pig manure	60,000 kip per 1000 liters	75,000 kip per 1000 liters

[24]

Slurry delivery is assumed to use returnable tanks, and is limited to a distance of 2 km. Delivery over larger distances, use of non-returnable tanks or other special requests by the buyer would require an additional charge. The prices may need to be revised downwards in the future if steep declines in the price of

24 As a reference, 1000 liters of slurry would be produced about every 18 days, or about 20 times per year. In reality, most BPP producers might want to use some slurry to fertilize rice crops during the rainy season, and sell slurry during the dry season when vegetable production is at its peak in the study area.

chemical fertilizer make biogas slurry less competitive, or if large amounts of slurry flood the market.

Estimated revenue calculations are based on the prices above, and assume that the 15,000 kip per ton delivery premium is used to cover delivery costs. This assumption is based on the observation that most BPP families have access to hand tractors and small carts suitable for transporting slurry, and that low cost re-useable containers such as used barrels are available at reasonable prices.

Table 3: Recommended Prices

Type of Slurry	Digester producing 20 tons of liquid per year	Digester producing 14 tons of liquid per year
Liquid slurry from cow manure	800,000 kip per year	560,000 kip per year
Slurry solids (wet) from cow manure	350,000 kip per year	250,000 kip per year
Liquid slurry from pig manure	1,100,000 kip per year	770,000 kip per year

Based on the above model, slurry sold from the pond would not require any variable or fixed costs, and very low costs if the seller decided to deliver. In cases where slurry is not currently being used, the money from slurry sales would lead to increased household income. In other cases, selling slurry would simply replace potential income lost from using or selling manure.

<u>PROMOTION:</u>

Promotion of slurry to organic vegetable farmers would allow the BPP to maximize the efficiency of its promotion activities by cooperating with the PROFILII project, and by cross-promoting slurry and biogas digesters at the same time. Promotion activities would focus around community meetings facilitated by both projects, with a focus on promoting bio-slurry and biogas digesters. If successful, this process could be replicated in different areas as PROFIL and BPP expand their operations in the future. More details about the promotion plan are given in Appendix 6 and in supporting documents supplied with this report.

6. Other recommendations and follow-up actions for BPP

This biogas slurry marketing survey is focused on a limited geographic area and was observed over a limited period of time. The results and conclusions of the report are specific to these circumstances, and will need to be reviewed regularly as environmental and market conditions change. Expansion of the Biogas Promotion Project will also bring new opportunities for slurry marketing and the sale of digesters generally.

6.1 Continued nutrient analysis of slurry

Inconsistent nutrient value results from different slurry ponds suggest that dilution by rainwater is a major factor in determining the nutrient content of specific samples of slurry. Additional analysis should take place during the dry season to determine whether the nutrient content is higher or more consistent at this time of year. Analysis of slurry produced in other BPP operating areas (Xieng Kuang) should also take place to help encourage slurry trading in the future

Pending the results of the nutrient analysis, the BPP may wish to encourage farmers interested in selling slurry to build shelters and/or drains to protect slurry ponds from rainwater and flooding. This could improve the consistency of the nutrient content of slurry, and allow farmers with covered ponds to charge slightly higher prices for their product.

6.2 Digester sales to organic rice farmers

While the sale of new digesters was not the focus of this study, it appears that organic rice farmers in Sangthong district may be an appropriate target market. Sangthong district has relatively large numbers of livestock over 500 organic rice farmers who have limited choices for fertility management. A well planned and executed promotion strategy in this area could lead to substantial sales.

Successfully marketing biogas digesters in this district must take the following into consideration:

1. Convenience will be the major selling point, and this includes the fact that digesters will make cooking faster and easier, and will reduce labour needed to gather fire wood and to make organic fertilizer.
2. Before attempting to sell digesters, BPP should prepare educational materials about how to use slurry to make rice straw and rice husk compost using slurry as an input instead of manure. This will make the sales presentation much more convincing for farmers.
3. Sales visits to rice growing groups in Sangthong must be convenient for farmers. Village visits during the rice planting and rice harvesting seasons are inappropriate because farmers must work and will not be able to attend meetings.

Appendix 1: Nutrient contents of on-farm residues

Table 9. Nutrient concentration of some on-farm residues.

Residue	Nutrient						
	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)	Mn ($\mu g\ g^{-1}$)
Rice straw	0.32	0.04	0.79	0.10	0.39	0.17	884
Rice husks[a]	0.43–0.55	0.03–0.08	0.17–0.87	0.05	0.07–0.15	0.03	116–337
FYM[b]	0.5–1.0	0.12–0.17	0.22–0.26	na[c]	na	na	na
Cattle dung[b]	0.35	0.11	0.09	na	na	na	na
Cattle urine[b]	0.80	0.02	0.26	na	na	na	na

[a]Juliano and Bechtel (1985). [b]Uexkull and Mutert (1992). [c]na = not available.

