ID China Biogas Program
法国发起发展组织(中国区)沼气项目

AGRICULTURE AND BIOGAS SURVEY
农业及沼气调查
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Nicolas Borchers, ID China Agriculture Officer[1]

[1] n.borchers@id-ong.org

Aknowlegments

I would like to thank all the interpreters and trainees, the essential hinges of every conversation, for their efficient work in sometimes difficult conditions. I do hope they have now forgotten the day-long uncomfortable motorbike drives through the dust, the rain and the muddy potholes.

My gratitude is also with all the farmers who opened their door for us, accepted to take some time to answer our questions, made a space around the stove, or invited us to share their lunch. By sharing their experience they allowed us to better understand how to improve our work in the region.

1 INTRODUCTION 介绍

In the summer/autumn of 2012, surveys were carried out amongst the beneficiaries of ID China's biogas programs to find out about the households' agricultural practises, their use of the biogas digester, and the role of the biogas residue (« bio-slurry») in the local agriculture.

Since 2010, ID China has assisted more than 2500 households with building a digester in Zhaotong prefecture (昭通), Yunnan province, in addition to older programs in Weining prefecture (威宁). Amongst these, 24 households were interviewed in Zhaotong and 4 in Weining.

The main goal of the survey was to gain an understanding of the current practises on the terrain. In the villages, households have had a biogas digester for only a short period, between one and five years. At building time, ID provides a training to the new beneficiaries, which includes advise on how to use the bio-slurry for agriculture. However, in the years after the digester has been built, its exact use and impact on the agricultural practises are unknown. The beneficiaries may have followed ID's advise, may have followed word-of-mouth advise or imitated the neighbour, may have experimented on their own, or may have completely reverted to previous habits and may not use the bio-slurry at all.

ID China is currently studying how its advise to the beneficiaries can be improved, and the NGO would like to review the content of its technical message, including such questions as when to open the digester, what to do with the residue, whether composting can be made, etc. So far this message was mostly adapted from second-hand sources such as the Chinese government or other biogas stakeholders. How does the message correspond to practise? Certainly there must exist discrepancies between the technical advise given and the methods effectively practised on the terrain after a few years.

On one hand, the surveys can help to point out the dysfunctions on the terrain. However, when some methods are used on the terrain despite repeated opposite advice by development organisations, one has to question whether it is not because of their ultimate suitability, in other words their optimal return compared to the work invested, a reality that can easily elude to external actors. Surveying hence allows to identify useful methods selected by the beneficiaries themselves, and potentially incorporate them in the trainings.

Great care should be taken in the task of distinguishing between the two scenarios (the habits taken by reason, and the ones taken by lack of knowledge or incentive), as the former can easily be mistaken for the latter. This survey will hence try to find objective facts that can help bridging the terrain knowledge of the farmers with the theoretical approach of the development actors.

在 2012 年夏季和秋季，ID 对沼气项目的受益者进行了调查，以了解农户的农事活动、沼气池的使用情况，以及沼渣沼液在农事生产中起到的作用。

自 2010 年起，ID 中国在云南省昭通市与 ID 的老项目点贵州省毕节威宁县为 2500 户农户修建了沼气池。在这些农户当中，ID 在昭通选择了 24 户，在威宁选择了 4 户进行访问调查。

调查的主要目的是获得当地农户沼渣沼液使用的现状。这些农户家中的沼气池已经使用了 1 至 5 年。ID 新建沼气池后，会给受益农户提供相关培训，例如怎样利用沼渣沼液促进农事生产。然而，培训之后农户使用沼渣沼液的情况，以及沼渣沼液对农事活动所产生的影响，ID 并不了解。农户也许听从了 ID 的建议，也许采纳了口口相传的方法，或者效仿邻居，或者自己进行了试验，或者仍然延续以前的做法没有使用沼渣沼液。

ID 中国目前正在探索如何改善我们给受益者的建议，并且检验我们在技术上的建议是否正确，例如沼气池什么时候出料、是否可以利用沼渣沼液来堆肥等。目前，这些技术上的建议大部分来自当地政府和村民。这些建议与实际情况相符吗？通常，在这些建议给出几年后，实际运用与建议本身是有差异的。

一方面，调查可以帮助我们发现我们的建议没有产生效果的原因。当外部的发展机构一遍遍重复自己的建议，而当地人却一直使用相反的一套方法时，我们就需要质疑，是否是因为我们的建议适用性不强，换句话说就是按照建议的做法，其产出与投入不成正比，而村民对这个事实也保持缄默。因此，调查可以知道受益者自己选择了哪些管用的方法，而我们有可能将这些方法融入到我们的培训里。

另一方面，我们要注意区分这两个情况：由一定因素决定的习惯，和缺乏相关知识或动机和诱因而产生的习惯。前者很容易被误认为是后者。这一调查可以帮助我们找出影响习惯的客观因素，并在村民的本土知识与发展工作者的理论方法之间搭建起桥梁。

2 METHOD

The interview team was made of ID China Agriculture Officer (agronomist) together with a Chinese trainee or interpreter. Two trainees and three different interpreters were responsible for the translation during about 20 days of terrain work spread between May and December 2012.

The households were chosen randomly while driving in the villages, according to the availability of family members for a discussion. We tried to meet families in diverse areas in proportion of the importance of ID China programs in the respective villages, therefore trying to acquire a representative sample. Since different agriculture systems coexist in the region, we also took care to meet at least a few households representing each agriculture type. Since the survey team was generally travelling by motorbike, villages which were difficult to access because of difficult road conditions in the rainy season might be under-represented.

Each interview lasted on average two hours. To conduct the discussions, we chose a semi-structured interview method. A supporting document/form was made to guide the discussions and collect the answers (see appendix). Many questions were related to quantitative enquiries (such as the field surface or number of animals), while others were categorical (such as on which crops bio-slurry is used). However, most questions had an open and general form (« how do you use the bio-slurry ») to let the discussion flow and try to understand in depth the system and habits used by the households, including all subtleties of method. These answers were then interpreted to fit in a predefined category when possible.

The interviews went through many improvements throughout the months, and the questions were fitted according to what had already been learned. This was reflected in the supporting form, which went through many versions. Some new questions were added, while some were dropped. Hence, some statistical results presented in this document will have less respondents than others. However, great care was taken to keep consistency throughout the surveys.

Understanding the full seasonal cycle of agriculture and the yearly use of the biodigester in a single interview presents huge difficulties due to the level of abstraction needed. Despite the committed work of all interpreters, many misinterpretations might subsist, whether these initiated between the interviewee and the interpreter (many of whom were not familiar with agriculture), or between the interpreter and the agronomist (who was neither familiar with the Chinese language or with the local agriculture). To reduce the risk of misinterpretation, the following methods were used.

Firstly, every question was asked several times in different ways, or the information was double checked indirectly. For example, if an interviewee pointed out that bio-slurry was not used, it was later asked whether bio-slurry was used on a certain crop, or whether it was poured on the compost. Many unexpected and surprising misunderstandings were cleared this way.

Secondly, we tried to move around the farm during the interviews, according to the current topic. When talking about the compost, for example, a very concrete picture would emerge by visiting the heap behind the house, rather than engaging in lengthy discussions about the composition and management of the compost. Whenever possible, we asked the interviewees to show us practically how things were done, however by lack of time we could not walk to the fields for a demonstration. Furthermore, many procedures, such as the emptying of the biogas digester, were out of season, and had to be imagined only. Besides the many walks around the farm, the bulk of the interviews was generally held around the stove, with a cup of tea.

When preparing for the surveys, the previous work done by the French agronomist François Sorba for ID China in the village of Shenjiagou (沈家沟) was an invaluable resource. His report "Agrarian Diagnosis in ShenJiaGou" (2010) is a detailed synthetic analysis of the agriculture systems in a village of the region, based on an extended stay in the village and numerous interviews. This document can be used as an excellent complement to this study. However, the present study focuses specifically to the agriculture in the context of the use of the biogas digester, a topic that is not covered in Sorba's report. Besides, further agriculture systems were studied, such as tobacco farming, and the agriculture amongst the Hui minority.

We hope that the present report will clarify many questions left open within ID China, and that the answers it provides will help the NGO in its decisions towards its work for the benefit of the people of Zhaotong and Weining.

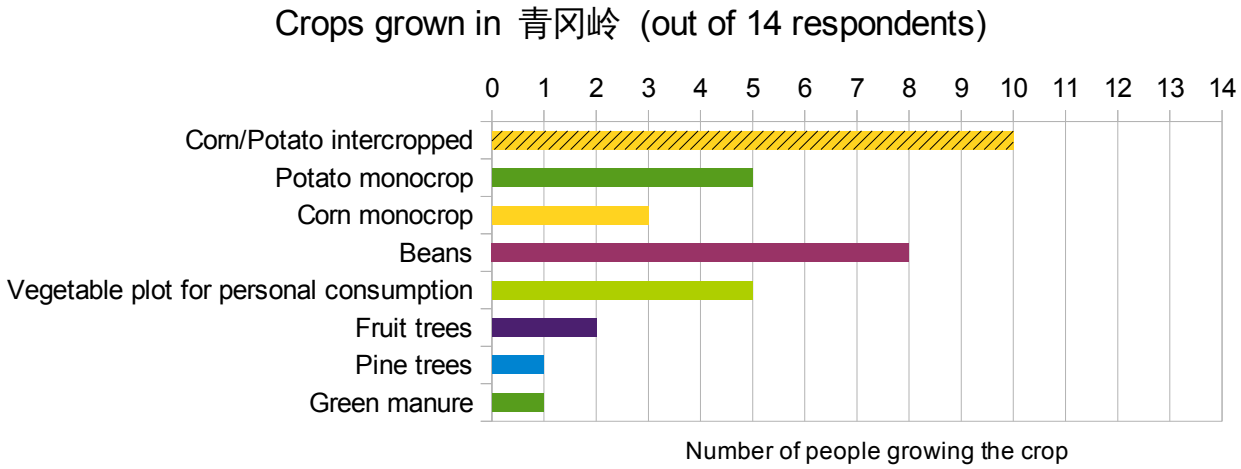
3 LOCATION OF THE SURVEYS

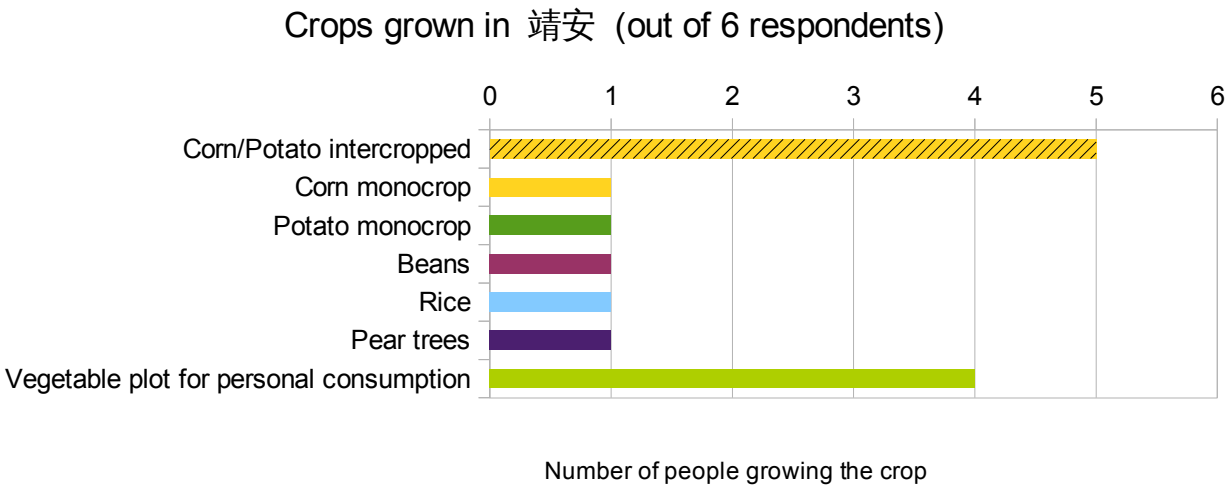
区 District	乡 Township	村 Village	Number of interviews
昭阳 Zhaoyang	青冈岭 Qinggangling	沈家沟 Shenjiagou	4
		新桥 Xinqiao	2
		白沙 Baisha	8
	靖安 Jingan	洪家营 Hongjiaying	5
		大耆老 Daqilao	1
	洒渔 Sayu	联合 Lianhe	1
	小龙洞 Xiaolongdong	中营 Zhongying	5
威宁 Weining	牛棚 Niupeng	范家 Fanjiatian	3
		邓家营 Dengjiaying	1
		Total	**30**

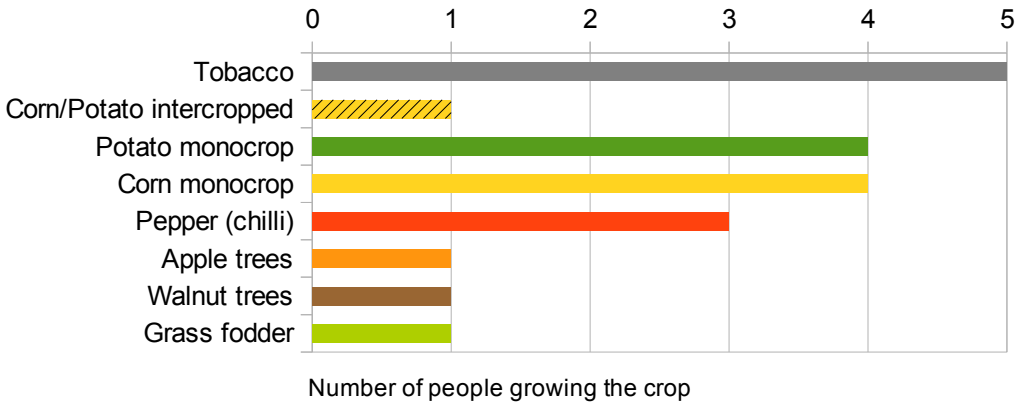
4 AGRICULTURE

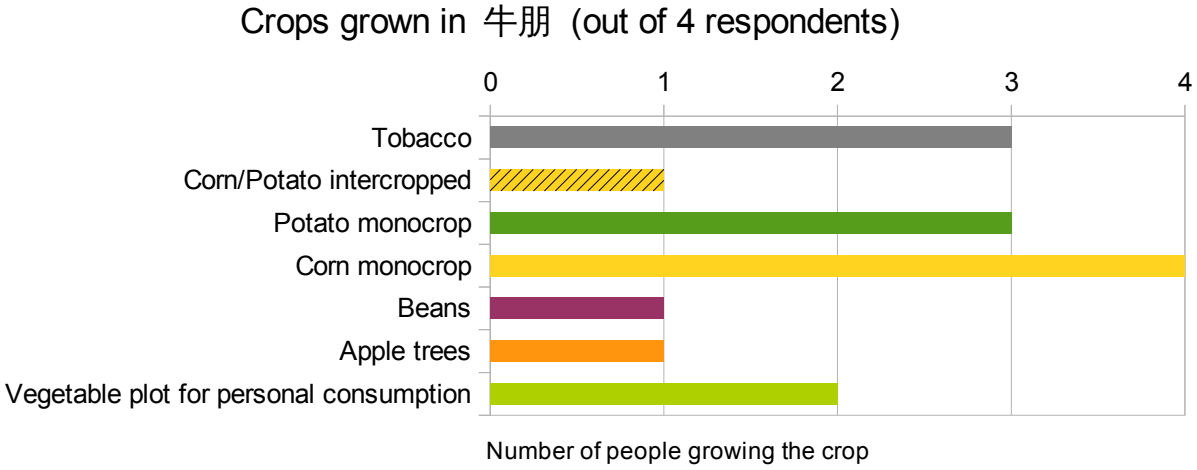
4.1 FIELDS AND CROPS

Agriculture systems are very variable from one village to another. However, within defined areas, they were found to be relatively homogeneous. Underneath, the repartition per crop are therefore presented per township.









In addition, the cultivation of radish for animal consumption is widespread. Radish is not grown as a main crop, but as a second rotation crop following a main crop. It is usually planted in place of potato, since potato is the earliest crop to be harvested, around September. It is sometimes also planted in the orchards, for example in the free space between apple trees.

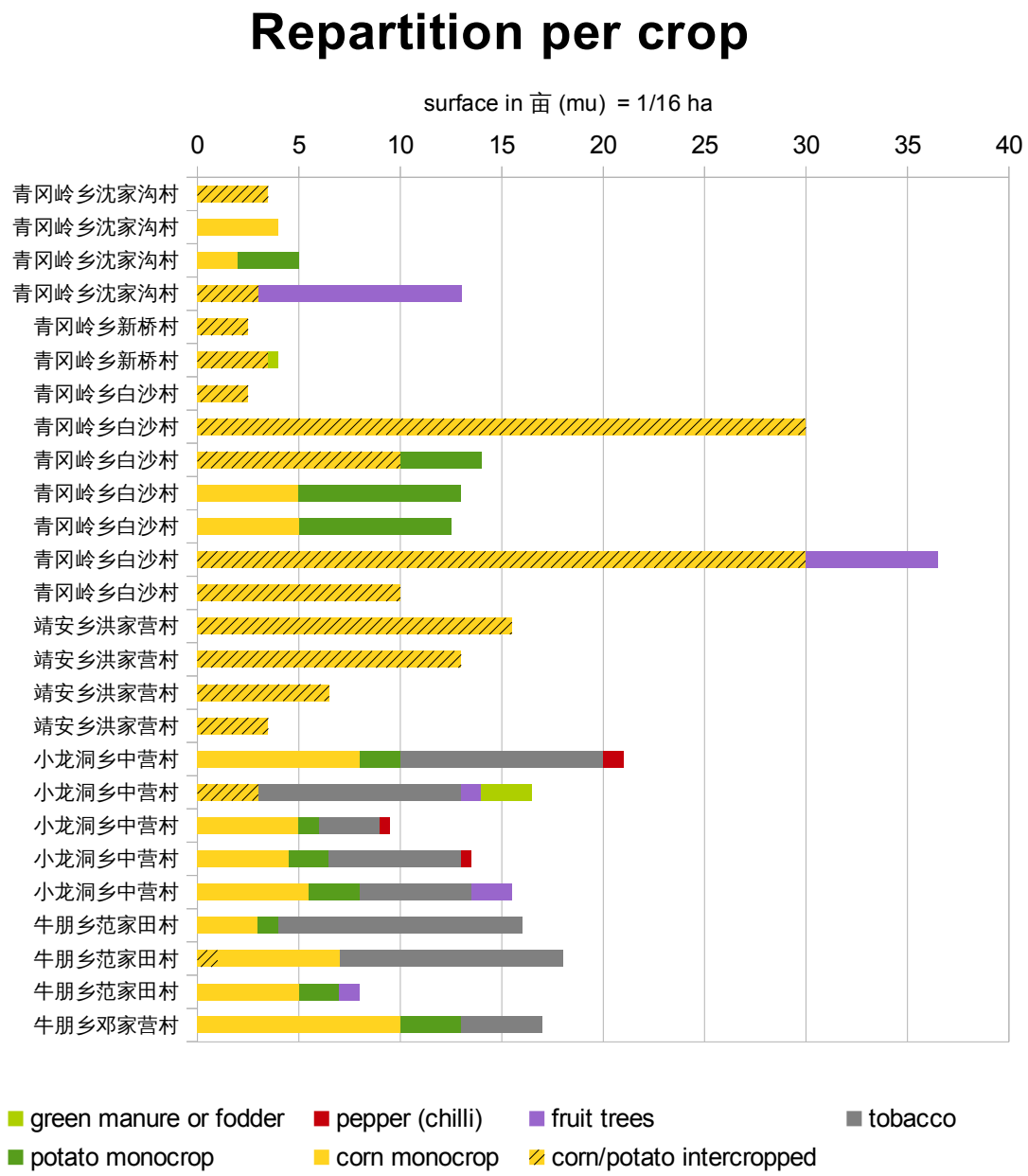
Township	Number of respondents	Number of respondents growing radish in second rotation
青冈岭	14	8
靖安	6	5
小龙洞	5	0
牛棚	4	0

4.2 Field sizes

A complete record of the interviewees with the surface of field of each crop is presented below. The median field surfaces in cultivation per household are as follows:

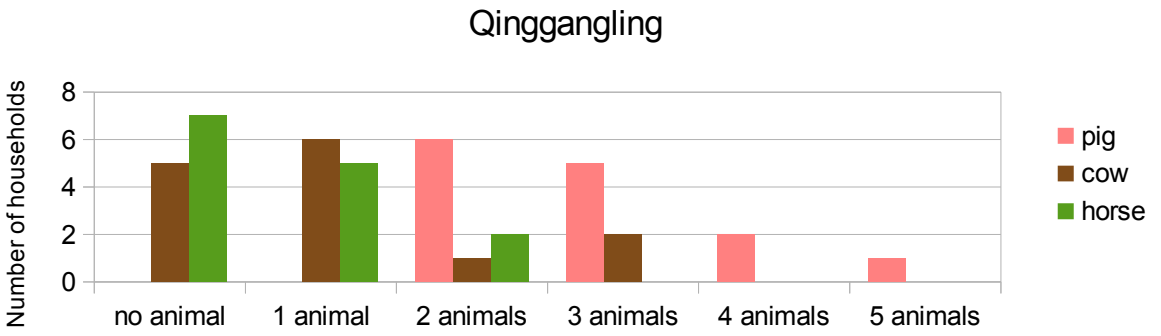
青冈岭	靖安	小龙洞	牛朋	**All townships**
4.5	6.8	5.5	4.0	**5.0**

