Incidence and impact of classical swine fever on smallholder pig production systems in Northeast India

Bernard Bett
Ram Deka
V. Padmakumar
Iain A. Wright

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

SIR RATAN TATA TRUST & NAVAJBAI RATAN TATA TRUST

January 2012

Contents

List of Tables

List of Figures

Abbreviations

ASF	African swine fever
CI	Confidence interval
CSF	Classical swine fever
CSFV	Classical swine fever virus
FMD	Foot and mouth disease
ILRI	International Livestock Research Institute
NE	Northeast India

Executive summary

Classical swine fever (CSF) or hog cholera, a viral disease of pigs, is endemic in South and Southeast Asia including India. The disease is a major constraint for the development of pig husbandry systems in the NE India where pig farming is one of the main sources of livelihoods for a majority of the households. The development of effective strategies to control the disease requires adequate knowledge on the epidemiology of the disease particularly among the small scale pig production systems that are more vulnerable to the disease. Some of the measures that can be used include culling of infected animals, quarantine or movement control, disinfection of infected premises and farm appliances, community awareness campaigns and vaccination.

A survey to estimate incidence and impact of CSF among small holder farmers was implemented in 6th June – 20th July 2011 in the NE India. A total of 60 villages distributed equally between 15 districts in Assam (5 districts), Nagaland (5 districts) and Mizoram (5 districts) states were used. The sample size (of 60 villages across the three states) was determined based on statistical and budgetary considerations. Data were collected using participatory epidemiological techniques. The participants recruited for the survey included farmers, veterinarians, and other key informants. The survey was implemented in each state by teams comprising 3 or 4 persons that had been trained on participatory epidemiological methods before the commencement of the work.

Key observations made from the study are as follows:

- Pigs are kept by a majority (slightly over 80%) of the households in the NE India. It is also considered as being the most promising source of income in the area. However, further development of the of the existing pig enterprises is constrained by: (i) lack of feed and poor management practices, (ii) lack of capital and (iii) infectious diseases and poor infrastructure for managing them.

- The incidence, morbidity and case fatality rates of CSF were estimated to be 5.4% (95%CI: 3.5 – 8.0), 28.1% (95% CI: 20.4 – 36.6%) and 51.1 – 94.5%, respectively. Piglets, as expected, suffer higher morbidity and mortality rates compared to the other age categories. The study also shows that an outbreak of CSF lasts for about 36 days (95% CI: 19.0 – 53.8). This implies that CSF outbreaks run their full epidemic course as there is not an adequate infrastructure for implementing response measures. Behavioural practices such as selling off infected/potentially infected animals in the face of an outbreak by farmers in a bid to avoid mortality losses promote the transmission of the disease.

- Some of the husbandry practices used by the local producers such as use of untreated left-over food as pig feed, free ranging/tethering, and lack of proper housing are important risk factors for CSF transmission. Native pig breeds could also be playing an important role in the epidemiology of the disease. Ecological studies need to be done to assess the relative impact of the native (kept by a majority of the farmers) verses exotic pig breeds that are being raised by a majority of the farmers on the epidemiology of the disease. It is known that native breeds have longer survival rates compared to exotic breeds and therefore shed the virus in small quantities over a prolonged period of time.

- Farmers spent up to USD $ 450,000 to treat animals that contract the disease yet their uncoordinated interventions do not help in controlling such a trans-boundary disease that has a high incidence and morbidity rates. Farmers in the area also incur huge costs from mortality and productivity losses and the government should urgently develop a CSF control program.

1 Introduction

Classical swine fever (CSF) or Hog Cholera is a highly contagious viral disease of pigs caused by a single stranded positive sense RNA virus (CSFV). The virus is classified under the genus *Pestivirus* and family *Flaviviridae*. The disease was first reported in 1883 in Ohio, USA from where it spread to Europe and Asia. It is now endemic in the East and Southeast Asia, India, China as well as in South and Central America. In Northeast India, the disease was first reported in the state of Meghalaya (Murti and Hazarika, 1982) followed by Nagaland (Das et al., 1983), Mizoram (Verma, 1988) and Assam (Sarma and Sarma, 1998; Rahman et.al., 2001; Barman et al., 2003). The disease later spread to the other NE states (Francki et al., 1991).

Susceptible pigs get exposed via direct or indirect contact with infected animals or inhalation of aerosolised viral particles (though the later mode of transmission is considered as not being important). The disease can manifest as an acute, sub-acute or chronic syndrome depending on the age of the animal affected, virulence of the virus and the time of infection (pre or postnatal) (Anon, 2004). Acute form generally results in high morbidity and mortality while sub-acute form exhibits atypical or less dramatic clinical sign (Rahman et al., 2001) and lower mortality rate. Chronic form of the disease causes reproductive disorders and birth of congenitally affected piglets (Van Oirshot, 1986).

CSF is a major constraint to efficient and sustainable pig production in the North East India because pig farming is one of the major sources of livelihoods in the area. Pigs are mostly reared by tribal communities who raise about 28% of the total pig population in the country (Deka et al., 2008) approximated to be 13.5 million. The region is also the highest consumer of pork; Table 1 compares pig production and consumption statistics from the NE India with the national (India) averages.

Measures that are often recommended for CSF control include culling, movement control, community awareness and vaccination. Furthermore, farmers are often encouraged to implement standard biosecurity measures including cleaning and disinfection of pig premises, farm equipment, proper disposal of contaminated material, etc. India currently produces CSF vaccine but the quantity of production is much lesser than its requirement possibly because of poor infrastructure for its production and distribution and inadequate availability of rabbits for production of lapinised vaccine. There are also reports of vaccination failure (Wright et al., 2010) but this has not been formally investigated.

The development of effective strategies to control the disease is constrained by lack of knowledge on the epidemiology of the disease particularly among the small scale pig production systems. Most of the studies that have been implemented in the region have been geared towards characterising the CSFV that are prevalent in the area, developing diagnostic tools or evaluating vaccine candidates. This survey estimated the incidence and impact of CSF among small holder farmers in the NE India. The survey employed participatory epidemiological techniques to collate perceptions of farmers, veterinarians, and other key informants on the incidence of CSF based on a CSF- clinical case definition. The cost of perceived CSF outbreaks (classified into mortality, productivity, treatment and replacement costs) over a period of one year was also estimated based on the incidence estimates obtained from the survey.

