Scientific Assessment Report

On

Bamboo Flowering, Rodent Outbreaks and Food Security: Rodent ecology, pest management, and socio-economic impact in the Chittagong Hill Tracts, Bangladesh

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UNDP
UN Offices, 18th Floor
IDB Bhaban
Agargaon, Sher-e-Bangla Nagar,
Dhaka 1207
Bangladesh

This report has been prepared by a team of authors drawn from many of the major research institutions and universities of Bangladesh, including Government and Non-Government institutions involved in the rural livelihood development sector and experts on rodent pest management research and knowledge extension. This team of authors has been led by the international expert on rodent ecology and management, Dr Steven Belmain from the Natural Resources Institute, University of Greenwich in the United Kingdom, who has worked in collaboration with many institutions within Bangladesh on improving the way in which rodent pests are managed. Dr Belmain is currently involved in the DFID-funded project Rat Management for Rural Communities in Bangladesh.

We, the below undersigned, declare ourselves to be the joint authors of this manuscript and have contributed to its preparation at the request of the United Nations Development Programme. We approve the contents of this manuscript and support its recommendations.

Md. Sayeed Ali
Director, Plant Protection
Department of Agriculture Extension (DAE)

Dr. Nazira Q. Kamal
Formerly: Head of Entomology, Director of Research and Director of Administration at Bangladesh Rice Research Institute (BRRI)

ATM Hasanuzzaman
Scientific Officer
Vertebrate Pest Division
Bangladesh Agricultural Research Institute (BARI)

Udayan Dewan
Director, Program and Communication
Organization for the Poor Community Advancement, Mirsarai, Chittagong

Mohammad Harun
Rodent Extension Specialist
AID-COMILLA
DFID-funded Rat Management for Rural Communities

Abul Kalam Azad
Community Extension Specialist
AID-COMILLA
DFID-funded Rat Management for Rural Communities

Dr. S.M. Fakhrul Islam
Professor
Department of Agricultural Economics
Bangabandhu Sheik Mujibur Rahman Agricultural University

Dr. Santosh Kumer Sarker
Formerly: Chief Instructor (Rodent Specialist) at at Department of Agriculture Extension (DAE)

Dr. Noor Jahan Sarker
Professor
Department of Zoology (Wildlife)
University of Dhaka

Dr Sohrab Uddin Sarker
Professor
Department of Zoology (Wildlife)
University of Dhaka

Md. Nazmul Islam Kadry
Community Extension Specialist
AID-COMILLA
DFID-funded Rat Management for Rural Communities

Lalit C. Chakma
Executive Director
Strategic Actions Society (SAS)
Rangamati, Chittagong Hill Tracts

And

Dr Steven Belmain
Team Leader & Rodent Ecologist
Natural Resources Institute, University of Greenwich
United Kingdom

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Acronyms and Terminology

AID-Comilla: Association for Integrated Development, Comilla
BARI: Bangladesh Agricultural Research Institute
BSMRAU: Bangabandhu Sheik Mujibur Rahman Agricultural University
CHT: Chittagong Hill Tracts.
DAE: Department of Agriculture Extension
District: The largest administrative unit, of which there are three in the CHT: Bandarban, Khagrachari, and Rangamati.
DU: Dhaka University
EBRM: Ecologically-Based Rodent Management, a concept of rodent management similar to Integrated Pest Management that aims to generate and use knowledge on rodent biology, behaviour and ecology to more effectively target management resources at the right time and place. EBRM aims to be environmentally sustainable and cost-beneficial for end users of EBRM.
FGD: Focus Group Discussion
FUO: Fever of Unknown Origin, a clinical category widely used when diagnostic screening has been unable to establish the causative etiologic agent or when diagnostic tests are unavailable
Hill District Council: Local governmental structures set up in each district after the signing of the 1997 peace accord.
Jhum: Rotational slash and burn cultivation practiced on steep hillsides by indigenous peoples of the CHT.
Jhumias: People who practice jhum cultivation.
Karbaris: Local village-level elected leaders, the lowest level of leadership in the traditional system of tribal governance.
NRI: Natural Resources Institute of the University of Greenwich, UK
Para: The administrative unit beneath Union level.
Regional Council: A local governmental structure set up after the signing of the 1997 peace accord.
UNDP: United Nations Development Programme.
Unicef: United Nations Children's Fund.
Union: The administrative unit beneath Upazilla level.
UP: Union Parishad: lowest level of government administration; committee membership is elected at the Ward level.
UPCs: Union Parishad Committees.
Upazilla: The administrative unit beneath District level.
WFP: United Nations World Food Programme.
WHO: United Nations World Health Organisation.
Zoonosis (pl. zoonoses): Any infectious disease that is able to be transmitted (vectored) from wild or domestic animals to humans. This includes all diseases with an animal origin such as malaria, dengue, rabies, ebola, leptospirosis, influenza, west nile virus, plague, sleeping sickness, leishmaniasis, crimean-congo hemorrhagic fever, yellow fever, bilharzia, anthrax, lassa fever etc. The pathogen may not actually cause disease symptoms in the animal, but when transferred to humans, it results in illness. Rodents are known reservoirs and vectors for more than 60 different zoonotic diseases transmittable to humans.