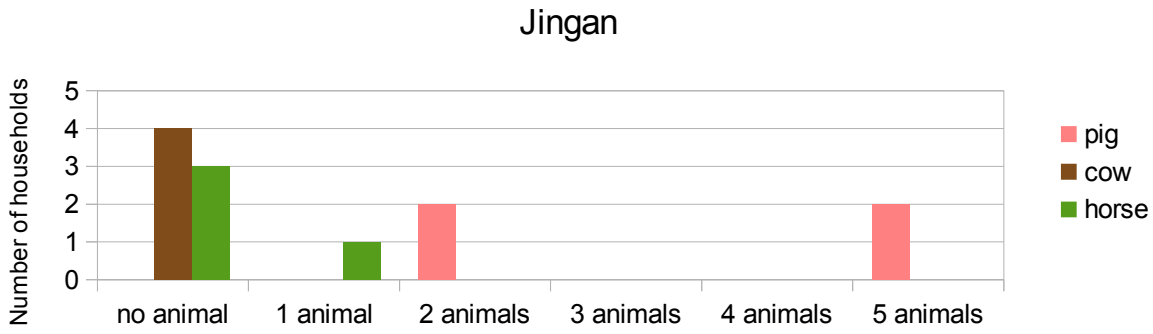
Table 1: Median field surfaces per household, in 亩 (mu) = 1/16 ha

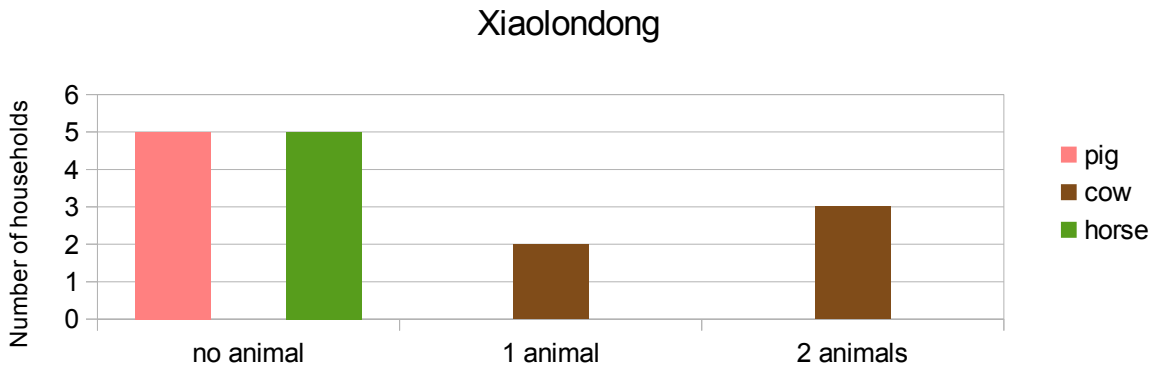


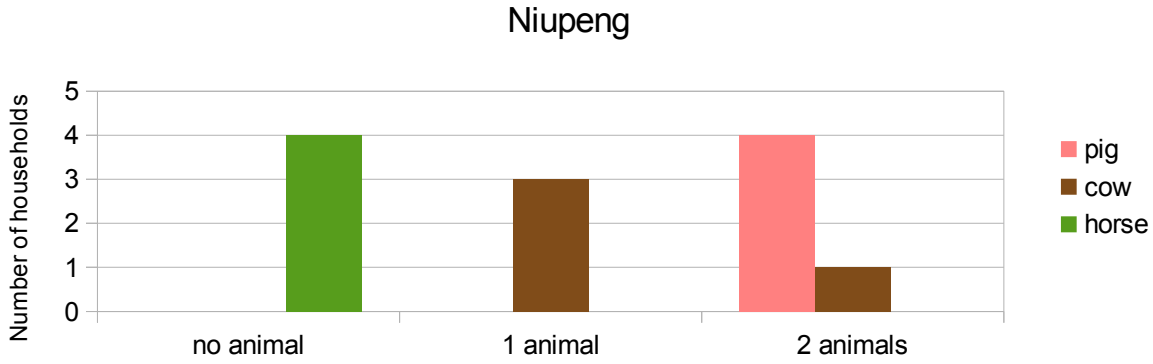
4.3 ANIMALS

The following charts show a breakup of household per number of animals:



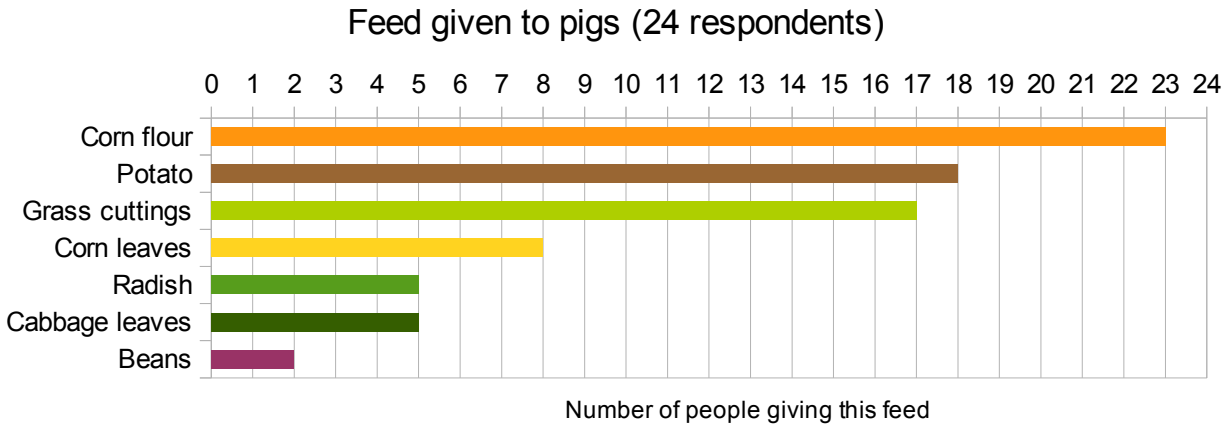






4.4 Animal diet

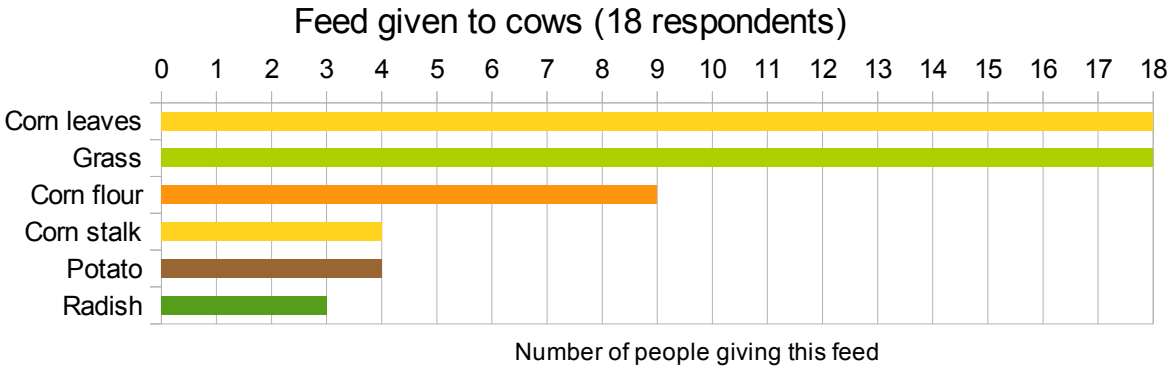
Interviewees were asked what they feed to their animals. Since the results are very similar from one village to another, the results are presented without distinction.



(Cabbage leaves means mainly the leaves not fit for human consumption, however radish is grown especially for pig feeding.)

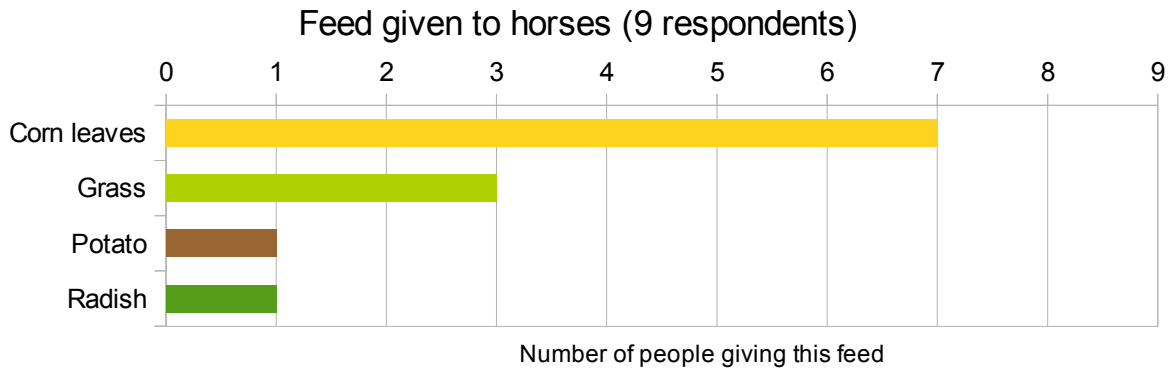
The main recipe for pig feeding seems to vary little between villages. In a very big pot are mixed together grass, corn flour, potatoes roughly cut, and water. Potato leaves or bean stalks are sometimes added, however in general the potato leaves are abandoned on the field. The grass is harvested daily in the surroundings using a bill-hook and a basket worn on the back. People busy with this task can often be seen along the trails. However, grass is sparsely available during the winter. The mixture is left to cook on the fire for several hours. Cooking pig food is therefore a major contribution to the fuel consumption of a family.

The reasons for cooking the pig food, according to the farmers, are for increased digestibility and palatability. When the feed is cooked and served warm, it is said, the pigs eat more and fatten faster.



In general, the corn stalks are given to the cows without preparation, that is with the leaves still attached to the stalk. The animal itself will pull the leaves for feeding, and the stalk will be left for bedding. However, we noticed that in Xialongdong, where livestock feed is scarce because of the large area allocated for tobacco, the farmers are trying to maximise the use of available feed, so even the stalk is fed to the cows. However, since this part of the plant is not palatable enough, the farmers have to grind it to flour first. This powder is then dissimulated within the other ingredients of the cow feed mix.

According to one source, grinding the stalk costs about 12-15¥ per 100 jin (50kg), while grinding the corn to coarse flour for animal feeding costs 3¥ per 100 jin.



Horses are mainly fed grass during the summer season, and many animals are brought out for grazing. In some households, the grass is collected by family members and brought to the horse in the barn instead. In the winter, the main feed is corn leaves. As with cows, in general the whole stalk is given to the horse, the animal consumes the leaves only and leaves the stalk as its bedding.

4.5 Grazing

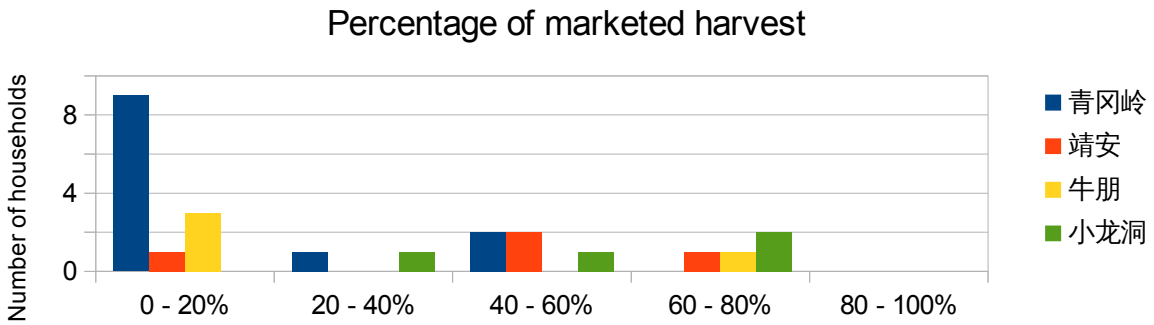
The following table shows, amongst the interviewees, the number of households which do bring their animal for grazing at least during a part of the year. Hence, "no" responses represent households which do keep their animal indoors all year.

Grazing: Yes / No	Qinggangling	Jingan	Xialongdong	Niupeng
Cow	7 / 2	N/A	1 / 4	1 / 2
Horse	6 / 1	N/A	N/A	N/A

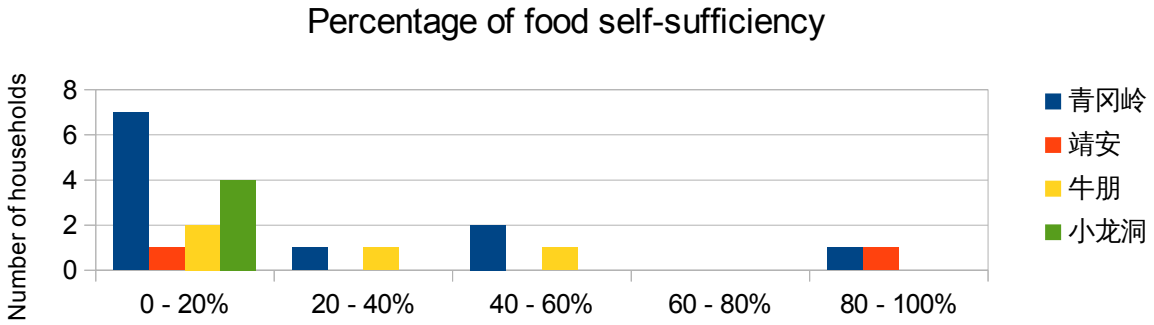
Important differences in grazing habits seem to exist according to the location of the village, depending on the availability of grazing areas. For example, in Shenjioagou, which is situated in the bottom of a valley surrounded by steep slopes, the important land abandonment in the upper fields mean that large grazing areas are available, and most animals are taken out. By contrast, in Xiaolongdong, little surface is available because of the intensive cultivation of tobacco, and most animals stay in the barn all year round. Cows are more likely to stay indoors year round compared to horses. Pigs are never brought for grazing, although it happens occasionally to encounter free pigs or piglets along the roads.

4.6 Food/feed self-sufficiency

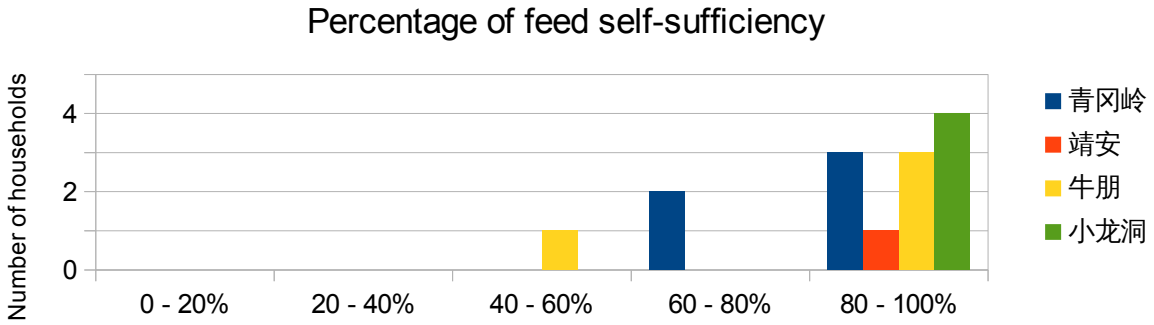
The interviewees were asked to estimate how much of their production they usually sell, versus how much is used for own consumption. Self consumption is mainly for animals (corn and potato), but a little part is also consumed by the family (potatoes and corn flour). Produce that is sold is mainly tobacco and apple, so the household which grow these crops responded to this question with high percentages. Corn and potato are rarely marketed, because families arrange to keep at all times a number of animals which is proportional to the amount of feed that the household can provide, according to their amount of land in cultivation. Therefore, generally all corn and potato go for animal feeding. However, the yields vary from year to year, which sometimes leads to excesses that can be sold to neighbouring families.



The interviewees were asked to evaluate their amount of food self-sufficiency. In general, this question was perceived as particularly tricky to understand and answer. Hence, answers were generally very approximative. One way of presenting the question during the interviews is to imagine, in a thought experiment, that all food eaten by the family can be placed at once on the table, and to try to separate mentally in two piles, one coming from outside (rice, noodles, vegetables, oil, tofu, etc...) and the other from the family's own production (meat, potatoes, corn flour, vegetables from the garden). The figures presented below are then the relative size of the latter pile.



The same question was asked about self-sufficiency of feed for the animals.



4.7 SUMMARY

The different systems of agriculture in the studied townships can be summarised as follows.

Qinggangling and Jingan: intercropped corn/potato and small scale pig farming

In these two neighbouring townships, the agriculture is exclusively focused on pig farming. Corn and potato are used as feedstock for the pigs, and usually intercropped. However, in certain plots, or in less favourable areas, such as steep mountain slopes, corn and potato are planted separately. Radish for livestock feeding is often planted in second rotation after the potato.

Some farmers keep one cow, which is used for tilling the field. A horse can also be kept for transport, especially in areas with steep slopes. On the plateau, a cart driven by the cow is usually preferred, or a small tractor when the household can afford it. The cows and horses are often brought outside for grazing. Alongside fresh grass, the corn leaves are a main feed for horse and cow.

Some farmers also have small surfaces of fruit trees (apple, cherry, walnut). No tobacco is grown in these areas.

The agriculture in this area works mainly in closed circuit, with the crop consumed by the livestock, and the livestock waste brought back to the field. Economically, few exchanges take place, apart from the selling of one or two pigs every year. The rest of the meat is consumed by the family.

Xiaolongdong: tobacco and apple orchards

In this township inhabited almost exclusively by people of the Hui minority, tobacco is the base for the economy. Many farmers also have apple orchards. Hence, here a large amount of the harvest is sold (cash crops), and the agriculture system works rather in open circuit. A large amount of cash is made with the selling of the tobacco, however costs are higher, in particular for the important amounts of coal needed to cure the harvest. Globally though, the crop is quite profitable and this village is better-off.

For cultural and religious reasons, Hui people do not keep pigs. Instead, it is common for each household to have one or two cows. Rotavators are getting more common for tilling, but the cow is still widely used. Feed for the cow(s) is provided by planting corn. Potatoes, which are a less appropriate feed for cows, are nevertheless grown both for feed and human consumption but occupy less surface than corn, therefore corn and potato are usually not intercropped.

Livestock feed and bedding are usually scarce in Xiaolongdong, because of the intense pressure for devoting the surface to tobacco rather than for feed. Even the corn stalk is often fed to the cows. Furthermore, the village has no access to forests and lacks pine needles for animal bedding. Because of this lack of biomass, the cows, which are mostly kept indoors year-round by lack of grazing space, are usually kept on very little bedding, but rather on a deep layer of wet manure mixed with some corn stalk.

Niupeng: a mix of the two previous systems

The amount of time (2 days) and the number of households interviewed in this township (4 families) are not sufficient to give a complete overview of the agriculture situation in this township, however it can be considered that a mixture of the two agriculture systems presented above can be found here.

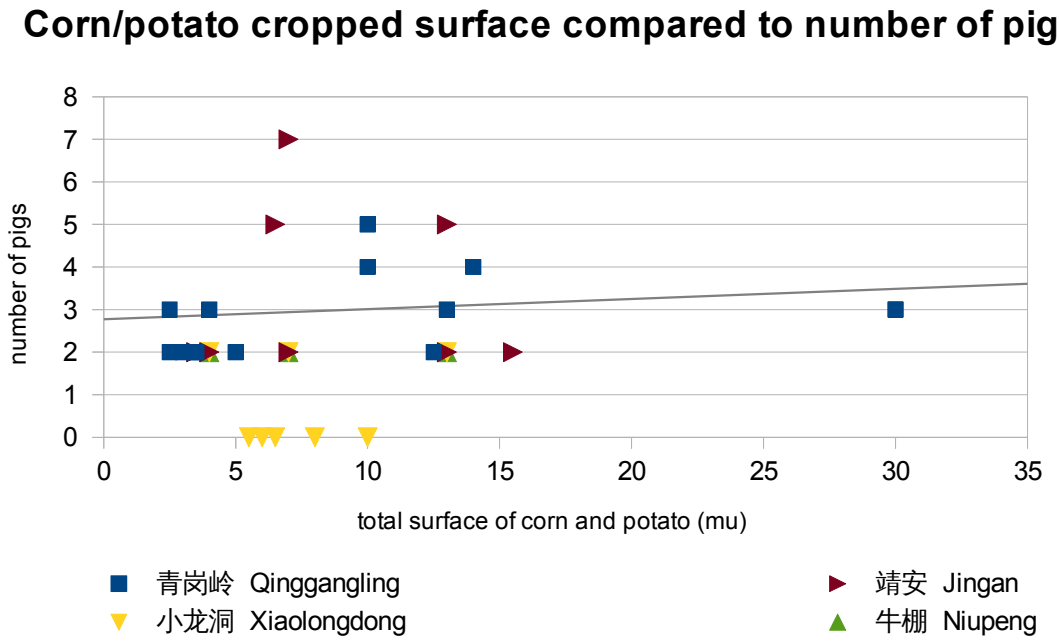
Indeed, in this township farmers generally breed pigs, but also devote a portion to their agriculture surface to tobacco. One or two cows are often kept. Horses are not common; thanks to the flat topography and the good road infrastructure, tractors and mechanised engines are more common. Potato is grown but in significantly smaller amounts than corn, hence they are not always intercropped. Both corn and potato are used as feedstock.