Table 1: Pig production and consumption scenario in North East India vis-a-vis India average (2003)

Name of the state	Pig population (in million)	Pig density/ 1000 people	% pork consuming household	Per capita consumption of pork among tribal (kg/annum)	% share of pork on total food
Assam	1.5	56	14.04	2.20	0.92
Arunachal Pradesh	0.3	294	22.67	1.66	1.69
Mizoram	0.2	238	66.82	5.35	7.68
Manipur	0.4	169	13.29	1.47	0.77
Meghalaya	0.4	177	65.33	2.43	4.22
Nagaland	0.6	316	83.98	8.37	6.57
Sikkim	-	68	37.86	2.24	2.57
Tripura	0.2	64	11.87	2.28	0.54
India	13.5	13	1.47	0.35	0.09

2 Materials and methods

2.1 Survey design

A total of 60 villages distributed equally between 15 districts in Assam (5 districts), Nagaland (5 districts) and Mizoram (5 districts) states were used in the survey. The sample size (of 60 villages across the three states) was determined based on statistical and budgetary considerations. A standard formula for estimating the sample size for categorical outcomes, i.e., $N = Z^2 * pq / L^2$, was used. In this formula:

- Z is the value that corresponds to 95% confidence level in a standard normal distribution,
- p is *a priori* prevalence of CSF in the northeast India; 50% was used because there was no existing reference on CSF incidence in the NE India,
- q is obtained as 100%-p; the product of p and q gives the variance of p,
- L is the margin of error; 13% margin of error was considered in this case.

The districts were selected purposively within each state to cover diversities within the state in terms of geographical location, ethnic groups involved, livelihood system, access to market and farm inputs and strategic importance from the standpoint of cross border transmission of disease. Within each district, 4 villages were randomly selected from a sampling frame that included villages that were expected to be having pigs. Each district also had 3 extra villages that could be used to replace villages that could not be accessed. The extra villages were serialised and used in the order in which they were selected. This means that village no 6 could only be used when village no. 5 has been used and village no. 7 could be used when both village no. 5 and 6 had been used.

2.2 Training of the survey teams and development of the survey instruments

The survey was conducted by a team (one for each state) comprising of 3 or 4 persons representing the State Veterinary department, a local NGO partner and ILRI. Before the survey commenced, the teams were trained on participatory epidemiological techniques over a period of one week in May 30th – June 5th 2011. Topics covered in the training are outlined in Appendix 1. Survey instruments were also developed over the same period; these included a case definition for CSF, interview check list, data form and a list of the survey districts and villages. The CSF case definition, interview check list and data form were pretested during the training period.

2.3 Data collection

The survey was implemented in 6th June – 20th July 2011. Surveys commenced with each team visiting Veterinary Offices in the districts to obtain secondary information on whether CSF outbreaks occurred in the past year (January 2010 – July 2011). If outbreaks fitting the case definition are recorded, the team sought more specific information on the names of the villages affected and the dates when such outbreaks occurred.

At least one group and one key informant interviews were conducted within a village. Each group interview involved between 5 and 30 participants. The number of key informants that could be interviewed at any one time ranged between 1 and 3. They included vets working in the local veterinary dispensaries, village heads or progressive farmers. Women played a very important role in pig farming; therefore, group interviews had to include women. Topics covered in the interviews include:

- Identification and ranking of sources of income used by village
- Estimating the average income from five key livelihood activities identified above
- Identifying promising sources of income not currently being utilized fully
- Livestock species kept
- Pig husbandry practices including:
    i. Rearing objectives (fattening, breeding or both and the percentage of the households in the village that raise pigs for the objectives mentioned)
    ii. Breeds of pigs kept in the village and the percentage of pigs in the village that could be classified into each breed type
    iii. Breeding practices and the percentage of the breeding sows served by the respective breeding method mentioned
    iv. Types of feed used and a ranking of the feeds depending on the frequency of use
    v. Rearing practices – tethering, semi-intensive, intensive or open.

The expected rearing practices include tethering, open/free range system, intensive and semi-intensive pig keeping systems.

- Diseases/syndromes in the last year (January 2010 to July 2011), while identifying:
    i. the main clinical signs
    ii. type of pig affected (piglets, growers, finishers and adults)
    iii. season when the disease occurred
    iv. the diseases were also ranked based on their impact on livelihoods
- Estimating the costs of mortality, productivity losses, treatment costs and replacement costs due to CSF occurrence
-

2.4 Data management and analysis

2.4.1 Estimating the incidence of CSF

Data were entered into a database developed using Microsoft Access. They were then cleaned and analysed using STATA (Version 10.1, College Station, TX, USA). Means were calculated for each quantitative variable and stratified by state. For qualitative data, e.g. the type of feed used, etc., frequencies were determined and also stratified by state. CSF incidence was determined by determining the number of outbreaks that were determined between January and December 2010 and the months at risk over the same period; incidence was then determined using the formula:

$$\frac{\text{No. of outbreaks}}{\text{Months-at-risk}}$$

2.4.2 Estimating the costs of the disease

The incidence, morbidity and mortality parameters derived above were used to estimate mortality, productivity, treatment and replacement costs of the disease. The incidence rate was used to determine the number of villages that would be affected by the disease over a period of one year while morbidity rate was used to estimate the number of pigs that would be affected in the affected villages. These estimates were derived at the pig level. The types of costs considered include: (i) mortality costs, (ii) treatment costs and (iii) replacement costs.

3 Results

3.1 Characterization of the survey villages and households

3.1.1 Percentage of households that kept pigs, by state

The median number of households in the villages surveyed was 132.5; Mizoram had a relatively higher median number of households (177.5) surveyed compared to Nagaland (140) and Assam (77.5). Overall, the median percentage of households that kept pigs was 80.3 %. This proportion was equivalent across states (Assam 84.1%, Mizoram 82.8%, and Nagaland 80.0%).

3.1.2 Common sources of income

Common sources of income that were identified in the survey include agriculture (mainly the cultivation of paddy, maize and horticulture), livestock farming (pigs, cattle, poultry, *mithun* and bee keeping), casual labour, small business formal employment (in government offices). Other livelihood activities included rice beer making, fishing, and sale of firewood, handicrafts or pottery. In a decreasing order of importance, the participants identified crop farming, livestock rearing, wages, salary and business as the five most important sources of income to a majority of the households (Table 2). This ranking was more or less consistent across the states although agriculture was commonly practiced in Nagaland and Mizoram than Assam.