Source: Linquist B, Sengxua P. 2001. Nutrient management of rainfed lowland rice in the Lao PDR. Los Banos (Philippines): International Rice Research Institute.

The information in the table provides information that can be used to compare slurry from biogas digesters and other forms of organic fertilizer found in the study area. While these products are not perfect substitutes for each other, they can all be used to contribute to the fertility of rice and vegetable fields. These products are also commonly used together to make compost.

The partial substitutability of these products and the fact that some (rice husk, rice straw, pig manure) are available for free limits the price that can be charged for biogas slurry. Biogas slurry (and biogas digesters) should therefore be promoted as an ***easy, convenient and labour saving*** source of organic fertilizer that also has special advantages for vegetable growers.

Appendix 2: Nutrient contents in rice

Table 8. Macro- and micronutrients in the rice grain and straw at harvest. Data are from experiments conducted in Laos.

Item	N	P	K	S	Ca	Mg	Mn	Zn	Cu
				Nutrient concentration					
	%	%	%	%	%	%	$\mu g\ g^{-1}$	$\mu g\ g^{-1}$	$\mu g\ g^{-1}$
Grain	0.79	0.19	0.28	0.10	0.04	0.10	103	23	39
Straw	0.32	0.04	0.79	0.10	0.39	0.17	884	25	25
				Nutrient per ton of grain yield ($kg\ t^{-1}$)[a]					
Grain	7.9	1.9	2.8	0.9	0.4	1.0	0.1	0.02	0.04
Straw	4.8	0.6	11.8	1.4	5.9	2.6	1.3	0.04	0.04
Total	12.7	2.5	14.6	2.3	6.3	3.6	1.4	0.06	0.08
				Percent of nutrient in grain or straw at harvest					
Grain	62	76	19	41	7	28	7	38	51
Straw	38	24	81	59	93	72	93	62	49

[a]Assumes a harvest index of 0.4. Therefore, if rice grain yield is 1 t ha^{-1}, the straw yield would be 1.5 t ha^{-1}.

Source: Linquist B, Sengxua P. 2001. Nutrient management of rainfed lowland rice in the Lao PDR. Los Banos (Philippines): International Rice Research Institute.

The amount of each nutrient removed from a field by a rice crop is not uniform for macro or micro nutrients. Harvesting rice grains removes a very large proportion of the nitrogen and phosphorus available in a crop, but only removes a small amount of the potassium. Because much less of the rice straw is removed from the field and because the straw that is removed is often returned as manure, rain fed rice fields are not normally deficient in K.

It should be noted that K deficiency is more likely in fields where rice stubble is burned, where rice straw and rice husks are not returned, or where irrigated rice is grown using 16-20-0 as basal fertilizer instead of 15-15-15.

Appendix 3: Conventional fertility program for rice

This recommended fertility management program comes in two parts, and is based on fertilizer recommendations for rice in rain-fed lowlands, as described by Lingquist and Sengxua[25]. The first year of the program is designed to build soil fertility, and should be used by farmers who have not used inorganic fertilizers or large quantities of manure (more than 6 tons per hectare) in the past 12 months. The second and subsequent years apply lower levels of fertilizer to maintain soil fertility. Farms that previously used inorganic fertilizer or large quantities of manure can move directly to the fertility maintenance program.

The fertility program described below applies sub-optimal amounts of nitrogen, especially if improved varieties of rice are grown. Lower levels of N application are recommended for rain-fed rice farming in Lao PDR because many traditional varieties do not respond well to higher N levels, and because weather conditions sometimes act as a limiting factor to rice production rather than soil fertility. In irrigated areas using improved varieties, farmers may therefore want to increase levels of N applied by 20-30 kg per hectare.

<u>Year 1</u>

Soil Type	KG of N-P-K required	Slurry Required (Liquid, from cow manure at .21-.22-.09 N-P-K)	Additional Fertilizer
Sand	60-20-30	9.1 tons per hectare	88 kg of urea, 44 kg at tillering and 44 kg at panicle initiation
Sandy Loam	60-30-30	13.6 tons per hectare	62 kg of urea, 31 kg at tillering and 31 kg at panicle initiation
Loam	60-45-30	20.5 tons per hectare	37 kg of urea applied at panicle initiation
Clay Loam (common in study area	60-60-30	27.3 tons per hectare	Not required