Hence, the agriculture in Niupeng presents the characteristics of a semi-open circuit system in which physical and economical exchange of produce is important, while another part of the agricultural activity stays concerned with the breeding of livestock in closed-circuit.

4.8 Relation between animal number and feeding capacity

It is generally assumed that in a small-scale subsistence animal breeding agriculture, the farmers will breed just as many animal as they can feed. In other words, there should be a correlation between the number of animals and the surface of field dedicated to their feed.

In the region, most of the feed is grown for pig breeding in the form of corn and potato. Cows and horses however, eat essentially grass harvested in the vicinity, as well as the by-products of the field (such as corn leaves), when they are not grazing themselves. Hence, one could expect to find a correlation between the number of pigs and the total surface of corn and of potato grown by the household.



On the previous graph, the results of all interviews have been placed. The horizontal axis represents the surface cropped with corn and potato, the vertical axis the number of pigs.

As it can be seen, the correlation between the number of pigs and the surface of corn/potato does not appear clearly. Several reasons might be put forward:

- the interviewees may have given unreliable answers either concerning their number of animals or their surface of corn/potato
- the number of animals vary through the year according to the breeding cycle (i.e. fattening of piglets; slaughtering for the Chinese New Year), and therefore according to the season of the interview. Piglets are often not accounted by the beneficiaries when asked about their number of animals.
- the harvest of grass has not been considered in the pig diet in this simplified scenario
- some beneficiaries sell a part of their harvest; some others do buy some supplementary feed
- the intra-consumption by the household has not been taken into account (i.e. potatoes)

In the light of these results, it is uneasy to conclude which criteria is best suited for evaluating the potential production of biogas by a household. ID China has generally always considered the number of animals to be a criterion of selection and eligibility for the subsidy of a biogas digester. However, an alternative evaluation would be to consider the amount of surface on which feed is grown, if one can postulate that this biomass will eventually be made available as manure, and that yields are roughly homogeneous amongst farmers.

The results above warn that the two criteria are not equivalent. Since the animal number criterion is more direct, it might be preferentially used.

5 BIOGAS DIGESTER MANAGEMENT

The second part of the interviews concerned the management of the biogas digesters. Out of the 30 interviewees, 29 had a biogas digester built with the support of ID China, and one had no biodigester yet. However, quite a few beneficiaries had their digester built recently (less than a year), and therefore did not have a full experience set on how to use their new system. In particular, many respondents had not emptied their digester for the first time yet, as is usually practised in the region. In these cases, the related questions of the survey were left unanswered, therefore the number of valid answers varies according to the question.

Two types of digesters were built with the support of ID China. In Weining region, the digesters were built in earlier programs in the years before 2008, and follow a construction design with multiple water chambers and often a hand-driven pump to recirculate the bio-slurry to flush the toilet. The later digesters built in Zhaotong between 2008 and 2012, are classical with a single water compensation chamber. Because of these different architectures, and perhaps also because the digesters have been in use for more years in Weining, while doing the surveys important differences in the use of the digester were noticed between Weining and Zhaotong. The results of the interviews shall therefore be well distinguished between the two regions. The set of answers for Zhaotong are more complete with 25 respondents, while only 4 households were surveyed in Weining.

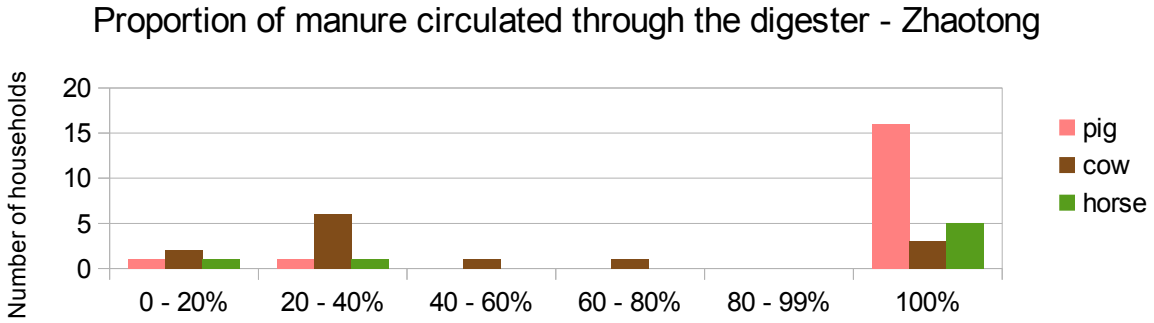
5.1 Inputs to the digester

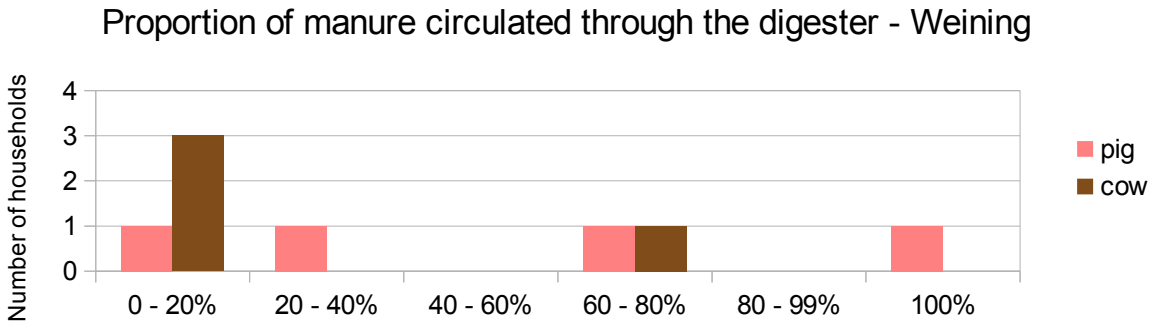
The interviewees were asked to estimate the proportion of animal manure that was circulated in the digester. In many cases, the digester had been built with the animal pen directly connected, in which case the totality of the manure flows from itself in the digester. In other cases, the manure needs to be transferred regularly to the digester using buckets.

Unfortunately, whether the animal pen was connected to the digester was not recorded in the surveys, so a break down of the answers depending on this criteria is not available.

The interviewees were also asked whether they used the toilet connected to the digester. Out of 27 answers, only one household said that the toilet was not used.

Finally, the interviewees were asked whether they had added any other materials to the digester, such as corn stalk, leaves, grass, pine needles, compost, etc, or if they had added manure bought from a neighbour. Only one household answered that it was regularly adding cow manure provided by a neighbour at the rate of 150 kg per week. All other households said that nothing else was added but the manure from their own animals.





Through these results it appear clearly that for the 4 households visited in Weining a lesser proportion of the manure is used for the digester. These findings shall be further supported by comparing the manure and composting habits of the households in the next sections.

In general in Zhaotong, pig manure is the most fully used for generating methane in the digester, compared to cow and horse manure. Two explanations can be proposed to explain this difference:

- the pig pen is generally directly connected with the digester, whether this is less frequent of the cow pen and horse pen, since these animals are more frequently kept separately on deep litter.

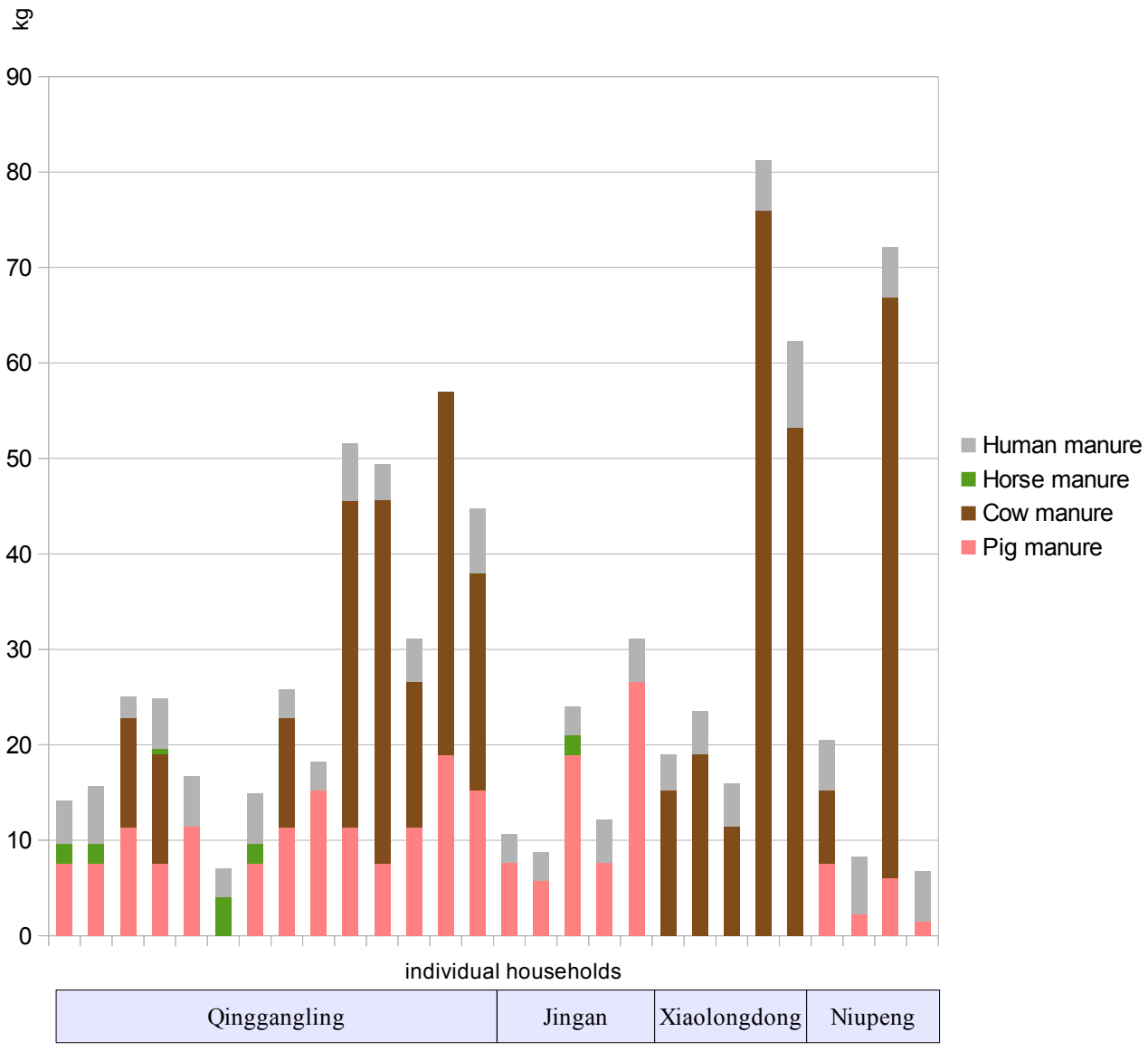
- cows and horses are often brought away from the farm for grazing. Collecting the manure to bring back to the farm as stock for the digester is not considered worth by the farmers.

In our interviews, it was not asked whether the users mixed water with the manure added to the digester, and in which quantity, or whether the pig pen, when directly connected, was flushed using water. This question of the dilution of the manure ought to be added to further similar surveys.

The following plot is an estimation of the daily manure inputs to the digester, in kg. The values are based on the respondents numbers of animals, their estimated proportion circulated through the digester, and estimated book values for daily manure production per animal.

Estimated daily manure production			
Pig	Cow	Horse	Human
3.8 kg	38 kg	26 kg	1.5 kg

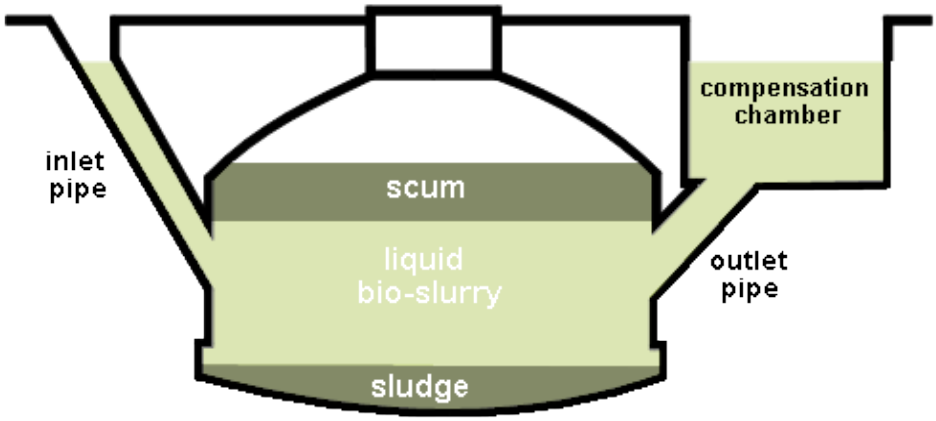
Estimated amounts of daily manure inputs to the digester



5.2 Outputs from the biogas digester

The interviewees were asked how often and how much bio-slurry they usually take out of their digester.

The content of these kind of digesters separates naturally by flotation and sedimentation. Hence, three types of biogas by-products can be distinguished[2]:



- The **scum** floats at the surface of the liquid, and is made of the bulk of fibres and plant residues, such as stalk and straw. The beneficiaries of ID China's biogas programs usually remove the scum once a year in January/March. The top lid is opened, the floating crust is broken and agitated with a wooden pole, and the floating residue is scooped out with a bucket. This fraction has a wet manure-like fibrous form, with more or less liquid depending on extraction and storage. Since biogas is called 沼气 in Chinese, literally "marsh gas", this fraction is referred to as 沼渣, literally "marsh residue".

- The **sludge** are the heavy particles such as sand which settle at the bottom of the tank. It does not need regular emptying. The beneficiaries rarely empty the digester completely.

- In between these two layers the content is mainly liquid. The height of the outlet tube leading to the water compensation chamber is built to match this liquid layer, so that the compensation chamber does usually not suck in the solid particles. The term "**bio-slurry**" usually applies to this fraction. It is a black liquid containing few or no solid particles. In Chinese the liquid fraction is generally referred to as 沼液, literally "marsh liquid".

[2] Bioslurry = brown gold? A review of scientific literature on the co-product of biogas production. Lennart de Groot, Anne Bogdanski, FAO, 2013. p1.

Hence, in the interviews it was necessary to make a distinction between the two methods of emptying of bio-slurry:

- Either the lid is opened to remove a large quantity at once (termed "batch output" in the interview sheet). As it shall be seen below, the interviewees usually batch-empty once a year.

- Or the bio-slurry is taken out without opening the main lid. This was termed "continuous output" in the interviews since it was assumed that bio-slurry would be taken out with a regular frequency, such as every week. In the facts, as indicated by the answers of the interviewees, this type of emptying without opening the main lid can be quite irregular and spaced in time. Indeed, some interviewees answered that they removed bio-slurry only every 3 months, or even twice a year. However, since the main lid was not opened, these answers were still held in the category called "continuous output".

With hindsight, the categories ought to have rather been called "liquid bio-slurry output" and "semi-solid bio-slurry output" rather than "batch output" and "continuous output", and these new terms will be used in the following sections.

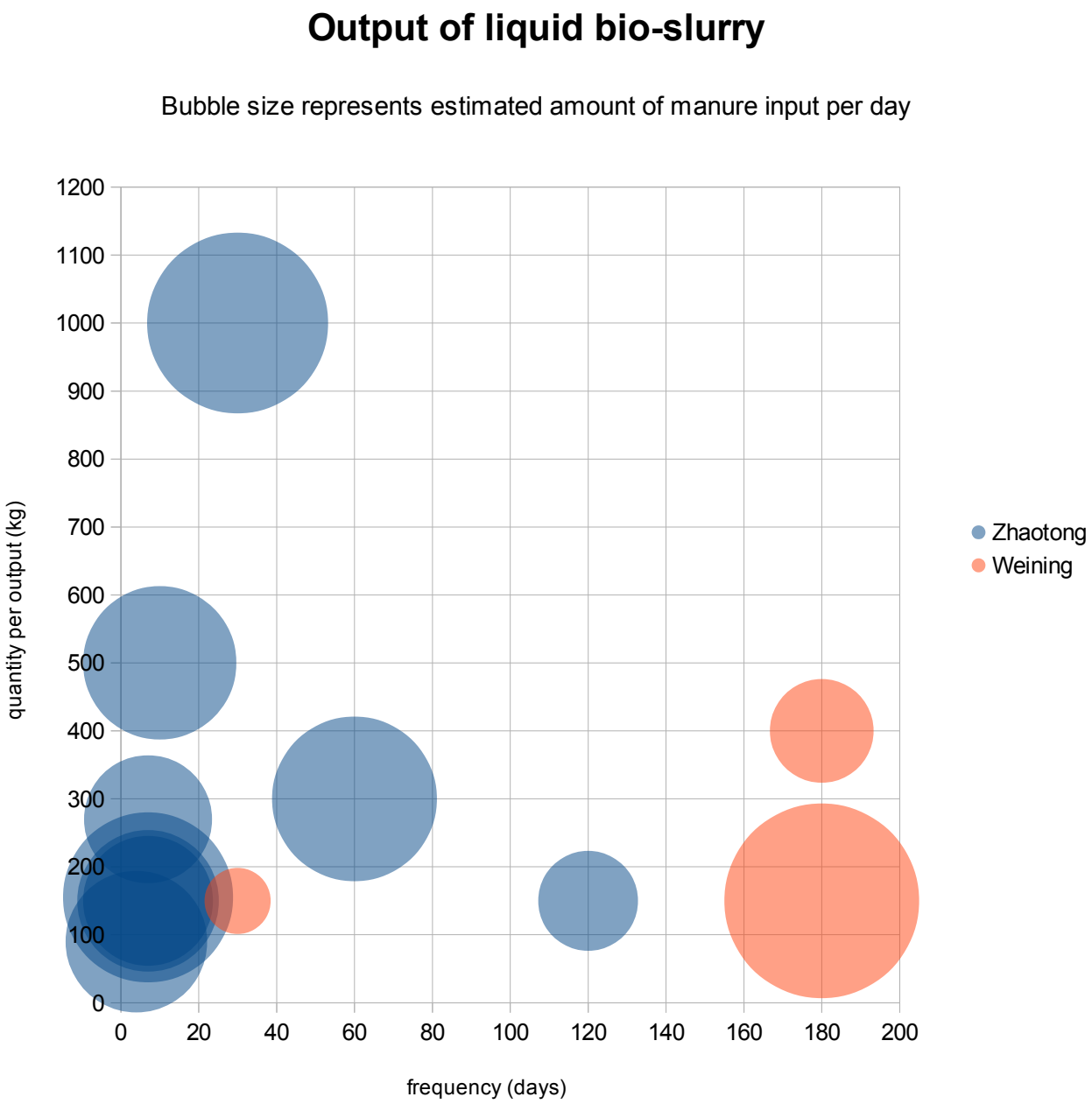
Furthermore, two methods can be used to remove bio-slurry without opening the main lid. Either the liquid is taken directly from the water chamber by plunging a bucket, or the hand pump can be used. The hand pump is a plastic tube plunging directly in the digester and equipped with a hand-driven piston. The material extracted using the hand pump is a liquid bio-slurry rather similar to the liquid found in the water chamber, but with a few more solid particles.

In Zhaotong, where most digesters are equipped with a hand pump, the answers shows that the hand pump is not used. Out of 16 respondents, none reported using the hand pump. Many users even seemed to ignore its proper usage.

In Weining however, the hand pump was widely used, probably because of the different design of the digesters, in which the hand pump feeds directly one of the water chambers. Hence, three of the four respondents answered that they used the hand pump, and one household said they took bio-slurry from the water chamber.

5.2.1 Liquid bio-slurry output

The following plot shows the 12 valid answers arranged by frequency, on the x-axis, and average amount (per individual bio-slurry output), on the y-axis. The bubble size is proportional to the estimated daily manure input in the digester, as already presented in the previous section.



Three households (out of 29) said that they do not remove or use bio-slurry at all during the year, except when they open the digester for seasonal cleaning (see next section). Out of these, two households said that they leave the water chamber simply overflow, and one throws the bio-slurry on some nearby trees.

5.2.2 Semi-solid bio-slurry output

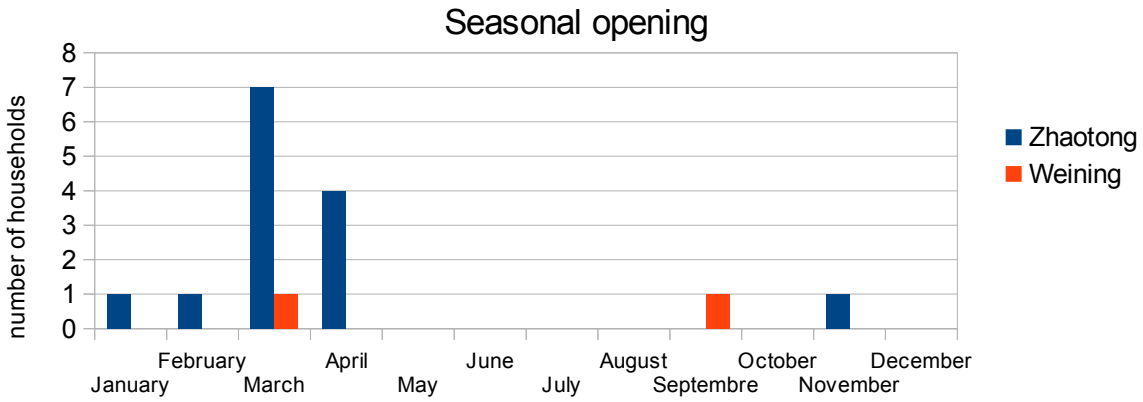
The interviewees were asked if they do open the main lid of their digester to remove bio-slurry. The frequency, date of last emptying, quantity removed were asked, as well as the motivations for emptying. The exact method of emptying were not asked during the discussions.