Table 2: Ranking sources of income in the villages surveyed in Assam, Mizoram and Nagaland based on importance to a majority of households

Rank	Crop farming	Livestock	Wages	Salary	Business
1	36 (61.0%)	13 (23.6%)	10 (24.4%)	-	1 (2.9%)
2	15 (25.4%)	25 (45.5%)	10 (24.4%)	-	3 (5.9%)
3	8 (13.6%)	14 (25.5%)	18 (43.9%)	6 (18.2%)	5 (14.7%)
4	-	3 (5.4%)	2 (4.9%)	21 (63.6%)	11 (32.3%)
5	-	-	1 (2.4%)	6 (18.2%)	14 (41.2%)
Response rate	98.3% (n = 59)	91.7% (n = 55)	68.3% (n = 41)	55.0% (n = 33)	56.7% (n = 34)

Table 2 gives the distribution of responses for each income source. Crop farming, for example, was ranked as the commonest source of income (no. 1) by 36 villages (61% of the total), the second most frequently used income source by 15 (25.4%) villages and the third by 8 villages (13.8%). The overall ranks (described in text) were based on this distribution of responses for each livelihood activity (i.e., a high percentage of responses for agriculture (61%) identified this activity as being no. 1 income source, a high proportion of responses for livestock (45.5%) identified livestock farming as no. 2 income source, etc.). Response rate also matched with this ranking (except for the last 2 positions) since agriculture and livestock farming had the highest and second highest response rates than the other livelihood activities that were not being commonly used.

3.1.3 Promising sources of income

Pig farming was identified by a large proportion (46.6%, 27/58) of villages as the most promising source of income. Others included cattle (including *mithun*) rearing (12.1%, 7/58) and rice farming (6.9%, 4/58). Villages in Mizoram and Nagaland identified pig farming and cattle rearing, in that order, as the most promising sources of income whereas those surveyed in Assam identified pig farming and rice farming. Constraints for the establishment of more productive pig enterprises that were enumerated by the participants include:

- Lack of feed and poor feeding management (29.6%, 8/27),
- Lack of capital and high costs of replacement stock (piglets) (25.9%, 6/27),
- Disease outbreaks and poor facilities for managing such diseases (25.9%, 6/27),
- Other constraints such as poor knowledge on pig management, labour and time constraints.

Constraints for cattle rearing were identified as lack of pasture, poor access to veterinary services and lack of funds to purchase replacement stock and fencing materials. The key constraint for rice cultivation was cited as lack of irrigation facilities.

3.1.4 Livestock species kept

All the villages surveyed kept pigs and poultry. Goats and cattle were also kept by a majority of villages across the states while buffaloes and *mithun* were kept in a few villages. The livestock species kept were ranked based on their importance to households' livelihoods; the results of this analysis are given in Table 3. The ranking obtained, in the decreasing order of importance, was pigs, cattle, poultry, buffaloes and goats. Other livestock species had low response rates. There were slight differences in the rankings by state although all of them had pigs as the most important livestock species. The reasons given for this ranking is that pigs are prolific and give high returns (from the sale of piglets or pork). They are also used for ritual purposes.

Table 3: Ranking of the livestock species kept in the villages surveyed based on their importance to livelihoods [results given as frequency (%)]

Rank	Pigs	Cattle	Poultry	Buffalo	Goat	*Mithun*	Other
1	37 (61.7)	1 (2.0)	15 (25.0)	4 (9.5)	2 (4.8)	1 (20.0)	0
2	6 (10.0)	24 (47.1)	12 (20.0)	8 (19.0)	6 (14.2)	0	3 (60.0)
3	10 (16.7)	11 (21.5)	16 (26.7)	10 (23.8)	2 (4.8)	2 (40.0)	1 (20.0)
4	5 (8.3)	7 (13.7)	15 (25.0)	17 (40.5)	9 (21.4)	0	1 (20.0)
5	2 (3.3)	8 (15.7)	2 (3.3)	3 (7.1)	23 (54.8)	2 (40.0)	0
Response rate	100% (60)	85.0% (51)	100% (60)	70% (42)	70% (42)	8% (5)	8% (5)

3.2 Pig husbandry systems

3.2.1 Breeds and breeding

A majority of the villages kept cross-breeds (Table 4). The other breeds kept were indigenous breeds and exotic breeds e.g. Hampshire/large white breeds.

Table 4: Pig breeds kept in the villages surveyed and the number of villages that kept each breed by state

Breed	State			Total
	Assam	Mizoram	Nagaland	
Cross-breeds	20	20	18	58
Indigenous breeds	7	3	7	17
Hampshire/large white, other exotic breeds	1	0	0	1

In general, a large percentage of households (median 90%) kept pigs for fattening purposes. Very few of them kept pigs for breeding (7.5%) or for both breeding and fattening (9%). This was a consistent observation across the three states. Almost all the villages used natural breeding practice as opposed to artificial insemination. The cost of each service ranged between Rs. 500-1000; a service could also be paid with a piglet.

3.2.2 Housing

A majority of households in Assam used free-range system while most of those in Mizoram used intensive housing system (Table 5). Nagaland had a balanced distribution between households that used intensive housing systems verses those that used semi-intensive housing systems. The type of housing system influenced the type of floor used. The free-range housing system (in Assam) had earthen floor while the intensive and semi-intensive systems (used in Mizoram and Nagaland) were associated with slatted floors (made up of wooden planks). Cement floors were not commonly used because of the low temperatures in the region – the participants indicated that cement floors predisposed pigs to cold chills. Under the free range system, however, pigs are tethered when they are pregnant or during the paddy growing season.

Table 5: Median percentage of households that raise pigs under the different housing systems housing systems

Housing system	State		
	Assam	Mizoram	Nagaland
Intensive	-	100	54
Semi-intensive	10	10	50
Tethering	20	-	5
Free range	100	9	10
Other	-	-	45

The table gives median percentages of households that use various types of pig husbandry systems (these percentages don't add up to 100% because medians are not proportions; they show the location of the 50th percentiles).

3.2.3 Feeds and feeding

Table 6 gives the types of feeds that were commonly mentioned in the interviews, by state. These feeds are often mixed in various proportions before being used. For example, rice is usually mixed with kitchen waste, jungle leaves, wheat bran, flour or concentrate feed before being used.