25 Linquist and Sengxua, ibid.

Subsequent Years

Yield in Previous Year	KG of N-P-K required	Slurry Required (Liquid, from cow manure at .21-.22-.09 N-P-K)	Additional Fertilizer
2 tons per hectare	60-12-30	5.5 tons per hectare	100 kg of urea, 20 kg basal, 40 kg at tillering and 40 kg at panicle intitiation
3 tons per hectare	60-18-30	8.2 tons per hectare	90 kg of urea, 20 kg basal, 35 kg at tillering and 35 kg at panicle intitiation
4 tons per hectare	60-24-30	11 tons per hectare	80 kg of urea, 40 kg at tillering and 40 kg at panicle initiation
5 tons per hectare	60-30-30	13.6 tons per hectare	60 kg of urea, 30 kg at tillering and 30 kg at panicle initiation

For reference, a 4 m digester running at 100% capacity 365 days per year would produce approximately 20 tons of liquid slurry per year and a digester running at 70% capacity would produce approximately 14 tons per year. A digester running at full capacity should therefore be able to fertilize about 2 hectares of rice using this program, while a digester running at 70 percent should be able to fertilize about 1.5 hectares.

Appendix 4: Applying slurry with green manure

Green manures are not popular in Lao PDR, but they could be used with slurry to boost levels of soil N for resulting crops of rice. While many options are available, stylo or Sesbania rostrata are two good choices which are appropriate for vegetable and rice land respectively.

Before planting green manure, enough slurry should be applied to provide at least 20 kg of phosphorus per hectare, or about 10 tons of liquid cow manure slurry per hectare. The slurry should be worked into the ground and the soil worked before planting the crop. Green manure crops should be incorporated into the soil at least 1 week before planting.

Attempts to introduce green manure crops in rain fed rice culture in the past have had limited success, due to the work required, the lack of seeds, inconsistent results[26]. Because of these factors, use of green manures is probably only viable for certified organic rice or vegetable production. Declining world prices for urea fertilizer make it increasingly unlikely that conventional rice or vegetable farmers would be willing to invest the money and work required to use green manure crops.

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[26] Roder et al, ibid.

Appendix 5: Liquid slurry as an input for vegetables

Using liquid slurry as an input to grow fruits and vegetables has two main advantages. The first important advantage is that slurry is a safer product than many substitutes, especially manure or sewage sludge which often contain pathogens such as parasites, bacteria and viruses. This factor will become increasingly important as consumers become more aware of the causes of food-borne illness. The second main advantage is that liquid biogas slurry can be applied as a side dressing for many types of vegetables, although it should not be applied to leafy green vegetables within two weeks of harvest.

A list of most appropriate vegetable crops for cow manure based slurry includes cucumbers, gourds, melons, pumpkins, eggplant, carrots and beets. Beans, peas and other legumes will also benefit from slurry application, but they are able to fix nitrogen, and will primarily benefit from the phosphorus and potassium in slurry.

Vegetable crops suitable for pig manure based slurry include broccoli, cauliflower, cabbage, kale, chili pepper, sweet pepper, tomatoes, mint, basil, coriander and other herbs. These plants need relatively more nitrogen and less phosphorus than crops recommended for use with biogas from cow manure slurry. The pig manure based slurry tested during the survey should provide a sufficient boost to these crops which require more nitrogen.

If slurry is applied to growing crops, farmers should normally be able to reduce the amount of compost or compost they need to use. Because organic farmers in the study area use much smaller amounts of compost than recommended (200-500 kg per ha instead of 5-6000 kg) slurry should be applied as an additional input along with the compost that is already being applied. For conventional vegetable farmers, slurry should be used as a substitute for the chemical fertilizers normally used for side-dressing crops.

One promising approach would be for vegetable farmers to buy liquid slurry and separate the solids from the liquid content. Slurry filtrate could be used as a top dressing for growing plants such as gourds, tomatoes, cucumbers or eggplants. Wet slurry solids removed from the liquid could be used separately to replace manure for making rice straw compost, or applied directly to fields prior to planting to improve soil fertility and texture. This efficient use of slurry would obtain maximum production and economic benefits for everyone involved.

Appendix 6: Proposed Agenda

Pilot Slurry Marketing Meetings

8:00-8:30	Arrival and registration
8:30-8:40	Introduction of participants
8:40-9:10	Background on PROFIL and Biogas Promotion Project
9:10-9:30	How a biogas digester works
9:30-9:45	Break and snacks
9:45-10:30	Using slurry as an agricultural input • Types of slurry • Characteristics of slurry as fertilizer • How to apply slurry to different crops (in field)
10:30-11:00	Buying and selling slurry • Recommended value of slurry products • Creation of buyer and seller contact lists • Plan for distributing and updating lists
11:00-11:20	Building a new biogas digester on your farm • Costs and benefits of digesters • Sign-up interested customers for follow-up by BPP
11:20-12:00	Visit to a nearby digester
12:00	End of meeting