The interviewees who built their digester in 2011 were not counted in this section, since most of them had not yet proceeded to the first seasonal opening.

Frequency of opening

Out of the 14 interviewees in Zhaotong, 13 said that they do seasonally open and partially empty their digester. 12 had opened their digester in the previous spring, and one in the spring before. Only one respondent said their household had not opened their digester since building in 2010. Almost all respondents said they planned to open the digester once a year.

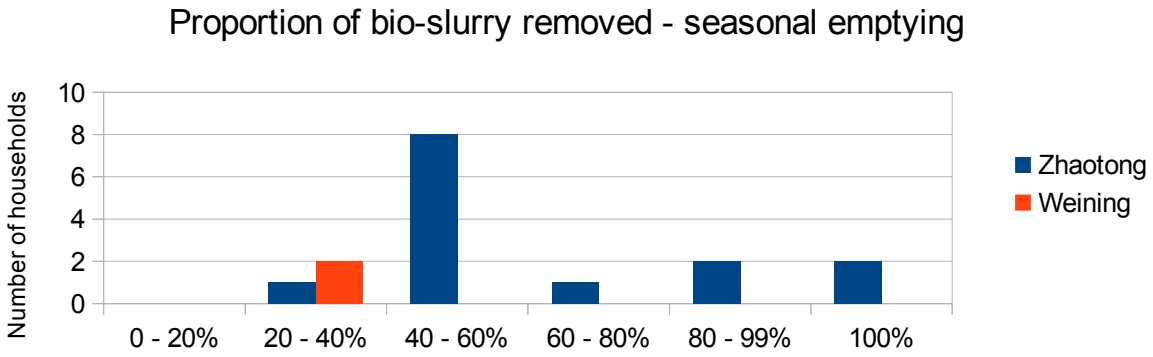
In Weining, two respondents said that they had opened the digester for partial emptying in the previous spring, and two said they did not recently open the digester.



Season

Quantity removed

The interviewees were asked to estimate the quantity of bio-slurry that was removed during the seasonal emptying, compared to the total volume of material in the digester. The total content of a digester is around 8000 litres.



Motivation for emptying

9 respondents said that the need for bio-slurry was their main motivation for opening and partially emptying the digester. One respondent also said that the gas production had fallen and that replacing the manure would resume production. One respondent said that he followed the advise of the biogas technician to open for changing the manure every three years.

Refilling

After the digester has been cleaned of the floating scum, the respondents explained that new manure is poured in the main chamber as a new substrate. In general, the manure that would have normally been added to the digester during the opening period is held aside and added at once when the digester is ready for refilling. Animal bedding from the previous year can also be kept for this purpose. When the digester is connected directly to the animal pen, the manure or slurry keeps on flowing to the digester during the opening time. In addition to the new manure, all users said that they also added water.

Summary

Throughout the discussions with the biogas users, as well as through observing the habits on the terrain while moving between the different villages, it became clear that **the practises regarding the opening of the digester and the removing of bio-slurry are very homogeneous in the whole region studied.**

The digester is opened once a year in the spring to match the planting season. In general, about a half of the content is removed, and sometimes more. This estimation might be quite imprecise, not only because of the difficulty of evaluating the volumes, but because our question could have been misunderstood by some respondents as being the proportion of the scum that was removed. In particular, it is possible that the respondents who answered 100% meant that all the scum was removed. In practise, digesters are rarely totally emptied unless for dredging the sludge. It is unclear how often, if at all, the sludge is cleaned from the digesters.

We noticed during our work on the terrain that the digesters can stay open for a quite extended time during the spring, from about 2 weeks up to 2 months.

The exact quantities and composition of the refilling material was not asked or recorded. The exact length of time during which the digester stays open before being refilled with manure and re-sealed was not asked either. The latest version of the survey was adapted to include these questions.

Despite the answers given, the individual motivations for batch-emptying once a year do remain somewhat unclear. The relative weight of several factors remain to explain: habit, word of mouth or imitation of the neighbour; advise or training given by the technician; annual cleaning of the scum to prevent the clogging of the digester; or interest for the agricultural properties of bio-slurry.

For information, a couple of experiments done by ID China in 2012 seems to support the thesis that the annual cleaning if the digester is beneficial to the gas production.

However, during the time that the digester is opened, anaerobic fermentation is likely to carry on and release methane to the atmosphere. In the context of a carbon project, **the opening duration could be better surveyed** to quantify the potential release of methane, which could partially offset the environmental benefits of the biogas digester and the carbon efficiency of the project.

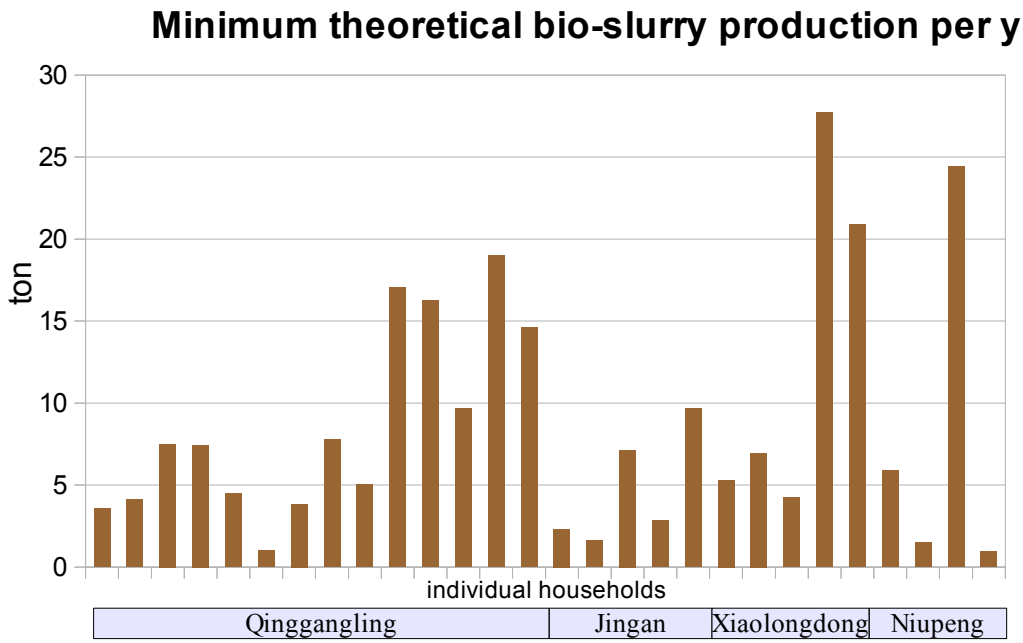
5.3 Relation of inputs to outputs

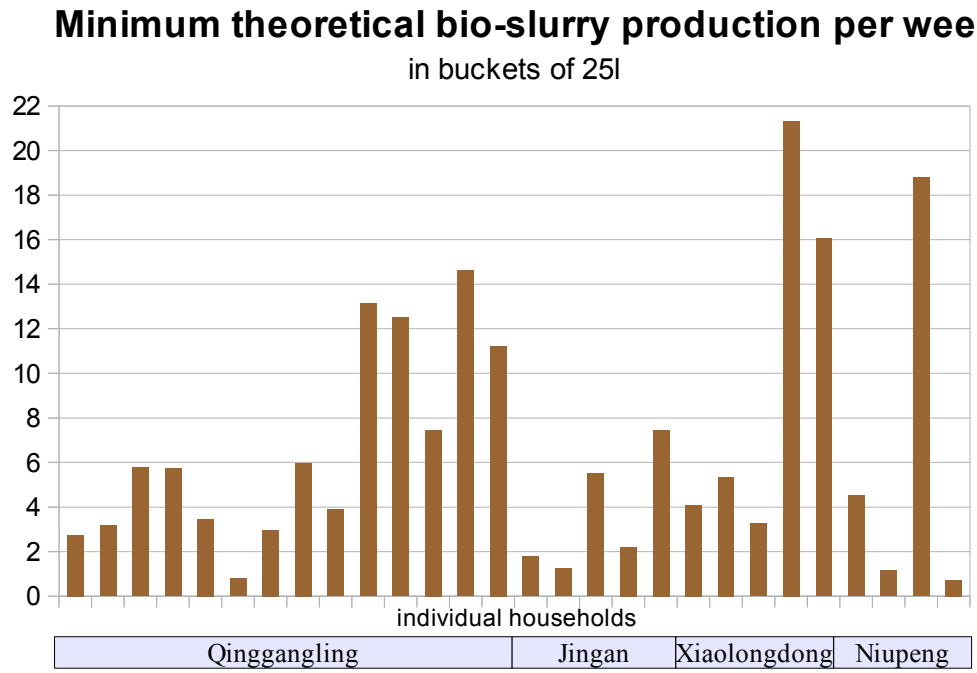
In principle, whatever volume enters the digester through the input must be taken out through the outlet to keep the level of substrate constant in the digester. This basic rule is always insisted upon during ID China biogas trainings.

In practise, the level in the digester can be allowed to fluctuate somewhat. In particular, the digester can be re-sealed in the spring with the liquid at its minimum height, so that a little more can be stored. The amount of this fluctuation cannot however exceed 1.5m^3.

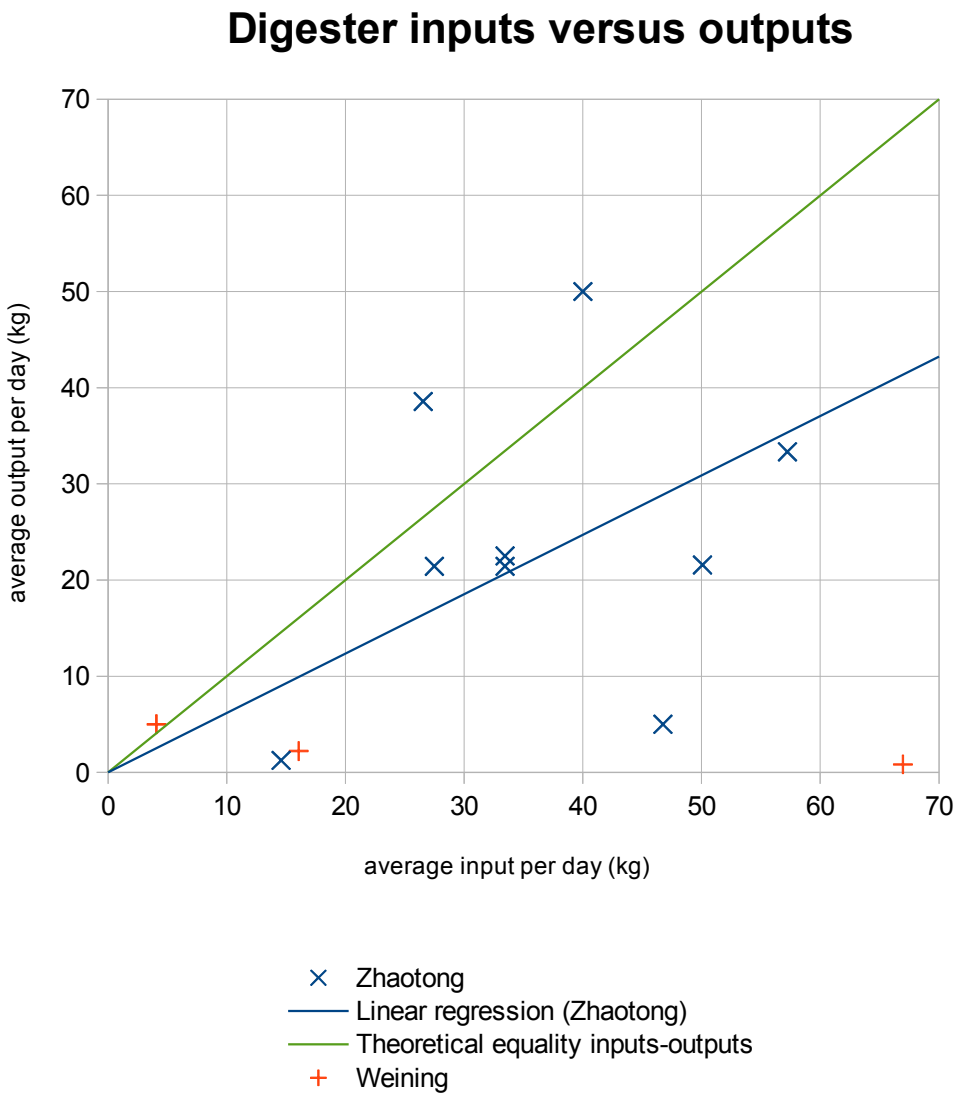
In theory, a fraction of the initial substrate is lost though transformation in methane and carbon dioxide. However, not more than 25% of the dry matter (DM) is transformed in gas, which accounts to a maximum reduction of 1.5% of the volume of slurry during the digestion.

The amount of bio-slurry that is theoretically produced per household can therefore be calculated. In the following charts we assumed a fluctuation of 1.5m^3 along the year. These results do not take into account the quantity of water that is possibly added by the households together with the manure, as this quantity is unknown.





12 respondents gave complete answers for both their manure inputs (in the form of their number of animals and percentage put in the digester) and their manure output (frequency and quantity). These results can be plotted on an input versus output graph, where in theory they should be aligned along the diagonal. In the following graph, the further a point from the diagonal, the less consistent the data for this particular household. When the data point is below the diagonal, the difference (measured vertically) gives the theoretical amount of leaked bio-slurry, in other words the wasted liquid which is allowed to flow out of the digester unchecked. However, it is just as likely that one or several of the four figures collected (number of animals, proportion of manure put in the digester, frequency or amount of removed bio-slurry) must present important errors, which can be due either to erroneous figures given by the interviewee, bad communication between the interviewers and the interviewee, mistaken interpretation by the interviewers, or translation issues.


Digester inputs versus outputs
average output per day (kg)
average input per day (kg)
0
10
20
30
40
50
60
70
Zhaotong
Linear regression (Zhaotong)
Theoretical equality inputs-outputs
Weining

6 BIOGAS DIGESTER - MEASUREMENTS

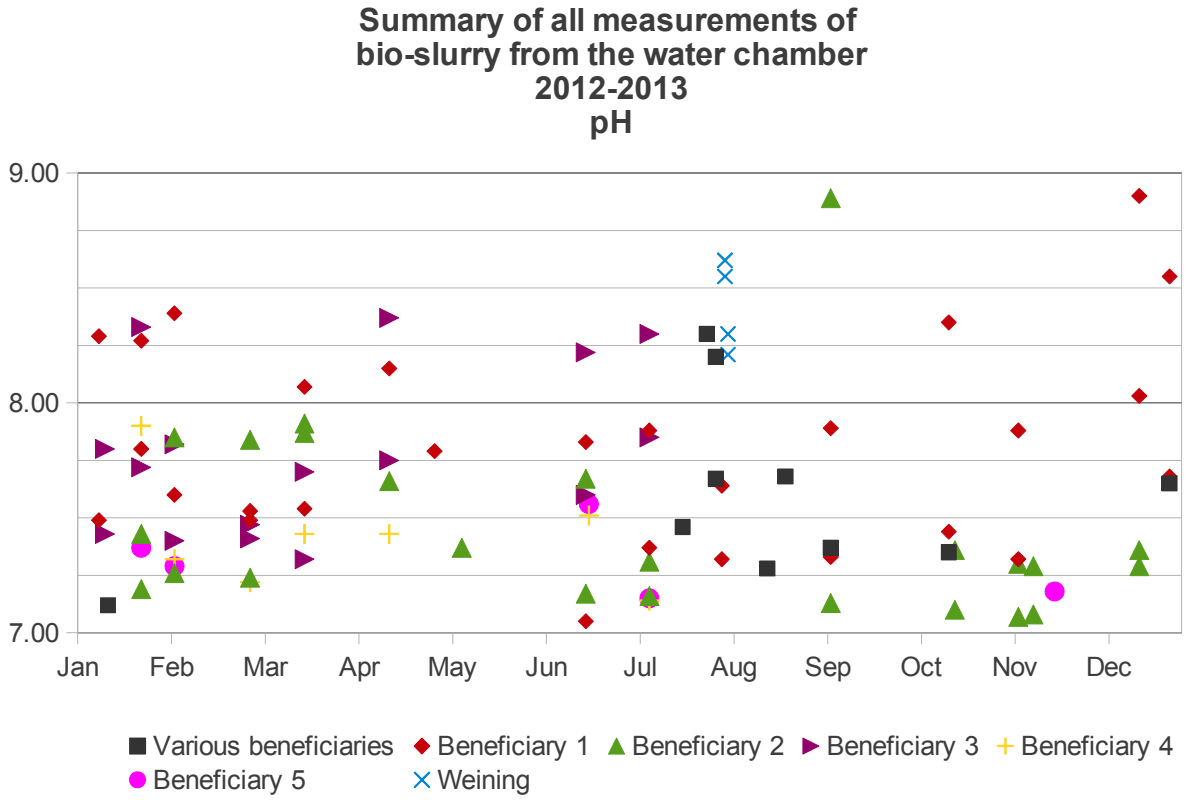
6.1 METHODOLOGY

The interviews with the farmers were used as an occasion to also take some routine measurements on the biogas digesters.

The measurements were taken on a sample of bio-slurry scooped out of the water chamber, using a Hanna HI98130, a pocket held meter measuring pH, EC (Electrical Conductivity) and temperature. EC was taken as a side-purpose only, since it is not well knows what relation the indicator has with the function of the digester or the effective properties of the bio-slurry.

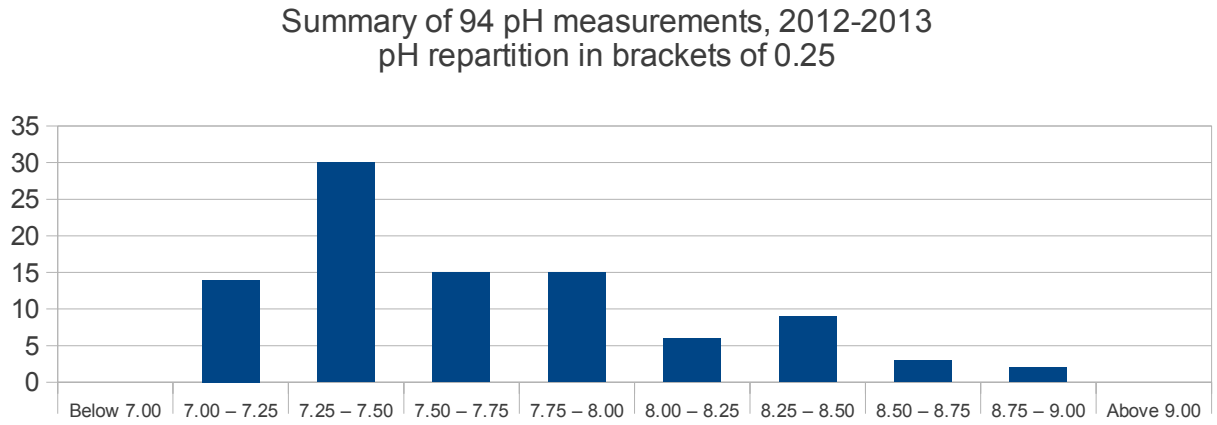
Other measurements done while on the field, although not part of the interviews described in this document, are also aggregated in this section.

6.2 pH

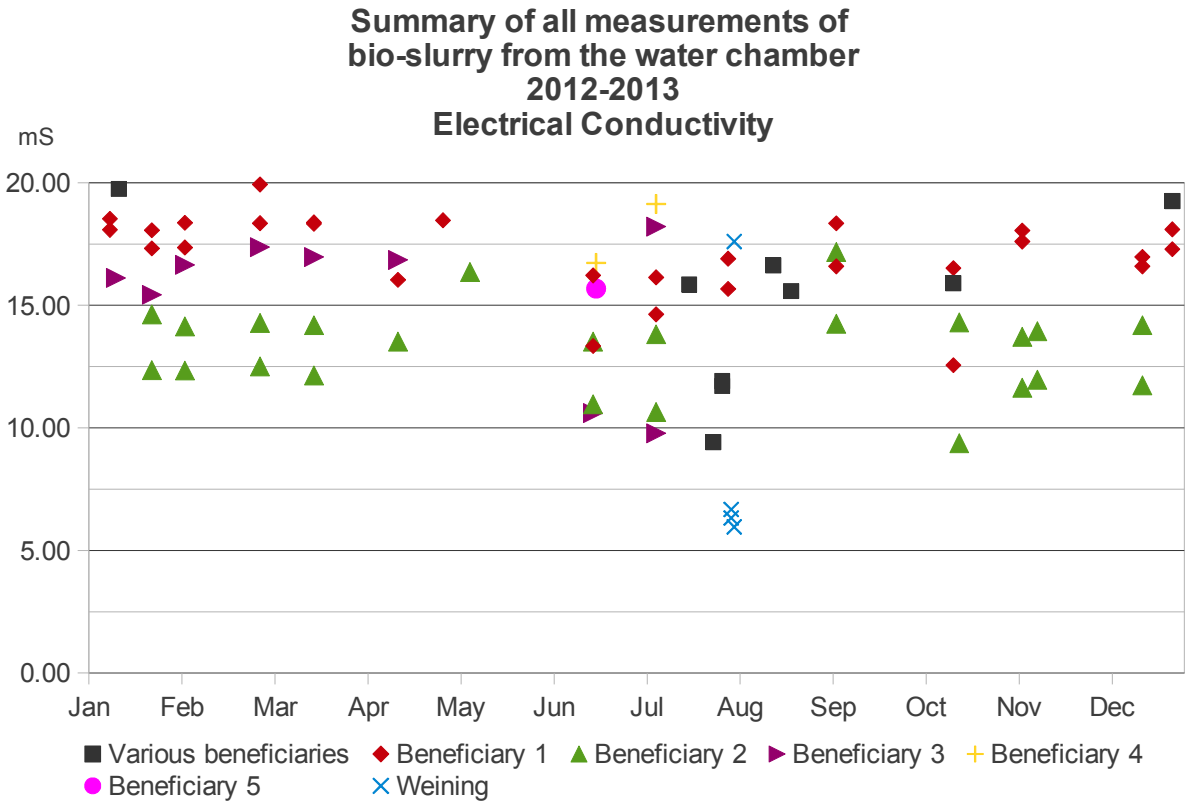


No clear seasonal or regional pattern appears in the **pH** measurements. It is likely that individual management differences amongst households (loading rate and frequency, ...) largely exceed possible global trends in seasonal management or the effect of seasonal temperature variations. **The median pH is 7.52**

The repartition by pH value is shown below.