Table 6: Types of feed that were commonly mentioned by pig farmers in the survey

Assam	Mizoram	Nagaland
Kitchen waste	Kitchen waste	Kitchen waste
Residue rice beer	Rice bran	Maize bran
Rice bran	Jungle leaves	Jungle leaves
Jungle leaves	Wheat bran	Rice bran
Wheat bran	Concentrates	Wheat bran

The participants also ranked the feeds identified (Table 6) according to the frequency of use. The ranking given, in a decreasing order of frequency included: rice bran, residues of rice beer and kitchen waste in Assam; rice bran, jungle leaves, and kitchen waste in Mizoram; and kitchen waste, rice bran and wheat bran in Nagaland. Maize and rice bran are usually more available during the harvesting seasons. Farmers also have perceptions on the effects of the different types of feeds on pig productivity. They, for example, believe that feeding pigs with tapioca leaves and roots make pigs grow faster.

3.3 Diseases

The participants listed diseases and syndromes that occurred in their villages in the past year (January to December 2010). These include:

- Classical swine fever (28.2%, n = 38)
- Skin diseases including mange (18.5%, n = 25)
- Parasitic infestations e.g. ticks, maggots, etc (10.4%, n = 14)
- Respiratory tract infections and pneumonias (6.7%, n = 9)
- Foot and mouth disease (5.2%, n = 7)
- Gastrointestinal worms (4.4%, n = 6)
- Swine pox (3.7%, n = 5)

Other diseases that were also mentioned, though not frequently, include brucellosis, swine erysipelas, collibacillosis, parturient paresis, anthrax, poisoning, and mastitis.

Clinical signs that participants associated with the classical swine fever include high fever, lack of appetite, trembling/shivering, ocular and nasal discharge, watery discharge from the mouth, reddish discolouration of the skin on the ears, feet and the lower abdomen, diarrhoea in piglets and constipation in adults and high mortality (usually within 2-3 days in piglets and up to 7 days in adults). Skin diseases were associated with alopecia, itching, skin rashes, wrinkling of the skin, loss of appetite and retarded growth. Perceptions regarding the distribution of the cases by age are presented in Figure 1. Fifty percent of the villages surveyed indicated that CSF affects piglets only.

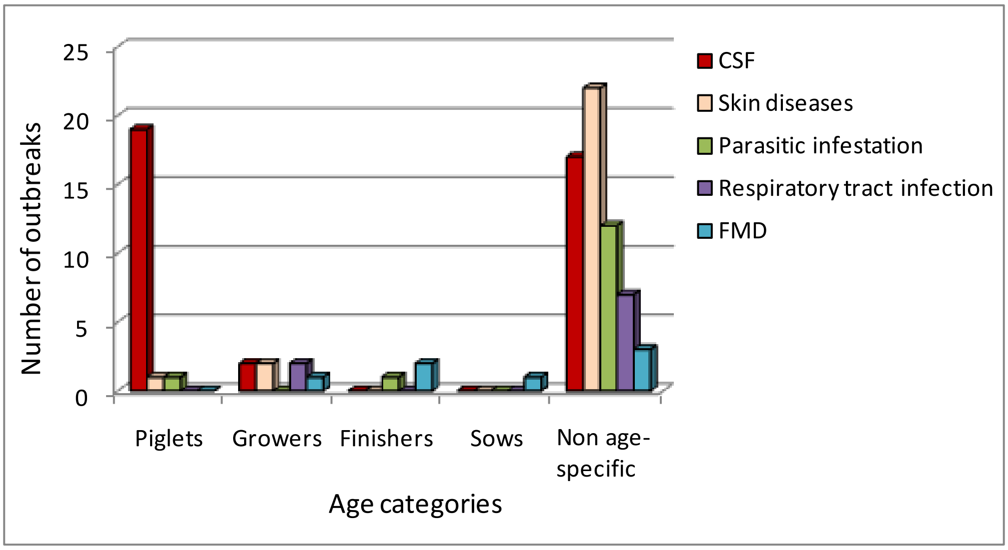

Figure 1: The distribution of the diseases identified by the participants by age categories of pigs

3.3.1 Incidence and case fatality rates of classical swine fever

A total of 29 outbreaks of CSF, which occurred between January 2010 and July 2011, were identified in the survey; 48% of these (n = 14) occurred in Assam, 37.9% (n = 11) occurred in Nagaland and 13.8% (n = 4) occurred in Mizoram. The incidence of CSF has been estimated based on the outbreaks that occurred in January – December 2010 to cover all the four seasons rationally. Figure 1 outlines the distribution of the number of the outbreaks by month and Table 7 gives estimates of the CSF incidence by state.

The graph shows that the incidence of CSF peaked in April 2010. This was followed by a gradual decline until November - December 2010 when a few outbreaks were observed. During this period, the incidence of the disease was higher in Assam than in Mizoram and Nagaland (Table 7).

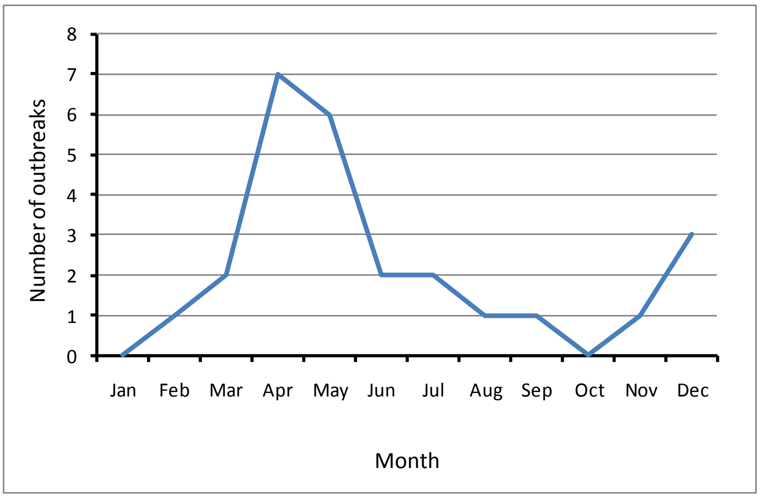

Figure 2: Number of CSF outbreaks based on participants' recall that occurred in the selected villages in January to December 2010.