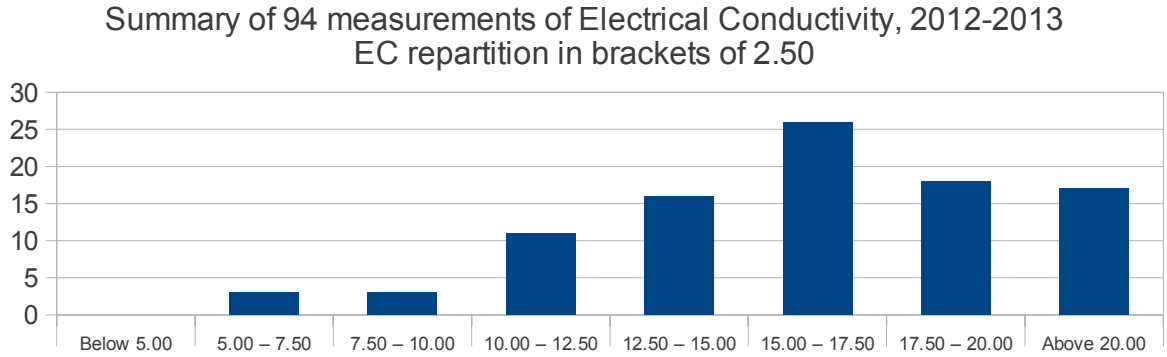


6.3 EC

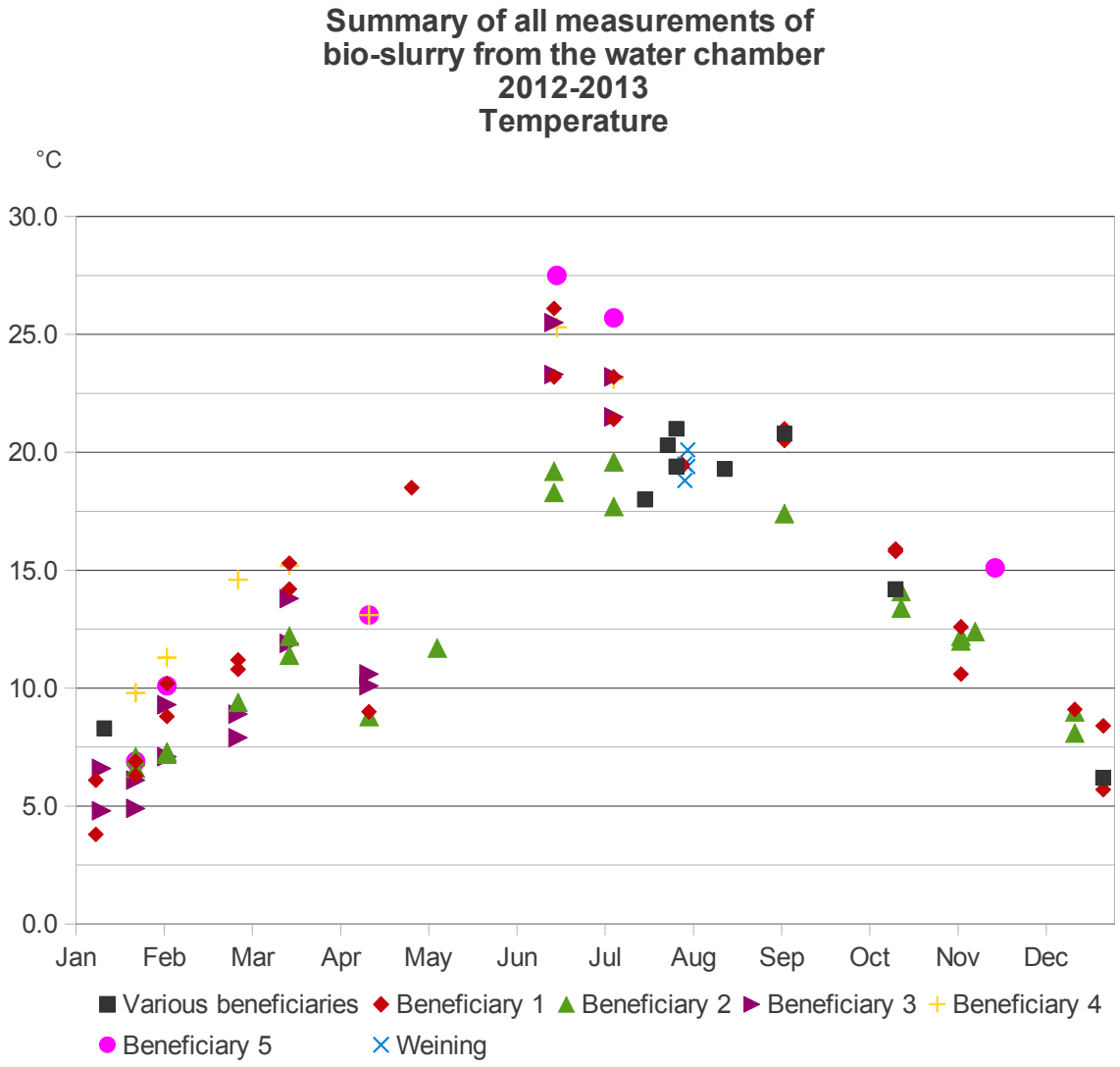


Several values were higher than the measuring range of the device (20 mS).

The values for Electrical Conductivity do not show any seasonal or regional trends either. It shall be noted however that three of the values for Weining are far below normal levels in Zhaotong, which is certainly a consequence of the different design of the Weining digesters. **The median EC is 16.04 mS**.

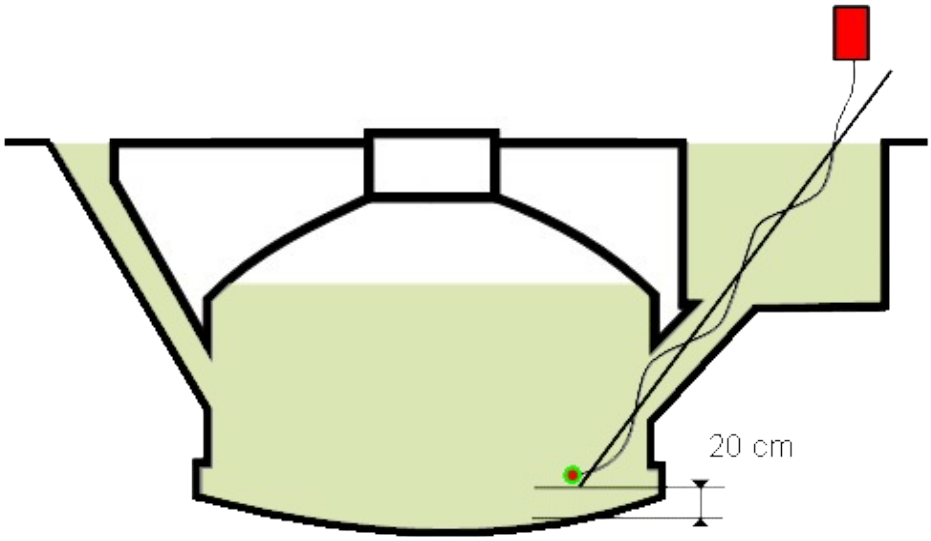


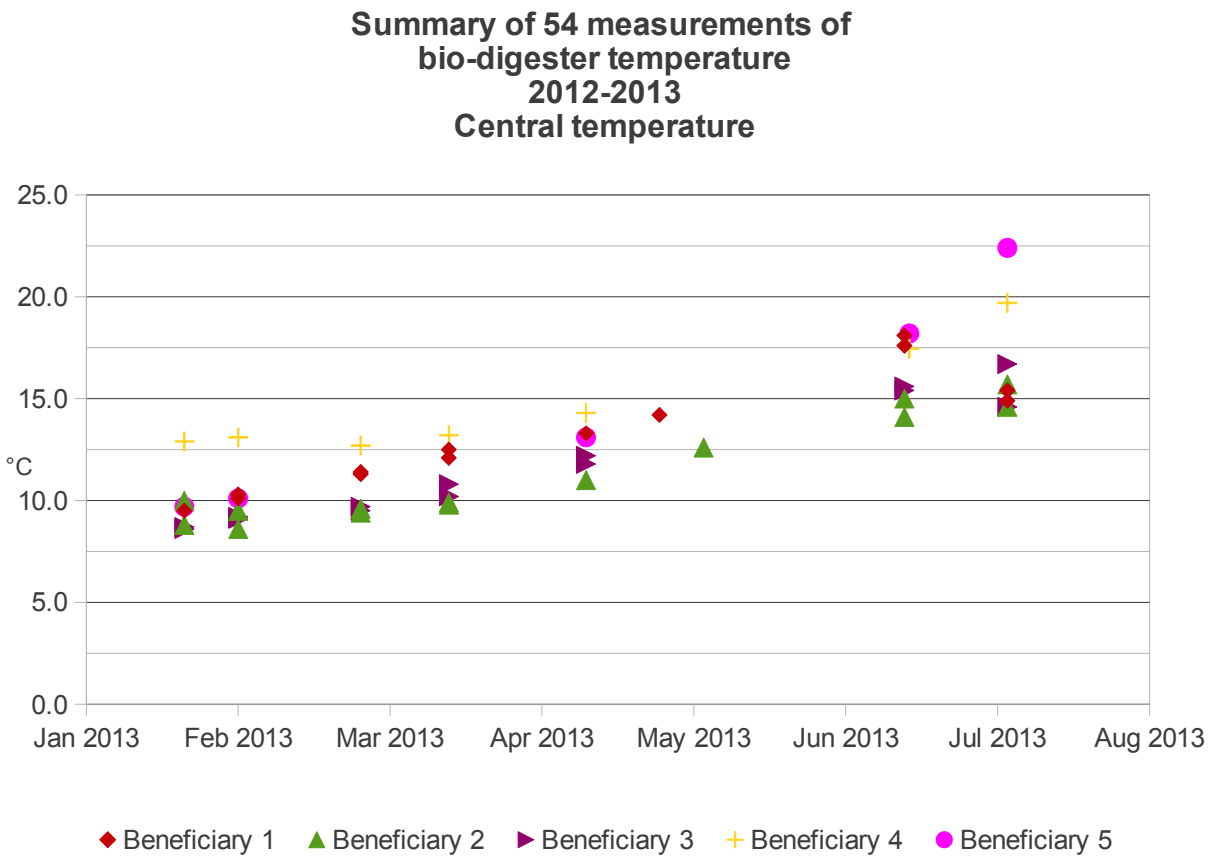
6.4 TEMPERATURE



The variations in **temperature** are very seasonal. No clear geographical difference appears between different townships.

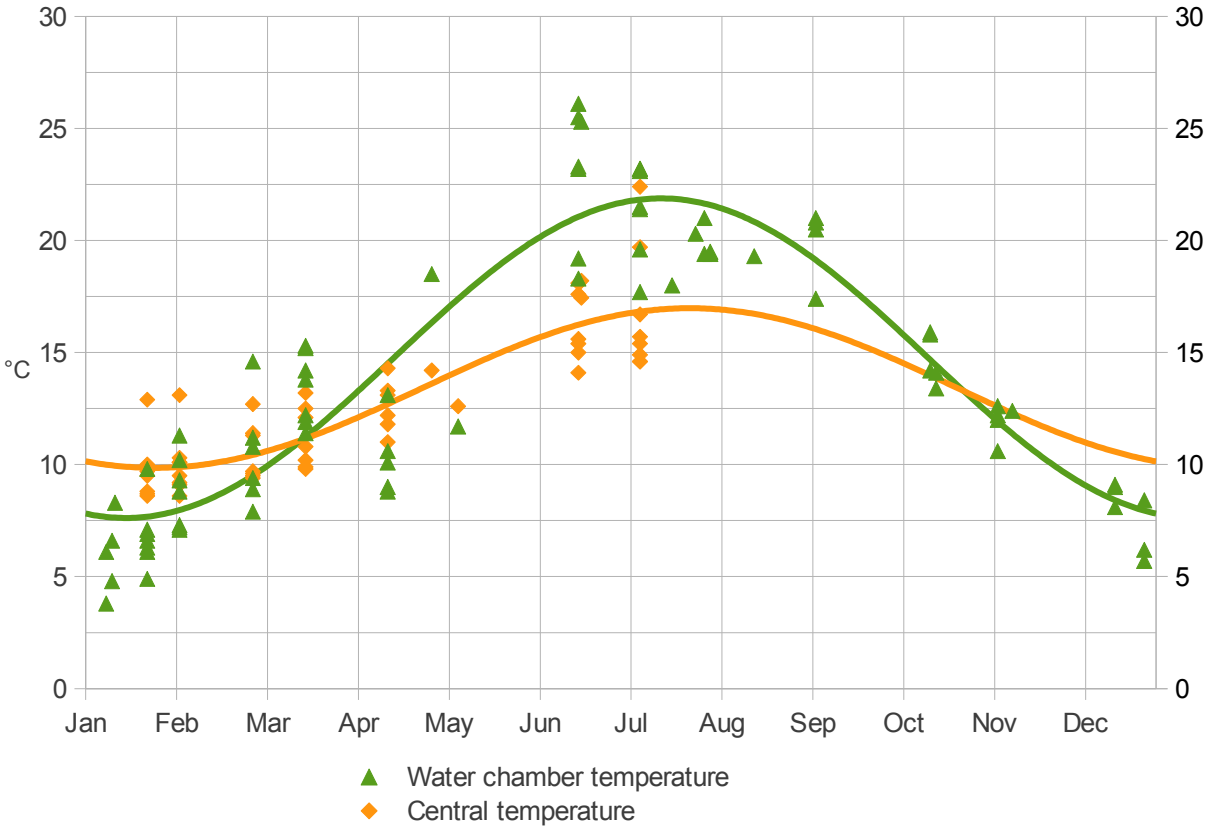
In addition to the temperature of the water chamber, a series of temperature measurements were taken with a Hanna Checkdip-temp, a specific probe that was inserted through the outlet tube. The protocol for these highly precise temperature measurements (± 0.2°C) involved holding the probe 20cm above the floor of the digester (see following illustration).





Finally, temperatures from the water chamber and the middle of the digester can be compared. The following graph includes all temperature measurements as well as sinusoidal regressions. For the central temperature, data was available on half a year only. Note the smaller amplitude of the central temperature curve as well as the slight phase shift: the variation in temperature of the centre of the digester is lower, and is also slightly delayed, reflecting the higher thermal capacity and the buffering of the surrounding soil.

Summary of 90 temperature measurements of bio-slurry from the water chamber and 54 measurements of central temperatures of the digesters 2012-2013



7 BIOMASS PATHWAYS - MANURE HEAPS

All farmers met in the course of these interviews maintained some sort of manure heap on which animal bedding, crop residues, raw manure, ashes etc are piled up. The material on these heaps are eventually brought back to the fields.

Understanding the composition and the life cycle of those heaps is important for a rural biogas project. Indeed, the manure pile, where the decomposition of the biomass proceeds aerobically, can be considered a direct competitor of the biogas digester, where the biomass is decomposed anaerobically and the energy recovered in the form of biogas.

This is not to say that composting and digesting are fundamentally antagonistic. In pure energy terms of course, every kilogram of manure that is piled on the heap is a kilogram that could have been used for gas generation instead. However, in agricultural terms, compost and bio-slurry, the end-products of aerobic and anaerobic decomposition respectively, serve different uses and purposes on the field. Furthermore, loading/unloading the manure in the digester represent an increase in work compared to a manure heap, especially because the high water content of the residue makes its transport more difficult. Finally, the amount of available biomass can exceed the loading capacity of the digester, so that excess manure still has to be piled.

It is therefore up to every family to make a choice between how much manure is used in the digester and how much is piled on the heap. Understanding the respective importance of the aerobic and anaerobic pathways on the farm, and the reasons behind these choices, is a key to understanding the relation of the users with their biogas system. In particular, distinguishing the part of rationality in the choices of using the biomass in the digester or not (limited workforce, transport issues, availability of other cheap fuels, seasonal need for bio-slurry, ..) from the non-rational part (unawareness, lack of training in the use of the digester, sticking to old habits, ...) is essential to guide the policy of a biogas program.

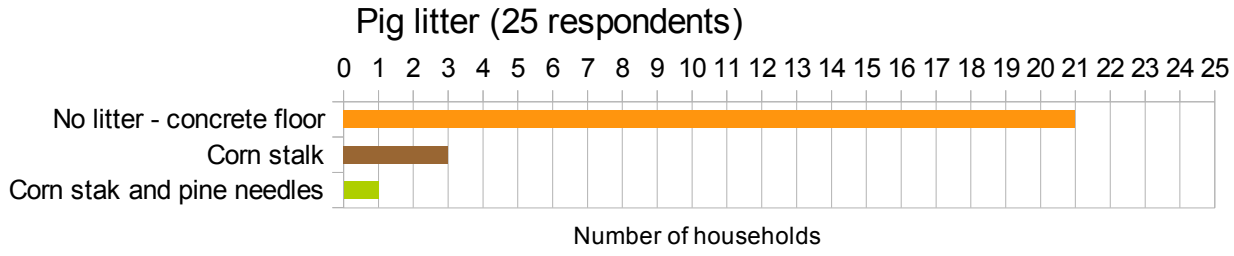
Besides, this survey intended to examine the availability of biomass that could be used for co-composting bio-slurry. Since bio-slurry is produced continuously throughout the year, mixing the outlet with dry biomass on a compost would be a way to buffer the slurry until it is used for the next planting season. The answers below will help to assess whether bio-slurry could be added on the manure/compost heaps.

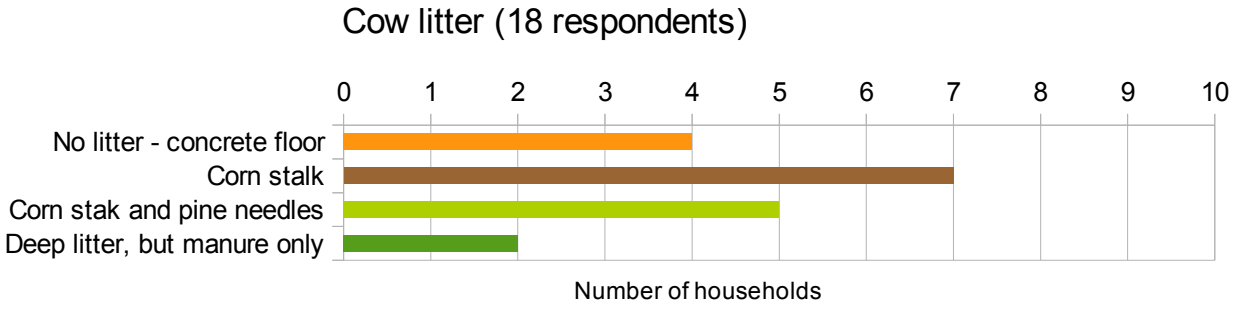
7.1 Animal bedding

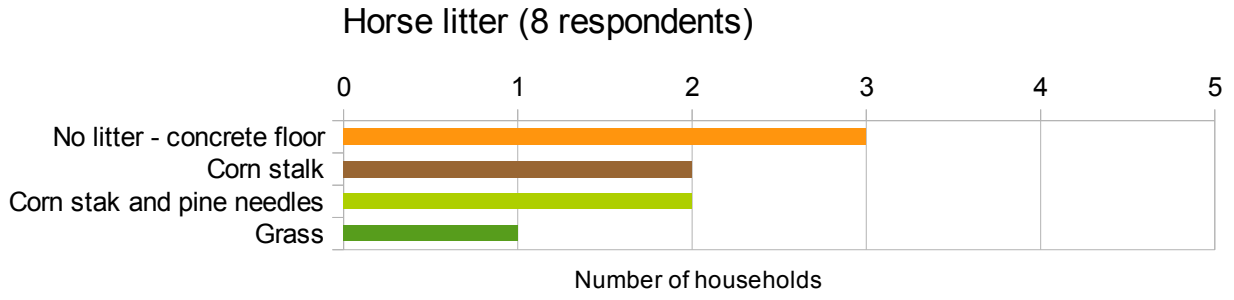
When farmers take the leap to biogas and build their first digester, their bedding system changes accordingly.

In the traditional system in use in the region, pigs are either kept on bedding (crop or forest residue is added progressively throughout the year in the animal pen, until the whole pen is emptied at once), or on bare floor, in which case the slurry or the manure is evacuated from the animal pen through a hole and flows into a slurry pit.

When farmers switch to a biodigester, litter is not used any more, so that the slurry/manure can flow into (or be transferred to) the digester. However, the answers below show that many respondents still use deep litter systems for the cows and horses, and even sometimes for the pigs (in Weining).



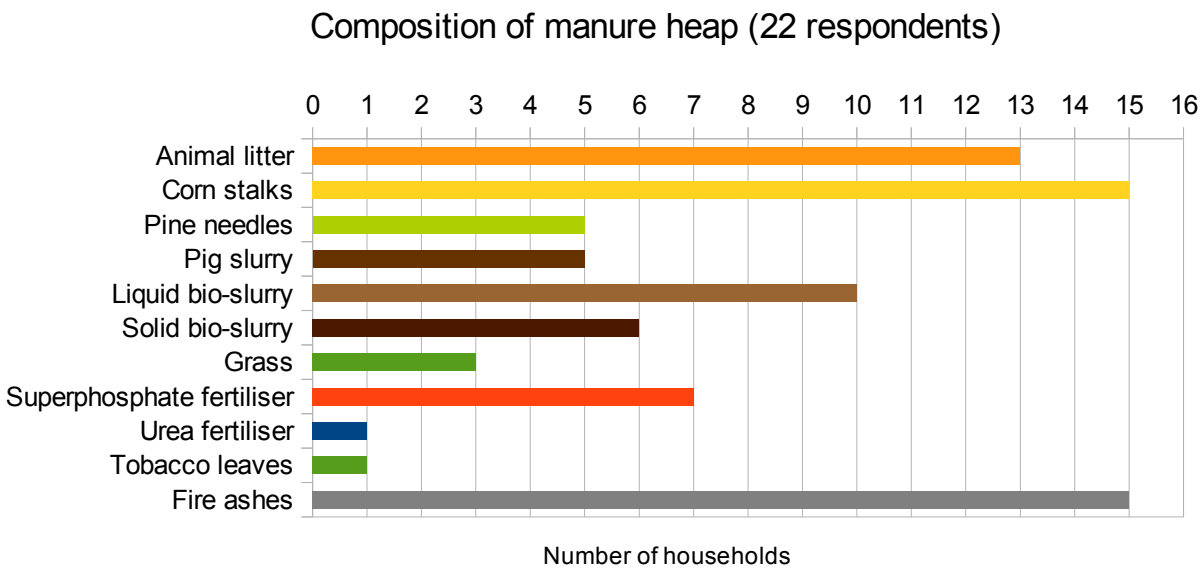




The answers vary strongly from one village to another. In particular, pine needle was only used in Baisha and Xinqiao, which have access to small forests. In Weining, all four respondents still kept some of their pigs on litter, while in Zhaotong on the contrary, none used litter for the pigs. Finally, in Xialongdong, very little litter is used, the cows are therefore kept in their own manure, sometimes as much as knee-deep.

7.2 The manure heap

All respondents kept a manure heap. None used a pit for keeping the manure or compost. The following materials were piled on the manure heap:



For most respondents, the manure heap cycle follows the following pattern:

- Starting from April, a new heap is initiated. During the warmer months, the cows and/or horses are tethered outside the house during the day, either directly on, or next to the manure heap. Manure as well as refuse feed (incl. corn stalk) therefore add to the heap. Ashes from the fire are also thrown on the heap.
- At some time between December and March, the cow/horse pen is emptied: the litter is taken out and piled on the heap. The litter is left at least one month to further decompose (anaerobic composting), which generates quite some heat (temperatures up to 40°C are common). The main reasons for this composting step are to further mature the compost, as well as dry the material for an easier transport.
- The digester is opened in February or March. The scum is scooped out. Some farmers choose to bring the scum separately to the field; some scoop the scum onto the manure heap, so that manure/litter and bio-slurry get mixed together
- At this stage, just before transport to the field, some farmers add superphosphate fertiliser. Several bags of 50kg are usually used per heap.
- In March or April, the heap is finally transported to the field, either on an ox-driven cart, on horse back or with a tractor.

8 AGRICULTURAL USE OF MANURE, BIO-SLURRY AND FERTILISERS

8.1 Farm yard manure (FYM)[3]

The next series of questions investigated how the content of the manure heap was used on the field, on which crops, and how it was exactly applied to the soil.

The answers were extremely consistent amongst the different villages and agriculture systems.

At a large majority, the interviewees answered that they use the FYM on all their crops (corn, potato, tobacco, apple trees, peppers,..). In Jingan, although corn and potato are grown intercropped, the FYM was preferentially applied on the potato.

The FYM is always used for planting solely, and is usually transported to the field in advance of the chosen planting period. For corn and potato, the FYM is transported to the field between February and March, for tobacco a month later.

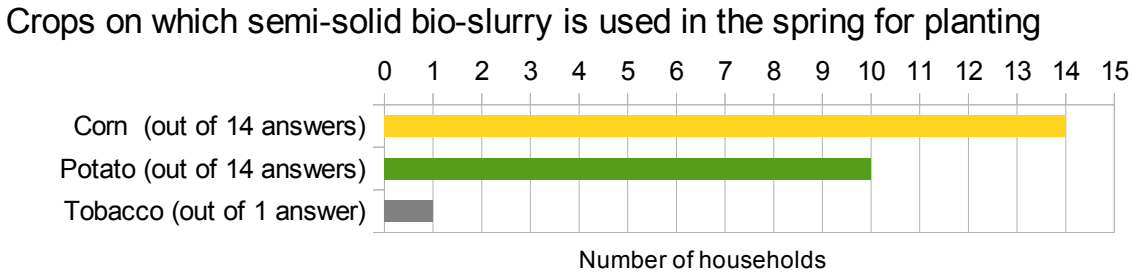
The method of application is very consistent amongst villages and crops. 24 respondents out of 26 said that they applied the FYM in the planting hole, and only 2 said that they applied the FYM to the whole surface of the field before incorporating it in the soil.

The application method in the planting hole is as follows. After the field surface has been tilled and prepared, holes are dug with a hoe. Each hole receives a handful of manure. The seeds are then placed, as well as the mineral fertilisers, but taking care that there is no contact between the two latter. The holes are then closed with the hoe.

[3] Farm Yard Manure: a mixture made principally of animal manure and crop residue or animal bedding

8.2 Use of semi-solid bio-slurry from annual cleaning

When the main lid of the digester is opened for annual or biennial cleaning, the removed material is used as a crop fertiliser and soil conditioner by all interviewees. The bio-slurry may transit for a little time on the household manure heap or be piled on its own, but the material is always used on the field in the same year.

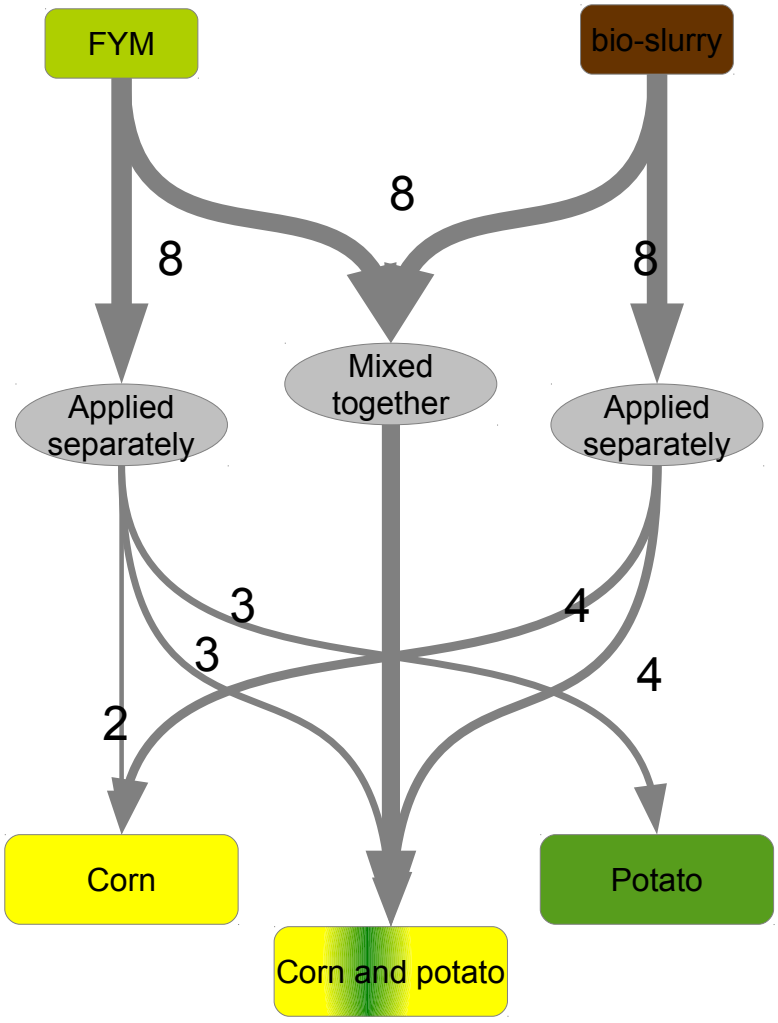


8 respondents out of 16 said that they mixed the bio-slurry with the FYM before applying to the field. Out of these, 6 mixed the materials at the farm on the manure heap, and 2 after transport to the field. See previous section for how the FYM/bio-slurry mixture is applied to the soil.

The other 8 respondents are applying the bio-slurry and the FYM separately. All said that they apply the semi-solid bio-slurry directly in the planting hole, as is done with FYM (see previous section). However, compared to FYM, half of the respondents growing both corn and potato applied bio-slurry on corn only, while not on potato (4 out of 8), while the other half applied on both corn and potato, and none applied on potato only.

No respondent answered that the bio-slurry was unused or thrown away.

The following chart shows the different pathways for FYM and bio-slurry, out of 16 complete valid answers (tobacco has been omitted).

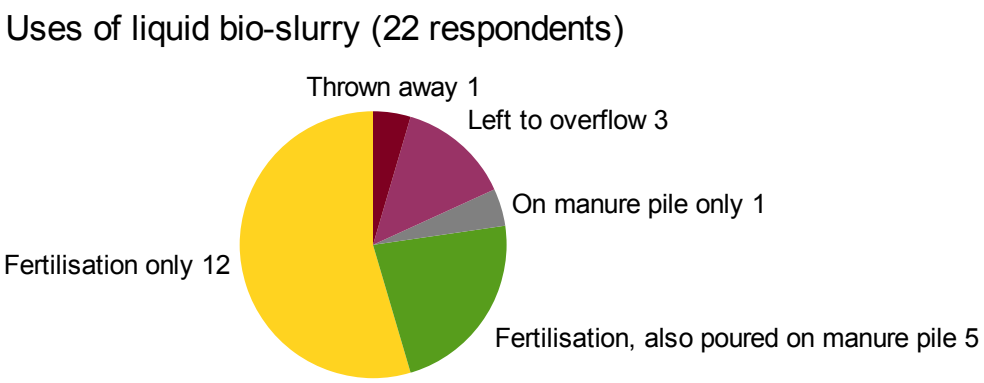


8.3 Use of liquid bio-slurry (from water chamber)

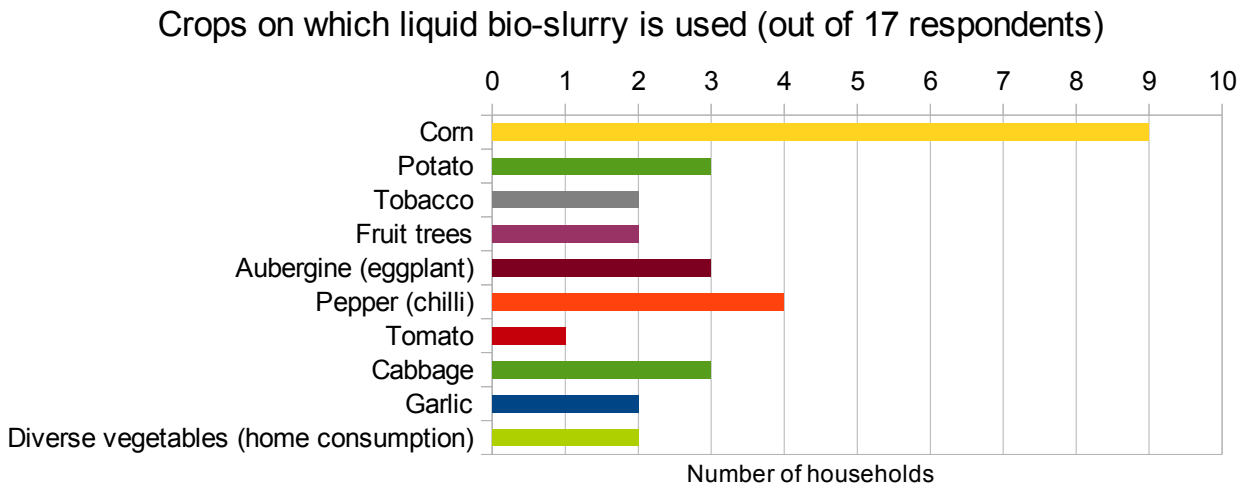
18 respondents out of 22 said that they removed liquid bio-slurry during the year. Unlike the semi-solid bio-slurry, used only once a year, **the uses of this liquid bio-slurry are very diverse**, depending on the individual households. Many different answers were given, which are summarised in the following sections.

8.3.1 Uses

When the bio-slurry was not thrown away, its only use amongst the interviewees was for fertilisation. None of the respondents did use bio-slurry as a pesticide, or in spraying, neither for seed soaking or for animal feeding. It is also common for liquid bio-slurry to be poured on the manure pile, especially out of growing season.

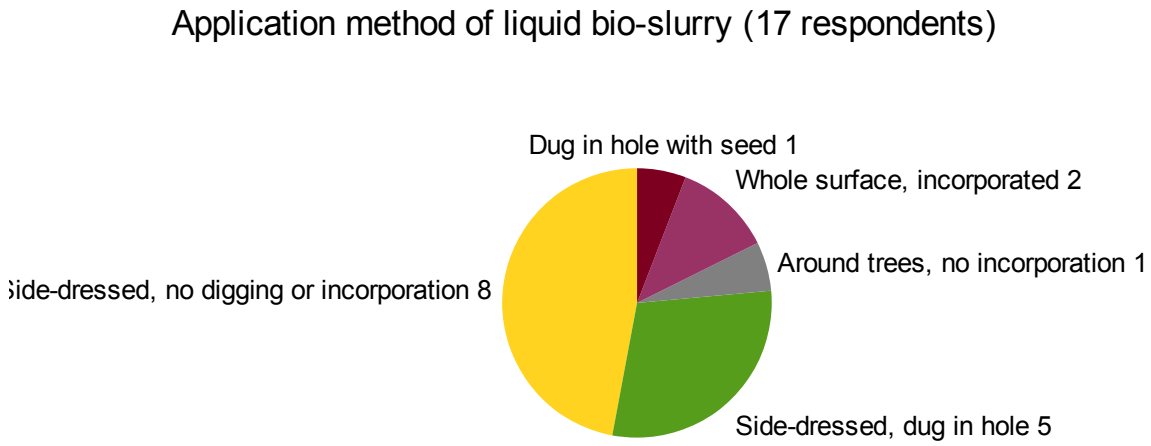


8.3.2 Crops



Aubergine, pepper, tomato, cabbage, garlic and other vegetables (last 6 categories above) are all vegetables grown in small quantities around the house for personal consumption. Therefore, these 6 answers correspond to the use of bio-slurry on the house vegetable plot. 8 respondents out of 17 gave at least an answer in the "vegetable plot" category, in other words **about half the interviewees use liquid bio-slurry from the water chamber on their vegetable plot**. Usually, a family's vegetable plot is located directly next to the house. More generally, because of transport difficulties, the liquid bio-slurry is used in proximity of the house, on the nearest available fields.

8.3.3 Application method



As can be seen in the pie chart above, the most common method of providing the liquid bio-slurry to the crops is through side-dressing. In other words, the liquid is poured on the soil around the base of the plants, rather than applied indiscriminately on the whole surface of the field, such as if preparing the plot for planting. This is an expected observation, since the crop is already established and growing when the liquid bio-slurry is used throughout the year, by opposition to the use of semi-solid bio-slurry for planting a new crop.

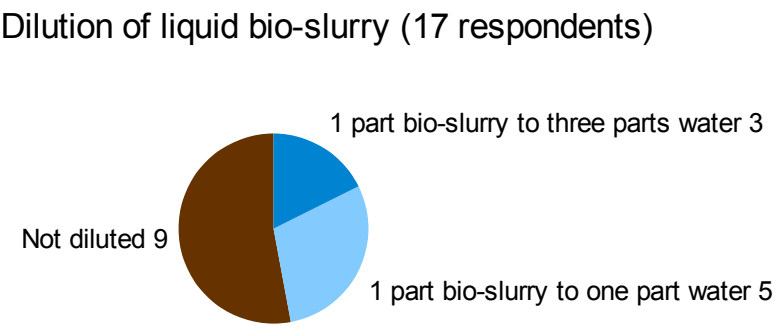
Two options of side-dressing are found. In the first one (8 respondents), the bio-slurry is not incorporated, but is simply left to infiltrate in the soil. In the second option, a hole is first dug close to the crop to fertilise, to retain the bio-slurry and direct the infiltration. Once the bio-slurry has been poured, or after it has infiltrated, the hole is usually filled back with soil.

Two respondents said that they distribute the bio-slurry on the whole surface of the field. However, because of the difficulty in the interviews to properly explain and picture the method without a practical demonstration on the field, these explanations could effectively also point at a side-dressing method, especially if the crop density is very high.

Obviously, there are a few months during which no crop can be grown in the climate of northern Yunnan. Some garden vegetables such as cabbage can be grown until late Autumn, however between December and March approximately, the bio-slurry cannot be used for the fertilisation of any crop. It is possible that some farmers continue to fertilise the soil even once the crop is gone, but this question has not been precisely discussed or investigated.

8.3.4 Dilution rate

It is common to dilute the liquid bio-slurry with water before application, to avoid risks of burning the crop with too concentrated amounts of minerals. 8 respondents said that they diluted the bio-slurry with water:



8.4 Mineral fertilisers and global fertility balance

8.4.1 Methodology of survey and calculation

The most difficult challenge of the interviews has undoubtedly been to evaluate the amount of fertilisers used by the farmers on their different crops.

Obtaining such figures involves patient enquiry into the memory of the farmers. To make sure which exact type of fertiliser had been used, we asked the respondents to show us the empty bags. To verify carefully the type of fertilisers, every figure had to be double-checked in a discussion with the farmer. Quantities were given by memory, in general in kg per mu. In general, the interviewees could remember the figures straightforwardly, so there is a fair chance that the answers are in general reliable although rarely precise.

Given the variety of types of fertilisers used on the terrain, all combinations cannot be presented here. Instead, the following illustrations show the equivalent total input of the three basic plant nutrients nitrogen (N), phosphorus (in equivalent P_2O_5) and potassium (in equivalent K_2O). The methodology to calculate these total inputs is simple:

- for mineral fertilisers: the quantities are multiplied by the respective proportions of the nutrients in the given fertilisers (information given on the bags, also available in standard tables for the most common fertilisers). For urea, the quantity of nitrogen has been slashed down by 30% to account for ammonia volatilisation which is common with this fertiliser. Otherwise, no availability factor has been applied for all other fertilisers.

- for FYM: the quantities have been inferred according to the number of animals given by the respondents, so as to obtain yearly manure productions, multiplied by the proportion of manure **not put** in the digester, and multiplied by standard proportions of N,P,K in the manure. The result is further multiplied by an availability factor.

- for bio-slurry: the amounts of bio-slurry taken out of the digester, as answered by the respondents, have been used, then multiplied by standard proportions of N,P,K in the bio-slurry, and by an availability factor. The NPK values are based on an average of laboratory analysis done by ID China on 8 samples of bio-slurry in 2012. Both the liquid bio-slurry from the water chamber and the semi-solid bio-slurry from the annual cleaning have been taken into account, and slightly different NPK values apply to both, according to the lab analysis.