Table 7: Monthly incidence of CSF outbreaks by state (i.e., the rate at which villages become infected per month)

State		MAR[a]	No. Of outbreaks	Incidence (95% CI)
Assam		82	14	17.1 (9.3 – 28.6)
Mizoram		220	3	1.4 (0.2 – 4.0)
Nagaland		176	9	5.4 (2.3 – 9.7)
Total		478	26	5.4 (3.5 – 8.0)

[a]MAR – Months-at-risk
[b]Incidence was calculated in STATA using the command: *cii months-at-risk no-of-cases, poisson*

The mean duration of an outbreak (based on the number of days between the start and end dates of each outbreak) was estimated to be 36.7 days (95% CI: 19.0 – 53.8). Overall, the perceived proportion of pigs that got sick in these outbreaks was 28.1% (95% CI: 20.4 – 36.6%); this, however, varied by state – the respective proportions in Assam, Mizoram and Nagaland were 14.9% (9.7 – 21.3%), 26.2 (7.6 – 50.5) and 48.6 (32.4 – 66.6%).

The perceived case fatality rates (the proportion of pigs that died after falling sick from suspected CSF) were estimated for each age group as follows:

Piglets	94.5% (91.8 – 96.9%)
Growers	76.2% (59.4 – 90.2%)
Finishers	62.3% (50.8 – 74.3%)
Sows	51.1% (37.4 – 66.7%)
Boars	83.3% (50.0 – 100%)

3.3.2 Laboratory results

3.3.3 Veterinary treatments

Most of the villages (51/56) reported that they treat their pigs when they get classical swine fever. It was estimated that 64.1% (51.7 – 76.5%) of the households from these villages treat their pigs with a majority (67.9%, n = 38) of the treatments being made by farmers themselves. The other treatments were provided by local veterinarians (16.1%, n = 9) or para-veterinarians (16.1%, n = 9).
Most treatments made by farmers (30/38) utilize pharmaceutical products purchased from local agro-veterinary shops. A smaller proportion of these treatments (8/30) utilized traditional medicine. The numbers of treatments made by farmers versus those made by veterinarians and para-veterinarians vary by state. The proportions of farmer-treatments are higher in Mizoram and Nagaland while those for veterinarians or para-veterinarians are higher in Assam.
The respondents also indicated that it is a common practice for farmers to sell pigs, particularly the adults, in the face of an outbreak in a bid to avoid outbreak-related losses e.g. morbidity, mortality and treatment costs. Such sales usually fetch only about 60% of the normal prices. Younger pigs (piglets and growers) are often slaughtered and consumed within the households rather than being sold.

3.3.4 Impacts of CSF

Impacts of CSF in terms of cost of mortality, productivity losses, treatment costs and replacement costs were estimated based on the annual incidence and case fatality rates estimated above. These costs were considered

3.3.4.1 Cost of mortality

Immediate costs of mortality is estimated by taking into consideration the proportion of villages that would be affected by the outbreak over a period of one year, multiplied by the proportion of pigs that would be affected by the outbreak in those villages and the case fatality rate to determine the number of pigs that would die following infection. This analysis is outlined in Table 8. The analysis shows that the costs of mortality would be much higher in Assam due to the higher population of pigs as well as the estimated CSF incidence.

Table 8: Estimating the cost of mortality due to CSF in Assam, Mizoram and Nagaland

Criterion	State		
	Assam	Mizoram	Nagaland
The proportion, *p*, of villages that would get infected over a period of one year based on the state specific monthly incidence rate, *I*, using the formula: *P* = 1-((1-*I*)^12)	0.85	0.135	0.425
Total number of villages (as per Census 2001)	26,312	437	1,219
Estimated number of pig rearing villages	4,405	393	1,097
The number of villages that would be expected to get at least one CSF per year (based on the number of pig rearing villages per state)	3,744 villages	53 villages	466 villages
Mean number of pigs by age category based on the results obtained from the survey	Piglets: 97.8 Growers: 94.2 Finishers: 58.8 Sows: 65.9 Boars: 5.6	Piglets: 42.5 Growers: 229 Finishers: 88.9 Sows: 18.5 Boars: 2.1	Piglets: 176.6 Growers: 90.2 Finishers: 79 Sows: 90.4 Boars: 2.1
The number of pigs in the villages affected based on the estimated mean pig population sizes per village and state	Piglets: 366,163 Growers: 352,685 Finishers:220,147 Sows: 246,730 Boars: 20,966	Piglets: 2,253 Growers: 12,137 Finishers: 4,712 Sows: 980 Boars: 111	Piglets: 82,296 Growers:42,033 Finishers: 36,814 Sows: 42,126 Boars: 979
The total number of pigs that would die as a result of the outbreak assuming a morbidity rate of 28% and the various age-specific case fatality rates described above	Piglets: 97,233 Growers: 75,518 Finishers: 38,540 Sows: 35,428 Boars: 4,908	Piglets: 598 Growers: 2,599 Finishers: 825 Sows: 141 Boars: 26	Piglets: 21,853 Growers: 9,000 Finishers: 6,445 Sows: 6,049 Boars: 229
Estimate the total cost of mortality/year using age specific market prices (piglet – 1818.10, grower – 8750.00, finisher – 9405.26, sow – 13941.18 and boar – 16666.67)	INR 1,775,737,680.6	INR 33,981,840.6	INR 267,245,581.5
Costs in of mortality in USD$/year (1 USD$ = 51.6 INR)	USD $ 34,413,520.9	USD $ 658,562.8	USD $ 5,179,177.9

3.3.4.2 Loss in the market value of a pig following an outbreak of CSF

Market values of pigs often decline in the course of a CSF outbreak particularly in the vicinities of an outbreak. Table 9 estimates the change in the market price of the different age categories of pigs following an outbreak of the disease. These prices could be used to estimate indirect losses that farmers of unaffected pigs incur due to a general decline in the market value of their animals. Most of these losses are however transient because some of the animals could be sold at a later time when the outbreak would have been controlled.

Table 9: Changes in the market value of a pig in villages affected by CSF

Age category	Mean market value with no CSF in INR	Mean market value with CSF in INR	Mean reduction in market value in INR	Mean reduction in the market value in USD $ (1 USD $ = 51.5 INR)
Piglet	2,213.00	265.63	1,664.58	32.3
Grower	6,774.19	3,375.00	2,225.00	43.1
Finisher	11,072.22	4,857.14	3,857.14	74.8
Sow	13,147.37	5,333.33	4,333.33	84.0
Boar	11,050.00	5,880.95	3,190.47	61.8

3.3.4.3 Cost of treatment

The average cost of treatment age category of pig was estimated as shown in Table 10. Most of the treatments were done by the farmers themselves. It is likely therefore that most of these treatments were not effective.