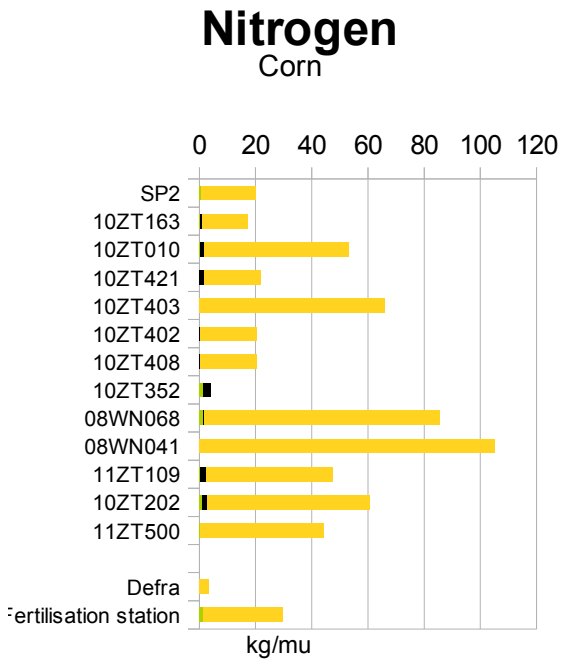
- the application rates of FYM and bio-slurry per unit of surface have been deducted from the answers of the interviewees about which crops the FYM/bio-slurry was used on; the total quantities were divided by the field surface of the specific crops

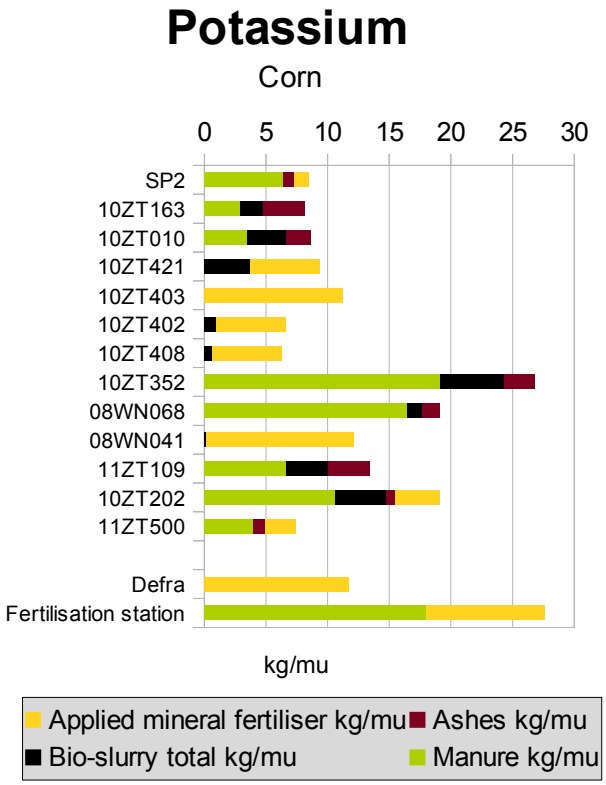
- for ashes: when the respondent answered that the ashes were thrown on the manure pile, the nutrient quantity and total amount were estimated using ID China average household energy data, and an estimated proportion of NPK in wood or coal ashes. The rate per mu was calculated proportionally to the FYM application rate.

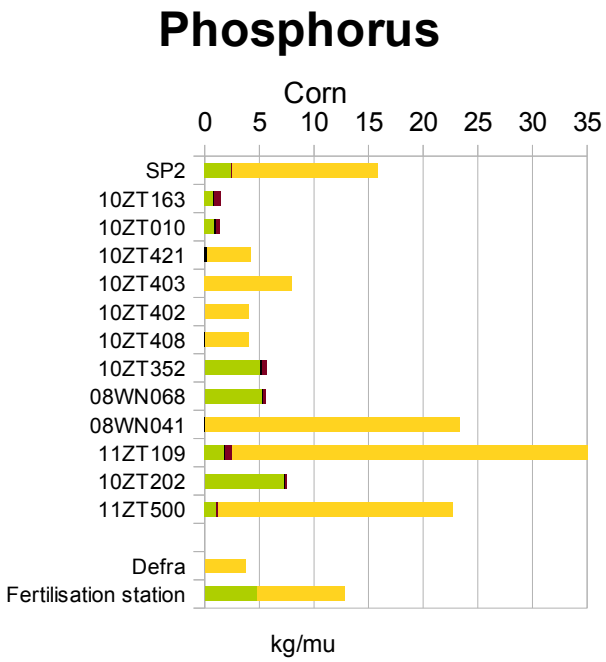
8.4.2 Corn

Urea and superphosphate are the common fertilisers, used by almost every farmer. Potash is used less frequently. About a third of the farmers also use specific compound formulations.

About a half of all the fertilisers are provided at planting time and directly dug in the planting hole. The other half is top-dressed, either at once, or in two steps, between May and July.







In these graphs, each interviewee is represented by a bar. The first bar, termed “SP2”, is the average value given by François Sorba in his report “Agrarian Diagnosis in ShenJiaGou” (2010).

The “Defra” bar represents the quantities of fertilisers as recommended by the Department for Environment, Food and Rural Affairs (Defra) in the United Kingdom, as published in “RB209 – Fertiliser manual”, while the “Fertilisation station” bar shows the quantities recommended by the governmental fertilisation station of Zhaotong prefecture.

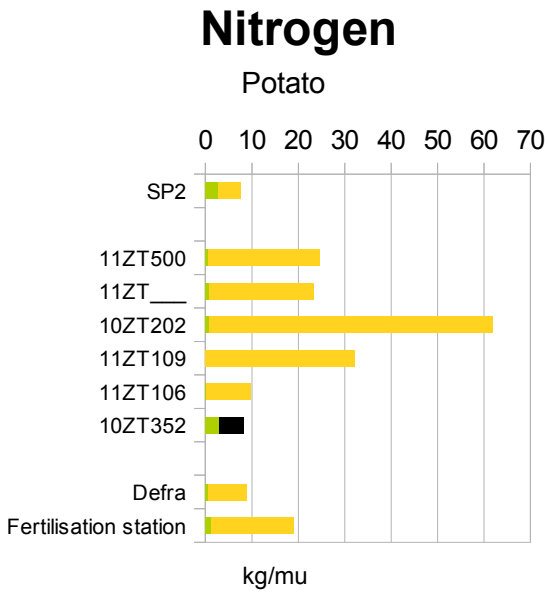
All quantities are represented as if the crop was grown alone, although it is actually intercropped. Phosphorus is reported in kg of equivalent P_2O_5 and potassium in equivalent K_2O.

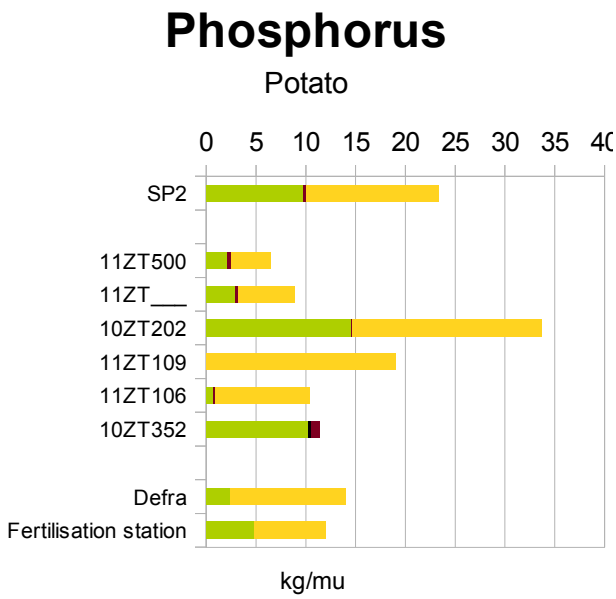
8.4.3 Potato

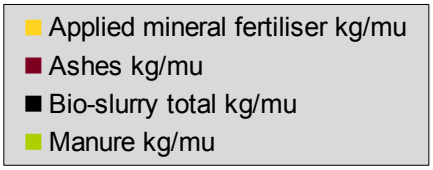
As with corn, urea and superphosphate are the common fertilisers, used by almost every farmer. Potash is used by about half the respondents. Compound formulations are more rarely used for potato.

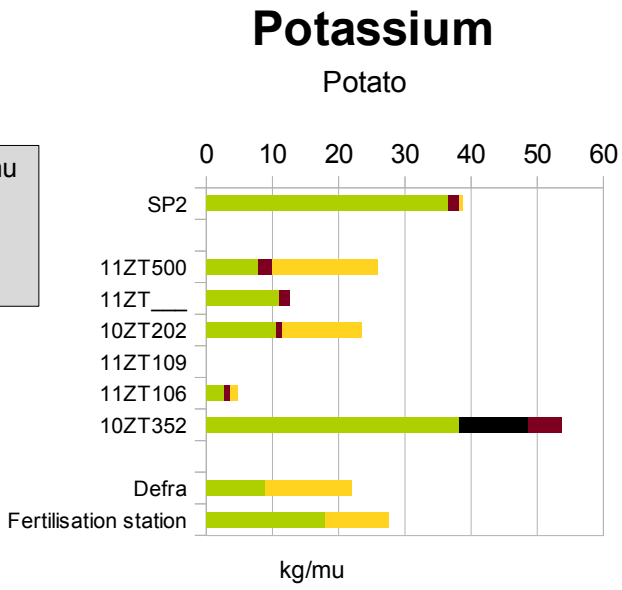
Most of the interviewees did only fertilise at planting time, without later top-dressing. The 2 respondents who top-dressed on the potatoes did so with urea in May or June.

Altogether, the general impression is that the farmers are more relaxed on the potato fertilisation compared to the corn. Corn is given more attention regarding fertiliser type, timing and quantity.









8.4.4 Bio-slurry used solely for the fertilisation of a vegetable plot

It could be imagined to use all of the liquid bio-slurry produced during the year to fertilise a vegetable plot close to the house, which would suppress the need for transport. What would the size of this plot need to be to optimally fit the amount of nutrients provided by the bio-slurry?

The following theoretical simulation supposes that three rotations of vegetables such as cabbage are planted on the same plot around the year. This would require 38kg N, 19 kg P_2O_5 and 38kg K_2O per mu. **At planting time, 0.5 t/mu of manure and 0.5 t/mu of solid bio-slurry** would be applied, like for the rest of the fields. The rest of the plant nutrients would be provided by the regular output of the digester (fertilisation once a week). On a nitrogen basis, **a total of 21 t/mu of liquid bio-slurry** would be needed throughout the season to meet the requirement for the three rotations.

According to the number of animals kept by the household, the ideal size of the vegetable patch would be as follows:

Number of animals	Output of bio-slurry per week (buckets of 25l)	Surface of vegetable plot (mu) 亩	Corresponding to a square of ___ metres side
2 pigs	5	0.2	11
4 pigs	8	0.35	14
2 pigs and 1 cow	16	0.6	20
4 pigs and 1 cow	19	0.75	22
2 cows	23	0.9	24

The simulation, which is based on nitrogen requirements, shows that the requirement in potassium would also be met optimally. However, most of the phosphorus (17kg/mu) would need to be supplemented.

8.4.5 Conclusions – fertilisers

A quick look at the bar graphs above will reveal at least two obvious conclusions.

Firstly, **the bio-slurry is only a minor contribution** to the global fertility balance. **In certain cases, bio-slurry has a noticeable contribution in potassium, up to 20%. However, its contribution in nitrogen and phosphorus is generally insignificant.** This is not to say that bio-slurry is necessarily ineffective. Indeed, the bio-slurry can potentially have beneficial effects on plant health and growth through other substances that it carries, such as micro-elements or biologically active elements (research carried out so throughout the world far has not come to definitive conclusions so far). However, on the base of pure nutrient supply, bio-slurry does not bring significant amounts.

Of course, the amount of nutrient provided by bio-slurry is the product of its content (amounts of nutrients per litre[4]) by its application rate. Hence, by increasing the quantity applied on each square meter, the crop nutrient need could theoretically be met. However, in the scope of a rural biogas program, this argument is pointless, since both the surface of land per family, and the yearly availability of bio-slurry, are fixed. As we have seen above, the median cropped surface per family is 5 mu, while the median yearly bio-slurry production is around 7 ton. Hence, **application rates above 1.4 ton/mu are not realistic**. All application rates illustrated in the bar graphs above are between 0.3 and 1.4 ton/mu.

However, the bio-slurry could potentially be reserved for a restricted surface such as a vegetable plot, while the other fields would receive none. Theoretical calculations shown above predict that **vegetables plots comprised between 0.2 and 0.9 mu (depending on number of animals) could be maintained this way, if phosphorus is supplemented**.

The second conclusion concerns the overall levels of fertilisation. Although important variations exist amongst the respondents, the following comparisons can be highlighted:

- in nitrogen, the respondents apply at least the recommended amount by the fertilisation station, and often more (or a lot more, up to 300%)
- in phosphorus, most apply less than recommended by the fertilisation station, although some apply a lot more
- in potassium, the results are more mixed, some respondents being below and some above the recommendation

Furthermore, as it can be seen, there are very important discrepancies between the theoretical recommendations given by the fertilisation station on one side, and by DEFRA on the other. These differences are particularly important for nitrogen. In general in fertiliser science, it is safer to use recommendations tailored for the local soil and climate. Hence, the UK values might not reflect particular conditions of this region of China, such as high soil infiltration rates, higher

[4] The values that we used are based on the laboratory analysis of our own samples, and these values correspond roughly with most values found in the scientific literature.

summer precipitation, leading to increased leaching of nutrients. However, the important differences in recommendations should be questioned and could be researched further.

In either case, whether taking the conservative values of the fertilisation station, or the lower ones by DEFRA, given the results above, and supposing that the answers given were reasonably corresponding to the reality, **there is a high suspicion that most households do apply more fertilisers than needed**. In many instances, the quantities applied seem several times too high. During our interviews with the farmers, our general impression was that the fertilisers inputs were not made with rigorous or scientific method. The recommendations on the bag were only followed by a few respondents. It may well be that families who have higher income (because of family members sending money from town) will increasingly spend this money on fertilisers, betting that their productivity will keep on increasing in proportion. However, at the current levels of fertilisation, **increasing the fertiliser inputs is not likely to further increase the yields**, and the excessive fertiliser is wasted. Hence, there is in the region a potential for a study or program aiming at a **reasonable use of fertilisers**, which would both benefit the farmer's incomes and address potential environmental pollution.

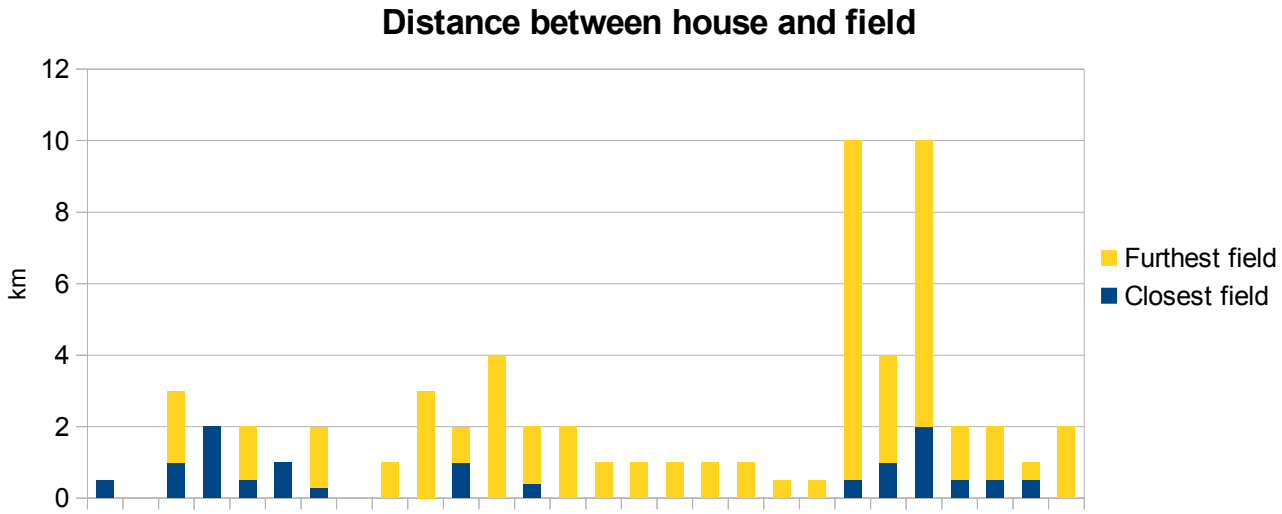
9 TRANSPORT AND WATER

Considering the transport issues is fundamental in understanding the local agriculture. In particular, the choice to use the bio-slurry or to dismiss it may be strongly linked to the difficulties in transporting the liquid or semi-liquid material to the field.

Therefore, the last set of questions focused in details on the available means of transport for FYM and bio-slurry between the farm and the field, as well as on the availability of water, which is both needed for agriculture, for filling the digester and for household consumption.

9.1 Distance between farm and field

Each interviewee was asked how close its nearest field is from the house (excluding the home vegetable plot), and how far the furthest.



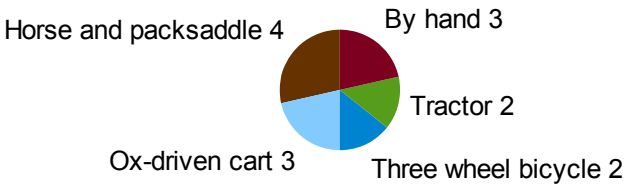
When no "closest field" bar appears (no blue bar), then the answer of the interviewee was that the closest field is just next to the house.

All townships considered, the median closest field distance is **150m** while the median furthest field distance is **2km**.

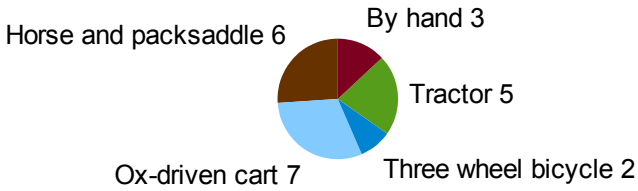
9.2 Transport of FYM and bio-slurry

Different transport methods are used in the region, ranging from direct transport by hand (usually using a shoulder pole) to animal transport (either by ox-driven cart or on horse back, which is equipped with a packsaddle) to mechanical transport by tractor. The answers of the interviewees are presented below.

Transport of bio-slurry (17 respondents)



Transport of FYM (17 respondents)



As it was pointed out by some farmers, the different forms of transport are not strictly exclusive. For example, the manure can be transported to the proximity of the field with the ox cart, but the last portion of the trip may have to be done by hand. Hence, the "by hand" answers above mean that no other mean of transport but hand has been used by these respondents.

The local tractors are generally of the smallest dimension, without cabin neither front bucket, but can tow a cart or small trailer. The tractor can sometimes be hired from a neighbour.

For transporting bio-slurry that is very liquid, at least two different systems are found. Some farmers use a closed metal container, resembling a milk tank, which has a capacity of several hundred litres. Some others line their cart with a plastic sheet, providing that the cart is equipped with boards on all sides. This system is said to work well and to efficiently prevent leaks.

Clear differences can be observed between villages. In particular, in Shenjiagou, a village lacking concrete roads and where many fields are situated on steep hill slopes, no tractors are used, and ox carts are rare. Instead, the transport is done by horse on the slopes. This probably explains why a higher proportion of farmers in Shenjiagou keep one or two horses compared to other villages. In townships with a flat topography such as Jingan, Xialongdong and Niupeng, horses are rare or absent, while ox carts and tractors are widely used.

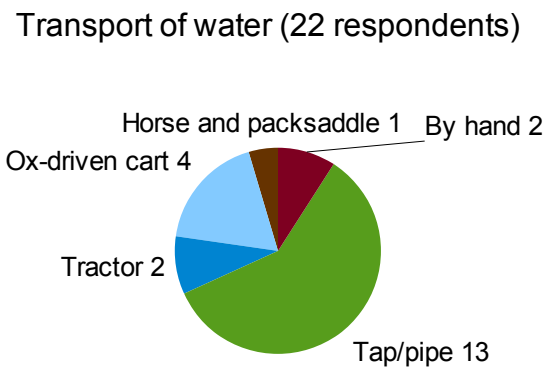
9.2.1 Number of transport roundtrips

The total workload for the transport of the manure and bio-slurry to the field can be estimated by asking how many round trips are necessary each year to bring the totality of the material to the field. This question was relatively easy to answer quantitatively by the farmers, however only 8 valid answers were recorded:

Method	Answers	
Horse and packsaddle	Several days	6 round trips
Ox cart	5 round trips	20 round trips
Three wheels bicycle	10 round trips	
Tractor	2 round trips	8 round trips
By hand	80 round trips – 1 week	

9.3 WATER

9.3.1 Transport



Important differences are found in the availability of water between villages, even within the same township. Indeed, the local topography (valley or plateau) is a main parameter. In one village amongst the survey, Baisha, the water supply is an issue. Many residents do not have a pipe flowing to their home, while water is also lacking for agriculture.

The answer above does not make a clear distinction between domestic and agricultural water supply, as ought to have been done, since our questions were not specific.

For agriculture purposes, the water is often pumped from a nearby river using a petrol-driven portable water pump (similar to a small generator, but pumping water instead of generating electricity). These pumps seem to supply water up to heads of several dozen meters. In some

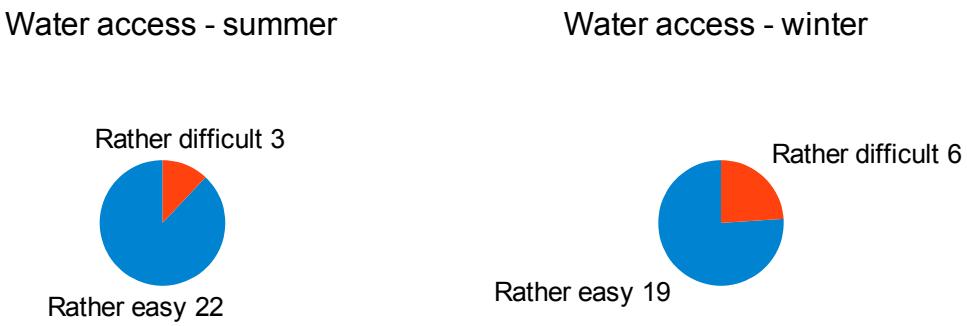
villages, in particular Hongjiaying and Zhongying, an extensive network of water channels have been built by the government. These channels can be used as a source for the water pumps mentioned above.