Table 10: Treatment costs

Criterion	Assam	Mizoram	Nagaland
The number of pigs in the villages affected based on the estimated mean pig population sizes per village and state	Piglets: 366,163 Growers: 352,685 Finishers:220,147 Sows: 246,730 Boars: 20,966	Piglets: 2,253 Growers: 12,137 Finishers: 4,712 Sows: 980 Boars: 111	Piglets: 82,296 Growers:42,033 Finishers: 36,814 Sows: 42,126 Boars: 979
The number of pigs that will be affected by the outbreak and therefore requiring treatment	Piglets: 102,892 Growers: 99,104 Finishers: 61,861 Sows: 69,331 Boars: 5,892	Piglets: 633 Growers: 3,410 Finishers: 1,324 Sows: 276 Boars: 31	Piglets: 23,125 Growers: 11,811 Finishers: 10,345 Sows: 11,838 Boars: 275
Total cost of treatment assuming that treatment of a piglet costs 105.00, grower 96.42, finisher 170, sow 132 and boar 50	40,321,998.23	658310.51	6901886.58
Percentage of households/village that actually treat their pigs when they fall sick	59.69%	66.67%	72.14%
The adjusted cost of treatment assuming that the percentage of households that treat pigs is proportion to treatment expenditures in INR	INR 24,068,200.7	INR 438,895.6	INR 4,979.021
Cost of treatment in USD $ (I USD $ = 51.6 INR)	USD $ 466,438	USD $ 8,505.7	USD $95.5

3.3.4.4 *Cost of replacement*

Table 11: Replacement costs

Criterion	Assam	Mizoram	Nagaland
Mean number of households/village that purchase replacement stock	4.84	8.88	20.4
Mean number of piglets purchased by each household for replacement	3	2	1
Total number of piglets purchased by each village for replacement	15	18	20
Total number of piglets purchased for replacement in each state in a year (only in the villages affected by outbreaks)	56160	954	9320
Price/piglet	1818.10	1818.10	1818.10
Total amount of money spent on replacement stock in INR	INR 102,104,496	INR 1,930,822.2	INR 18,799,154
Cost of replacement stock in USD $ (1 USD $ = 51.6 INR)	USD $ 1,978,769.3	USD $ 37,419.0	USD $ 364,324.7

4 Discussion

There is limited information on the epidemiology and impact of CSF in India – most of the studies that have been done focus on phylogenetic analysis of the CSFV. This study utilized participatory epidemiological techniques to collate perceptions on the incidence and impacts of CSF in the Northeast India. These techniques are increasingly being used to assess the impacts of important livestock diseases on livelihoods (Mariner and Paskin, 2000). The clinical case definition used in the study comprised key clinical signs that were thought to be consistent with CSF including diffuse reddish or bluish discolouration of the skin, especially at the extremities (feet, ventral side of the abdomen, etc), convulsions and staggering gait, huddling and congenital tremor (in the newly born piglets). Most of these clinical signs have been observed in recent CSF outbreaks reported by Kumar et al. (2007) and Basheer et al. (2009), etc. However, the usefulness of a variety of clinical signs and macroscopic pathological features in the diagnosis of CSF has been re-evaluated by Elbers et al. (2001), Elbers et al. (2002) and Elbers et al. (2003); they suggest that none of the signs or pathological lesions, alone or in combination, are sufficiently sensitive or specific for CSF. They recommend the use of laboratory tests to distinguish CSF from other diseases that present similar signs, in particular African Swine Fever (ASF), porcine reproductive and respiratory syndrome (PRRS), and bacterial septicaemia or pneumonia (Sandvik *et al.* 2005). In this study, laboratory tests were used in conjunction with participatory methods to increase the accuracy of the diagnoses made.

CSF is thought to be endemic in India -- farmers involved in the study could enumerate most of the clinical signs associated with the disease. Phylogenetic analyses of CSFV isolates show that CSF viruses circulating in the country belong to sub-groups 1.1 and 2.2 with the predominance of the former group (Patil et al., 2010). It has not been assessed, however, whether clinical presentation and epidemiological profiles of CSF vary with CSFV serotype as has been reported for other viruses such as blue tongue virus (Brenner et al., 2011). This would have implications on the disease surveillance particularly in remote areas where syndromic surveillance could play an important role. It is assumed that the clinical syndrome described in this study relate more with the serotype 1.1 given that CSFV isolated from Assam belong to this subgroup (Sarma et al., 2009).

Measures of CSF-burden that are available in the literature have been obtained from surveillance activities implemented in the course of the disease outbreaks. Kumar et al. (2007), for example, indicated that the morbidity, mortality and case fatality rates of the disease following an outbreak in Punjab state were 88.2%, 77.5% and 87.8% in piglets $\leq$3 months of age and 20.5%, 8.2% and 40.0% in older pigs, respectively. Clinical signs observed included high fever, erythema of the skin of the ears, abdomen, and medial thighs, and greenish watery diarrhoea. Nandi et al. (2011) also reported that 63.3% of the samples collected from 12 states in India had CSFV antibodies while 76.7% of the samples collected from 13 states had CSFV antigens. The case fatality rates obtained from this study approximate those published by Kumar et al. (2007) but the incidence estimates vary because they measure different but related events. Incidence estimates published by Kumar et al. (2007) represent the number of animals affected in the CSF outbreaks studied while those obtained from this study represent the rate at which villages are affected by CSF outbreaks over a period of one year. All these findings show that young pigs suffer heavier mortalities compared to older animals. Wright et al. (2010) have characterised husbandry systems (feeds, housing, and breeds and breeding) used to raise pigs in north-eastern India. Their observations are very similar to those reported in this study. In general, most villages used low input-output husbandry systems. Given that the participants identified pig farming as the most promising source of income, this sector has the potential to grow provided that the constraints identified (i.e., lack of feed and poor feeding management, lack of capital, diseases and poor method for managing them and lack of adequate knowledge on pig farming) are addressed.