Water can also be delivered by truck. Large plastic “balloons” are used for holding the liquid.

The water supply, soil and topography are only adequate for rice paddies in small and specific part of Jingan and Sayu.

9.3.2 Availability

The interviewees were asked to subjectively estimate whether they found the water access to be “rather easy” or “rather difficult”, both in the winter and in the summer.



Amongst the beneficiaries that found water access “rather difficult”, 5 were located in Baisha and 1 in Xinqiao.

10 CONCLUSIONS 结论

To better reflect how the survey results have contributed to shape answers to pending questions, this conclusion shall be presented in the form of questions and answers.

How does the agriculture affect the way the biodigester is used?

There is a clear impact of the type and size of the agriculture of a household on the inputs of the digester. The more land available, the more animals the family keeps, and the more manure is fed to the digester. Otherwise, the type of agriculture, or the type of crops grown, does not seems to influence significantly how the digester is emptied, or how the bio-slurry is used. Bio-slurry is used on whatever crop is available.

How does the biodigester influence the agriculture?

The presence of a biodigester in the family, compared to the traditional system without a digester, only impacts little on the agriculture. First of all, the fertilisation potential of the bio-slurry is very limited in comparison to the level of mineral fertilisers used by most farmers. Secondly, the scum (=solid bio-slurry removed from the digester once a year) is used in a way absolutely similar to the normal animal manure, and is often actually incorporated to the manure heap. Although bio-slurry is known to have its nutrients in a more available form compared to traditional manure, there is therefore probably no significant fertility impact to expect from the use of bio-slurry.

Is the bio-slurry used at all by the beneficiaries? It is well used?

The bio-slurry is generally well used. All beneficiaries remove the scum once a year and use it in an appropriate way, similar to the traditional manure. Furthermore, a majority of the beneficiaires do use the liquid output during the year. When it is used, this liquid is used in the best possible way, since it is used directly, and left to infiltrate the soil.

Are the beneficiaries aware of the value of the bio-slurry?

Most beneficiaries seem well aware of the agricultural value of the bio-slurry. Even when the liquid bio-slurry is not used, it is generally not because of lack of awareness, but rather because the work is excessive. This should come as no surprise, since the bio-slurry is easily assimilated to traditional manure, which benefits are well perceived.

Are there differences amongst the beneficiaries in their use of the digester/bio-slurry ?

The habits amongst the households are surprisingly homogeneous. Almost every household follows the same method for emptying the biodigester and applying the bio-slurry on the fields.

What are the main constraint on the use of bio-slurry?

The main obstacles in using the liquid output, as perceived by the beneficiaries, is the difficult transport. Indeed, bio-slurry is not only liquid, but also more heavy because of its water content.

Furthermore, a main constraint is the seasonality. Liquid needs to be removed from the digester all year round, however during 5 months of the year, no plants are available which could be fertilised with the liquid. A solution adopted by some households is to pour the liquid on the manure heap, which is a good solution as long as some absorbing biomass such as corn stalks or pine needles are available.

Does the biodigester system involve much more work than the traditional system?

Since the traditional system also involves either cleaning the animal pen into a slurry pit (which is basically equivalent to a digester), piling up the manure outside on a heap, or keeping the animals on bedding which has to be cleared in the spring, a great amount of the workload is common to both systems. The only significant differences are in the transport of the liquid output of the digester. Since water is added to the digester for dilution, the effort for transport is increased. However, the liquid bio-slurry is rarely used far away from the digester.

Are the beneficiaries on the terrain using mineral (artificial) fertilisers?

Mineral fertilisers are used by every household in the region. The quantities used are definitely on the high end, with a suspicion that most farmers do overfertilise.

How effectively is the potential of the digester used (in terms of gas production)? How much of the manure is used in the digester?

The continued existence of a manure pile is in itself a proof that not all available biomass is circulated through the digester. However, in Zhaotong the manure pile is always from the cow or the horse, and has a high proportion of corn stalk, pine needle, or other bedding. It is not yet clear if it is reasonable to circulate this material through the digester, since it may lead to excessive scum and eventual clogging, as reported by some farmers. Specific trials could be conducted with households to test this possibility.

In Zhaotong, all pig slurry is fed to the digester, so it can be said that this potential is maximised. However in Weining, in our limited sample only a fraction of the pig slurry seems to be circulated through the digester. Contrary to Zhaotong, about half the pigs are still kept on bedding, and their slurry is not circulated through the digester. It is not yet clear whether this is linked to local farming habits or to the different design of the digesters. The farmers explained that it is due to a lack of space in the digester, which is overflowing. This could motivate training initiatives to encourage the farmers to use more bio-slurry or remove the scum more regularly.

To summarise, in Zhaotong there could be a potential (to confirm) for more gas production under optimised manure management (+ 20% gas?), and a very clear potential in Weining (+ 50%?).

What if mineral fertilisers are suppressed?

If the fertilisation of the plants was to depend solely on the bio-slurry and manure, the nutrient input would be divided by a factor of at least 10 (at equivalent surface). This would lead to a sharp drop in yields.

However, if bio-slurry is used for the exclusive fertilisation of a vegetable plot, calculations show that the plot could be optimally between 0.2 and 0.9 mu according to the number of animals. Bio-slurry would provide all the nitrogen and potassium, while most phosphorus should ideally be supplemented. This possibility is the most interesting for a rational use of the bio-slurry and for limiting the transport, and is already put in practise by some beneficiaries.

调查结论以提问和回答的形式来呈现，以便更好地对疑问做出解答。

农业活动是如何影响沼气使用的？

农户所从事的农业活动的类型和规模对沼气池的入料产生了显著影响。如果农户拥有更大面积的土地，就能饲养更多的家畜，就会产生更多的粪便以投入到沼气池内。否则，农户耕种哪种作物对于沼气池投料与否，不产生明显影响，又因为沼渣沼液可以被使用于任何农作物上，其对农户如何使用沼渣沼液，影响也不显著。

沼气池如何影响农业？

农户有无沼气池，对于其农业生产的影响较小。首先，比较大部分农户使用的化肥，沼渣沼液用于施肥的潜力十分有限。第二，每年大换料后所产生的沼渣，其使用方式与传统的动物粪肥和传统户外堆肥所生产的肥料完全相似。与传统粪肥相较，虽然沼渣中的营养成分更容易被农作物吸收，但使用沼渣对于提高农业生产力没有显著影响。

沼气项目受益者有没有使用沼渣沼液？沼渣沼液有没有被很好地利用起来？

农户能够适当地利用沼渣沼液。所有受益者每年进行一次大换料，并用与传统粪肥相似的方法使用沼渣。此外，大部分受益者确实使用了每年沼气池所产生的沼液。因为沼液可以被直接使用，且土壤渗透力强，所以沼液能够被充分利用。

沼气项目受益者知道沼渣沼液的使用价值吗？

大部分受益者都很了解沼渣沼液对于农事生产的益处。即便是在沼渣沼液没有被很好利用的情况中，通常来说并不是因为农户知识的缺乏，而是因为农户不愿意付出额外的劳动。当然，相较于传统的粪肥，沼渣沼液能够更好地被农作物吸收，农户对这一益处是了解的。

受益者使用沼气池和沼渣沼液的方法有不同吗？

农户给沼气池换料和沼渣沼液用于农事生产的方式都十分相似。

使用沼渣沼液有哪些限制？

受益者认为，因为沼渣沼液有一定的重量，其使用的最大障碍是运输上的困难。其次是季节性的约束。沼液需要定期从沼气池中抽出，而一年中有 5 个月的休耕期，农田里没有作物需

要施肥。一些农户解决这一问题的方法是把沼液泼到户外传统堆肥法的肥料堆上。如果肥料堆里有一些如玉米秸秆、松针等的吸收性能好的生物质，这便是一个好的解决办法。

管理沼气系统需要农户投入更多劳动力吗？

因为传统的做法也需要定期清洁畜圈，即将粪便扫入肥料坑中。肥料坑相当于沼气池。之后将粪肥在户外堆成一堆。或者在畜圈里垫上干草，再在春季对其进行清理。所以，无论是传统的做法还是管理沼气系统都需要大量劳动力投入。唯一明显的区别就是在沼液的运输上。因为稀释的需要在沼气池中加水，增加了运输的难度。然而，沼液并不在距离沼气池很远的地方被使用。

受益者使用化肥吗？

这一地区的农户都使用化肥。化肥的使用量很高，有过量施肥的情况存在。

沼气池潜在的使用率如何？农户使用了多少沼气池所产生的肥料？

从农户仍在使用传统的户外肥料堆堆肥来看，农户并没有循环利用所有沼气池所产生的可用生物质。在昭通，传统户外肥料堆的原料通常来自牛马粪便，并掺有一定比例的玉米秸秆、松针、和从畜圈清理出的草垫。我们还不清楚使用沼气池来循环利用这些材料是否合理，根据一些农户的报告，在沼气池中放入这些材料会产生过多的沼渣，最后可能堵塞沼气池。可以与农户合作进行试验来验证其可能性。

在昭通，所有猪的粪便已最大程度地投入了沼气池进行循环利用。然而在威宁我们有限的调查样本中，只有一部分猪的粪便通过沼气池被循环利用。与昭通相反，大约一半的猪在传统的畜圈里饲养，它们的粪便没有通过沼气池被循环利用。我们还不清楚这是与当地农户的习惯相关，还是与沼气池的不同设计相关。农户解释说，因为沼气池内缺乏空间，将粪便放入会使池内材料溢出。我们可以通过培训来鼓励农户更多地使用沼渣沼液，或更频繁地对沼气池进行换料。

总之，如果农户对粪便进行积极良好的管理，在昭通，沼气池的沼气产出能够增加20%，在威宁能够增加50%。

如果控制化肥的使用会怎样？

如果对农作物的施肥完全依靠沼渣沼液和粪便的话，那么营养成分的投入会减少，从而降低农作物的产量。

然而，如果沼渣沼液作为唯一的肥料被施于菜地里，计算得出，一定量家畜粪便所生产的沼渣沼液可以为0.2至0.9亩菜地施肥。沼渣沼液能够提供农作物生长需要的所有养分和钾，同时需要适当地补充磷肥。在菜地距离沼气池不远的情况下，一些受益者能够充分利用沼渣沼液。

11 APPENDIX – SURVEY FORM

访问员Surveyors :	**Bio-slurry usage and agriculture survey**
答卷人姓名（最好询问户主） Respondent's Name (better to be family leader): 男 Male 女 Female	访问日期(Date)：20_____年 year_____月 Month_____日 Day
访问地点 Address :	地区 District_____镇/乡 Town_____村 Village_____组 Group_____号 plate N_____

沼气池编号 biogas tank number : _____ 电话号码 Telephone number : _____

受益农户基本信息 IDENTIFICATION OF THE BENEFICIARY & GENERAL DATA

户主姓名（申请沼气姓名） Household Name (biogas application name) : _____	家中平均每天有几口人吃饭：Average Daily Number of people eating in the household： 成年人Adults_____小孩Children_____（界限为18岁）

田地和农作物 FIELDS AND CROPS

面积/数量 Surface / #	农作物或者轮种 Crops or rotation

最近距离 Nearest field: _____ 千米 km　　最远距离 Furthest field: _____ 千米 km

土壤类型和特性 SOIL AND SLURRY CHARACTERISTICS

☐ 沙质土 sand　☐ 壤沙土 loamy sand	☐ 沙质粘壤土 sandy clay loam　☐ 粘壤土 clay loam ☐ 粉砂黏壤土 silty clay loam	
☐ 沙壤土 sandy loam　☐ 亚粘土 loam　☐ 粉砂壤土 silt loam	☐ 砂质粘土 sandy clay　☐ 粘土 clay　☐ 粉质粘土 silty clay	
土壤pH值0.01M氯化钙: Soil pH 0.01 M CaCl2: _____	活性淤泥pH值 Bio-slurry pH: _____	活性淤泥固形物含量 Bio-slurry dry matter content: _____%

畜牧（只算成年牲口） **ANIMAL HUSBANDRY** (count the adults only)

动物 Animal	#	牲畜平时吃什么？ Diet	是否放牧 Grazing	粪便放入沼气池的量有多少Input in BGT	
				投入量 How much	频率 How often
猪Pigs			Y是☐ N否☐	☐ _____%	_____ 天days
牛Cows			Y是☐ N否☐	☐ _____%	_____ 天days
马Horses			Y是☐ N否☐	☐ _____%	_____ 天days
			Y是☐ N否☐	☐ _____%	_____ 天days
			Y是☐ N否☐	☐ _____%	_____ 天days

天然气储存罐输入BIOGAS TANK INPUT

厕所使用且与沼气池相连接 Toilet used and connected to BGT?　☐ 是 yes　☐ 否 no

其他添加到沼气池的物料或肥料 OTHER MANURES OR MATERIALS ADDED TO THE BIOGAS TANK

有机物的种类 （除了牲畜的粪便之外添加的其他物料）Type of organic material	*数量（平方米或斤）* Quantity (m^3 or jin)	价钱 Price	何时添加 When

每年在供家庭成员消耗的粮食中，自己生产的占几成 Proportion of food self-sufficiency (household food): _____ %

每年在供牲口消耗的粮食中，自己生产的占几成 Proportion of food self-sufficiency (animal feed): _____ %

1 – 水压间出料 CONTINUOUS BGT OUTPUT, FROM: ☐ **通过水压间 WATER CHAMBER** ☐ **通过手泵 HAND PUMP**

数量 Quantity:	___________ 斤 jin 多长时间取一次 taken out every ________ (frequency, days)（频率，天数）
用途 Use:	☐ 沼液沼渣用在什么农作物上 fertilisation, on the crop(s): ______________________ 是否稀释 Dilution: ☐ 是 yes： 比例（沼液沼渣：水）rate _____ vol bio-slurry :_____ vol H_2O ☐ 否 no 是否与化肥混合 Mixed with fertiliser? ☐ 是 yes： __________________ ☐ 否 no 处理地点 Localisation: ☐ 整块地表面 whole surface ☐ 和种子一起埋入 with seed ☐ 犁沟， 侧沟 furrow/side-dressed ☐ ________________ 运用方式 Method of application: ☐ 放在土上 left on surface ☐ 和土壤混合 incorporated ☐ 在农作物周围挖坑埋入 dug in hole ☐ 喷在农作物上 spraying
	☐ 在堆肥上 on compost ☐ 直接扔掉 thrown away ☐ 其他 other:______________________

2 – 整池清理出料 BATCH BGT OUTPUT

Month(s) when the tank is usually emptied:	1 2 3 4 5 6 7 8 9 10 11 12
取出了百分之多少 How much is emptied: ________ %	是否打开上盖 Lid opened? ☐ 是 yes ☐ 否 no
换料原因 Reason for emptying:	☐ 没有沼气产出 no gas production ☐ 需要沼液沼渣 need for bio-slurry ☐ 其他, 请说明 other, please specify:______________________
用途 Use:	☐ 沼液沼渣用在什么农作物上 fertilisation, on the crop(s): ______________________ 是否稀释 Dilution: ☐ 是 yes： 比例（沼液沼渣：水）rate _____ vol bio-slurry :_____ vol H_2O ☐ 否 no 是否与化肥混合 Mixed with fertiliser? ☐ 是 yes： __________________ ☐ 否 no 处理地点 Localisation: ☐ 整块地表面 whole surface ☐ 和种子一起埋入 with seed ☐ 犁沟， 侧沟 furrow/side-dressed ☐ ________________ 运用方式 Method of application: ☐ 放在土上 left on surface ☐ 和土壤混合 incorporated ☐ 在农作物周围挖坑埋入 dug in hole ☐ 喷在农作物上 spraying
	☐ 在堆肥上 on compost ☐ 直接扔掉 thrown away ☐ 其他 other:______________________

3 – 整池重新进料 REFILLING

沼气池重新进料的月份 Month(s) when the tank is refilled: 1 2 3 4 5 6 7 8 9 10 11 12

整池出料及重新进料的过程持续几天（沼气池开盖的时间长度）How long does BGT stay opened (emptying -> restarting)? _________ 天 days

重新进料时添加的物质 Refilling materials:	数量 Quantity	何时添加 When
1 - 水 Water	___________ 升 l	
2 -	___________ 斤 jin	
3 -	___________ 斤 jin	

牛、马棚垫料 BEDDING COMPOSITION

组成牛圈底的成分 Cow bedding composition: ☐ 玉米秸秆 Corn stalks ☐ 松针 Pine needles ☐ ____________________

组成马棚底的成分 Horse bedding composition: ☐ 玉米秸秆 Corn stalks ☐ 松针 Pine needles ☐____________________

堆肥 COMPOST OR MANURE HEAP

添加的物质（包括化肥） Material added including fertiliser(s) 牛，马粪便 活性淤泥 玉米秸秆 松针	Quantity (m3) 数量（平方米）	When 何时添加
☐ Cow/horse litter/manure ☐ Bio-slurry l/s ☐ Corn stalks ☐ Pine needles ☐ ____________		
☐ Cow/horse litter/manure ☐ Bio-slurry l/s ☐ Corn stalks ☐ Pine needles ☐ ____________		
☐ Cow/horse litter/manure ☐ Bio-slurry l/s ☐ Corn stalks ☐ Pine needles ☐ ____________		
☐ Cow/horse litter/manure ☐ Bio-slurry l/s ☐ Corn stalks ☐ Pine needles ☐ ____________		
☐ Cow/horse litter/manure ☐ Bio-slurry l/s ☐ Corn stalks ☐ Pine needles ☐ ____________		

堆肥和粪便的用途 COMPOST OR MANURE USE

用在什么农作物上 Used on crop(s): _____

运往田地使用的月份 Taken to the fields in (month) _____

处理地点 Localisation: ☐ 整块地 whole surface ☐ 和种子一起埋入 with seed

☐ 犁沟， 侧沟 furrow/side-dressed ☐ _____

运用方式 Method of application: ☐ 放在土上 left on surface ☐ 和土壤混合 incorporated ☐ 在农作物周围挖坑埋入 dug in hole

火灰的用途 ASHES

燃料 Fuel sources: ☐ 木材 wood ☐ 农业废弃物 agricultural residue ☐ 煤或者褐煤 coal/lignite

火灰 Ashes: ☐ 和堆肥混合 mixed with compost ☐ 直接扔掉 thrown away ☐ _____

农作物施肥情况 FERTILISATION AND MANURING

农作物 Crop	化肥，粪肥，堆肥 Fertiliser / manure / compost	数量 Amount	何时施肥 When
		/ mu 亩	
		/ mu 亩	
		/ mu 亩	
		/ mu 亩	
		/ mu 亩	
		/ mu 亩	
		/ mu 亩	
		/ mu 亩	

选择这些化肥的原因 How is the fertiliser choice determined?_____

为什么要这样使用化肥 How is the fertiliser rate determined? _____

农业废弃物利用情况 PLANT RESIDUE

种类 What	用途 Usage	何时使用 When
☐ 玉米叶和秸秆 Corn leaves/stalk		
☐ 土豆叶 Potato leaves		
☐ 豆叶或茎秆 Bean leaves/stalks		
☐ _____		
☐ _____		

农作物的一般情况 CROPS

农作物 Crop	种子 Seeds			产量 Yield	交易比例Proportion of marketed harvest
	循环利用Reused	购买Bought	选择种源的原因 Reason for seed choice		
	☐	☐		_____ 斤/亩	_____ %
	☐	☐		_____ 斤/亩	_____ %
	☐	☐		_____ 斤/亩	_____ %
	☐	☐		_____ 斤/亩	_____ %

农作物的疾病情况 PLANT HEALTH

农作物 Crop	害虫或者疾病 Pest or disease	何时发生 When	损害程度 Severity
			☐ 轻light ☐ 重 severe
			☐ 轻light ☐ 重 severe
			☐ 轻light ☐ 重 severe
			☐ 轻light ☐ 重 severe

杀虫剂使用情况 PESTICIDES

农作物 Crop	使用的杀虫剂 Pesticide used	数量 Amount	何时使用 When
		/ mu 亩	
		/ mu 亩	
		/ mu 亩	
		/ mu 亩	

运输方式 TRANSPORT 马驮 牛、马车拉 自用拖拉机、租用拖拉机 手工

沼液 Bio-slurry	☐ horse and packsaddle	☐ cow/horse and cart	☐ tractor own/hired	☐ by hand	☐ _____
堆肥 Compost	☐ horse and packsaddle	☐ cow/horse and cart	☐ tractor own/hired	☐ by hand	☐ _____
水 Water	☐ horse and packsaddle	☐ cow/horse and cart	☐ tap/pipe	☐ by hand	☐ _____
运送堆肥或者沼液沼渣到田地需多少趟 How many trips needed to bring the compost and/or bio-slurry to the fields? _____					

取水条件 ACCESS TO WATER

夏季 Summer	☐ 简单 rather easy	☐ 困难 rather difficult
冬季 Winter	☐ 简单 rather easy	☐ 困难 rather difficult
水源距离农田有多远 How far is the water source from the farm? _____		

农户对沼渣沼液利用的看法 BENEFICIARY'S IMPRESSIONS

沼气池的优点和缺点 BGT/biogas system has following advantages / disadvantages	
优点 ADVANTAGES	**缺点 DISADVANTAGES**

访问员补充说明GENERAL COMMENTS & ADDITIONAL INFORMATION

农户的意见以及对有机物处理上可能会遇到的困难 BENEFICIARY'S REMARKS AND POTENTIAL DIFFICULTIES RELATED TO ORGANIC MATTER MANAGEMENT

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