The husbandry systems described in the study are associated with low biosecurity standards especially in Assam where a large proportion of villages kept pigs under free range system. Pigs raised in such a systems would have a greater risk of coming into direct or indirect contact with contaminated material, visitors and domestic or wild animals. Most villages in all the states also used unprocessed leftover food, residues of local beer and food feed crops as pig feed. The use of leftover food heightens the risk of introduction of CSF and other diseases such as foot and mouth disease, swine vesicular disease, transmissible gastroenteritis among other diseases. It is recommended that food waste or garbage fed to pigs must be heat-treated before being used to reduce the risk of disease transmission. With regard to the types of breeds kept, both native and improved pig breeds are fully susceptible to CSF infection (Blacksell et al., 2006). Native breeds, and to some extent cross-breeds such as those raised in the study area, however demonstrate longer survival times, have delayed onset of viraemia and pyrexia compared to improved pigs. This contributes to the maintenance and spread of the disease (Blacksell et al., 2006). With regard to pig marketing, Deka et al. (2008) have identified some of the biosecurity breaches that are likely to exacerbate the transmission of the disease. Traders often move from one farm to another looking for pigs to buy. Pigs purchased are often transported on bicycles, vans or public service vehicles. Mortalities encountered during transportation are usually slaughtered immediately and kept in cool boxes.

Livestock farming (with pigs playing the dominant role) was the second most important source of livelihoods; this implies that the impacts of CSF were expected to be substantial. This study attempted to evaluate the costs of CSF at the farm level while cognisant of the fact that its economic impacts are much more complex and go beyond the immediate impacts on producers. The analyses did not also account for farmer adaptations, for example engaging in other livelihood activities in the event of an outbreak or market price adjustments (depending on whether the commodity produced can be consumed locally or exported from the affected area). The costs obtained are therefore not absolute but they should be considered as being indicative of the CSF losses. Productivity losses, for instance, were not fully analysed given that it has numerous parameters that are often difficult to determine in the village settings (e.g. amount of feed used and change in the conversion ratio, change in growth rates, delayed maturity rates, etc. Some of the productivity losses are long-term as their effects drag on for a prolonged period of time. There is also scanty information in the literature on the magnitude of these losses. Otte (1997) found out that productivity impacts of CSF in Haiti amounted to USD $ 2.7 million per year. Analyses of the treatment costs indicate that farmers spent about USD $ 450,000 in an attempt to treat CSF yet it is expected that reactive interventions do not work well particularly when implemented haphazardly. The government needs to develop a CSF intervention program given the fact that the control of a transboundary disease requires well coordinated regional programs. Future analyses of the costs of CSF in the NE India should therefore include the expected benefits from control interventions so as to inform the development of an inclusive CSF control policy.

CSF can be eradicated through stamping out of infected and in-contact pig herds with destruction of carcasses. This however requires prompt identification and diagnosis to delineate affected herds. There are also concerns about the feasibility, costs and acceptability of such a measure. Alternative interventions include enforcement of sound biosecurity measures on-farm (Pritchard *et al.*, 2005) in addition to vaccination. In cases of emergency responses, a modified live vaccine should be used since immunity develops rapidly following its administration (Suradhat *et al.* 2001; Van Oirschot 2003). The usefulness of vaccination campaigns have however been constrained by lack of effective vaccination regimes. Some of the factors that should be considered while developing a sound vaccination regime include: (i) presence of colostral antibodies in young animals, (ii) pig population dynamics and movement patterns, (iii) production system and presence of wild hogs in the target area, and (iv) the epidemiology of the disease.

5 Conclusions

This was a preliminary participatory epidemiological study aimed at collating information on the incidence and impacts of CSF from farmers and a few key informants in the NE India. The conclusions drawn from the study include the following:

- Pigs are kept by a majority (slightly over 80%) of the households in the NE India. Pigs are also considered as being the most promising source of income in the area. However, further development of the of the existing pig enterprises is constrained by: (i) lack of feed and poor management practices, (ii) lack of capital and (iii) infectious diseases and poor infrastructure for managing them.

- The incidence, morbidity and case fatality rates of CSF were estimated to be 5.4% (95%CI: 3.5 – 8.0), 28.1% (95% CI: 20.4 – 36.6%) and 51.1 – 94.5%, respectively. Piglets, as expected, suffer higher morbidity and mortality rates compared to the other age categories. The study also shows that an outbreak of CSF lasts for about 36 days (95% CI: 19.0 – 53.8). This implies that CSF outbreaks run their full epidemic course as there is not an adequate infrastructure for implementing response measures. Behavioural practices such as selling off infected/potentially infected animals in the face of an outbreak by farmers in a bid to avoid mortality losses promote the transmission of the disease.

- Some of the husbandry practices used by the local producers such as use of untreated left-over food as pig feed, free ranging/tethering, and lack of proper housing are important risk factors for CSF transmission. Native pig breeds could also be playing an important role in the epidemiology of the disease. Ecological studies need to be done to assess the relative impact of the native (kept by a majority of the farmers) verses exotic pig breeds that are being raised by a majority of the farmers on the epidemiology of the disease. It is known that native breeds have longer survival rates compared to exotic breeds and therefore shed the virus in small quantities over a prolonged period of time.

- Farmers spent up to USD $ 450,000 to treat animals that contract the disease yet their uncoordinated interventions do not help in controlling such a trans-boundary disease that has a high incidence and morbidity rates. Farmers in the area also incur huge costs from mortality and productivity losses and the government should urgently develop a CSF control program.

6 References

Anon, 2004. Manual of diagnostic tests and vaccines for terrestrial animals, 5th ed. Pp. 1-19

Barman, N.N., Nath A.J., Hazarika, M.P., Barman, B., Thakuria, D., 2003. Outbreak of classical swine fever in regularly vaccinated pig herd. Indian Journal Comparative Immunology and Infectious Diseases 24, 89-90.

Basheer, A. D., Azimi, S., Sood, S., Sharma, A. K., Kumar, G. S., 2009. An outbreak of classical swine fever (CSF) in Jammu region (India): A pathomorphological study. Indian Journal of Veterinary Pathology. 33, 101 – 102.

Blacksell, S. D., Khousny, S., Van Aken, D., Gleeson, L. J., Westbury, H. A., 2006. Comparative susceptibility of indigenous and improved pig herds to classical swine fever virus infection: practical and epidemiological implications in a subsistence-based, developing country setting. Tropical Animal Health and Production. 38, 467 – 474.

Brenner, J., Batten, C., Yadin, H., Bumbarov, V., Friedgut, O., Rotenberg, D., Golender, N., Oura, C. A. L., 2011. Clinical syndromes associated with the circulation of multiple serotypes of blue tongue virus in dairy cattle in Israel. Veterinary Record. 169, 389.

Das, P., Ghosh, S.S., Dutta, M., Sonowal, D.K., Mehta, S.N., Borthakur D.N., 1983. Resources Inventory, Kohima district (Nagaland). ICAR research complex for NEH region.

Deka, R., Thorpe, W., Kumar, A., Lapar, M.A., 2008. Assam's pig sub-setor: current status, constraint and opportunities, International Livestock Research Institute (ILRI), New Delhi.

Elbers, A. R. W., Bouma, A., Stegeman, J. A., 2002. Quantitative assessment of clinical signs for the detection of classical swine fever outbreaks during an epidemic. Veterinary Microbiology. 85, 323-332.

Elbers, A. R. W., Moser, H., Ekker, H. M., Crauwels, P. A. A., Stegeman, A., Smak, J. A., Pluimers, F. H., 2001. Tracing systems used during the epidemic of classical swine fever in the Netherlands, 1997-1998. Revue scientifique et technique Office International des Épizooties. 20, 614-629.

Elbers, A. R. W., Vos, J. H., Bouma, A., Van Exel, A. C. A., Stegeman, A., 2003. Assessment of the use of gross lesions at post-mortem to detect outbreaks of classical swine fever. Veterinary Microbiology. 96, 345-356.

Francki, R.I.B, Facquet C.M., Knudson, D.L., Brown F., 1991. Fifth report of the Internatioanl Committee on Taxnomy of Viruses, Archives of Virology, suppl. 2, 223-233.

Mariner, J., Paskin R., 2000. FAO Animal Health Manual. Manual on Participatory Epidemiology. Rome 2000. www.fao.org/docrep/003/x8833e/x8833e05.htm.

Murti, P.S.R.C., Hazarika, G.C, 1982. Retrospective epidemiological studies on common diseases of livestock and poultry in Meghalaya. Journal of Research, Assam Agricultural University. 3, 56-59

Nandi, S., Muthuchelvan, D., Ahuja, A., Bisht, S., Chander, V., Pandey, A. B., Singh, R. K., 2011. Prevalence of classical swine fever virus in India: a 6-year study (2004 – 2010). Transboundary and Emerging Diseases. 58, 461 – 463.

Otte, M. J., 1997. Consultancy report on cost-benefit of different vaccination strategies for the control of classica swine fever in Haiti. FAO, Rome.

Patil, S. S., Hemadri, D., Shankar, B. P., Raghavendra, A. G., Veeresh, H., Sindhoora, B., Chandan, S., Sreekala, K., Gajendragad, M. R., Prabhudas, K., 2010. Genetic typing of recent classical swine fever isolates from India. Veterinary Microbiology. 141, 367 – 373.

Rahman T., Sarma D.K., Baruah, G.K., Chakraborty, A., Pathak, D.C., Goswami, S., Tamuli Rajbonghsi, G., 2007. Isolation and characterisation of classical swine fever virus, M.V.Sc thesis, Assam Agricultural University

Sandvik, T., Crooke, H., Drew, T. W., Blome, S., Greiser-Wilke, I., Moennig, V., Gous, T.
Sarma P.C., Sarma, D.K., 1998. Isolation and characterization of virulent strain of hog cholera virus from field outbreaks. Indian Journal Virology. 14, 41-42

Sarma, D. K., Mishra, N., Vilcek, S., Rajukumar, K., Behera, S. P., Nema, R. K., Dubey, P., Dubey, S. C., 2009. Phylogenetic analysis of recent classical swine fever virus (CSFV) isolates from Assam, India. Comparative Immunology, Microbiology and Infectious Diseases. 34, 11 – 15.

Suradhat, S., Intrakamhaeng, M., Damrongwatanapokin, S., 2001. The correlation of virus-specific interferon-gamma production and protection against classical swine fever virus infection. Veterinary Immunology and Immunopathology. 83, 177-189.

Van Oirschot, J., 1986. Hog Cholera In: Disease of Swine. Lowas State University press, USA, pp. 289-300

Verma, N.D., 1988. An outbreak of swine fever in Mizoram state. Indian Journal of Animal Science 58, 774-776.

Wright, I.A., Deka, R., Thorpe, W., Lapar, M. L., 2010. The pig sector in the northeast India: status, constraints and opportunities. A paper presented at the international symposium "Sustainable Land Use and Rural Development in Mountainous Regions of South East Asia, Hanoi 21-23 July, 2010.

7 Appendices

Appendix 1. Program used for the participatory epidemiology training

Day 0, Sunday 29/5/2011	Arrival at the hotel
Day 1, Monday , 30/5/2011	
8.30 – 10.30	Introductions – Objectives of the CSF study/Objectives of the training Participatory Epidemiology: theory and its role in the study
10.30 – 11.00	Break
11.00 – 13.00	CSF – presentation of the disease CSF case definition, sensitivity and specificity
13.00 – 14.00	Break
14.00 – 15.30	Semi-structured interviews, introduction of the survey to community, Running an interview – dos and don’ts
15.30 – 16.00	Break
16.00 – 17.00	Practice on how to introduce the survey to the community
Day 2, Tuesday, 31/5/2011	
8.30 – 10.30	Review Types of PE tools: Ranking and scoring; Visualization; transect walk
10.30 – 11.00	Break
11.00 – 13.00	Proportional piling/exercise
13.00 – 14.00	Break
14.00 – 15.30	Relative incidence scoring/exercise
15.30 – 16.00	Break
16.00 – 17.00	Disease impact matrix scoring/Other ranking techniques
Day 3, Wednesday, 1/6/2011	
8.30 – 10.30	Review Timeline/exercise
10.30 – 11.00	Break
11.00 – 13.00	Mapping/exercise
13.00 – 14.00	Break
14.00 – 15.30	Qualitative livelihood impacts – matrix scoring
15.30 – 16.00	Break
16.00 – 17.00	Quantitative livelihood impacts – checklist of questions
Day 4, Thursday, 2/6/2011	
8.30 – 10.30	Data forms/summaries and database
10.30 - 11.00	Break
11.00 – 13.00	Review of methods for analysing PE data
13.00 – 14.00	Break
14.00 – 17.00	Exercises
Day 5, Friday, 3/6/2011	

9.00 – 13.00	Field practice
13.00 – 14.00	Break
14.00 – 17.00	Review
Day 6, Saturday, 4/6/2011	
9.00 – 13.00	Field practice
13.00 – 14.00	Break
14.00 – 17.00	Review
Day 7, Sunday 5/6/2011	
8.30 – 10.30	Selection of villages/coding and identification of teams/coding
10.30 – 11.00	Break
11.00 – 13.00	Teams to develop work plans
13.00 – 14.00	Lunch
14.00 – 15.30	Wrap up