Executive Summary

Rodent population outbreaks following gregarious bamboo flowering is a real and scientifically accepted phenomenon occurring in the Bengal Bay eco-region (India, Bangladesh, Myanmar) as well as in other parts of the world where bamboo naturally grows. The dominant bamboo species in the region flowers on a 40-50 year cycle. Expansion of the rat population occurs through the provision of large quantities of bamboo seed, which the rats eat and use to fuel their reproductive rate. When the bamboo seeds eventually become scarce, the rats move out into agricultural fields and rural communities in search of food, eating everything they can find.

Damage to people's livelihoods is severe. Rodent damage levels in the Hill District communities are conservatively 4-5 times greater than that seen in the flood plain areas of Bangladesh. In addition to the destruction of nearly all field crops, the rats get into people's houses, eating stored food and damaging all sorts of personal possessions and biting people while they sleep. Higher incidence of fevers of unknown origin (FUOs) and increased dysentery is documented in affected communities and most likely attributed to several different rodent-borne diseases known to be present in Bangladesh. However, the causes of the increased incidence of disease have not been clinically confirmed. There is an increased potential threat of bubonic plague entering Bangladesh over the Myanmar border due to large numbers of dispersing rodents moving out of this plague-endemic country. The chances of plague re-entering and establishing endemicity in Bangladesh are greater now than they ever have been, with national economic security consequences for Bangladesh if this were to transpire through the imposition of a national quarantine as occurred to India in 1994 due to a small plague outbreak in Surat.

Technical and managerial solutions exist to help reduce the impacts of rat floods on people's livelihoods and avert potential disasters. Mitigating the effects of rat floods upon livelihoods is possible by empowering communities to more effectively manage the rat outbreaks through a combination of training and demonstration programmes that provide knowledge and better technology and tools for dealing with the outbreak.

Further research to understand the ecology of rodent outbreaks and the bamboo ecosystem is urgently required. An increased understanding of the ecosystem changes caused by bamboo flowering would help the development of ecologically-based rodent management strategies, optimising indigenous knowledge systems and lead to better targeting of actions where rodent outbreaks are predicted to be most severe. This knowledge would not only assist during the current crisis but help prepare the country for the next outbreak in 50 years' time.

Rat floods are certainly occurring this year and next year in many parts of the CHT, with rat floods in 2010 also likely in localised areas of the Hill Districts where bamboo forests are found. This will be followed by a 5-6 year period of bamboo regeneration during which time bamboo resources will be extremely limited at a national level.

The joint-authors of this report propose that Government adopts a cross-departmental strategy that builds on the experiences of a similar strategy employed by the Mizoram State Government to deal with the multi-sectoral problems caused by the ecological upheaval induced by periodic bamboo flowering. The components of this strategy are proposed as follows: 1) community training and capacity building programme; 2) ecosystem research; 3) formation of a bubonic plague action committee; 4) fire prevention; 5) economic reconstruction; 6) health research; 7) law & order and emergency relief; and 8) publicity and awareness campaign

Introduction and Background

The potential ecological and socio-economic problems associated with bamboo flowering and rat floods came to the attention of the UNDP through its CHT-based field staff as well as through a number of national and international media reports that have highlighted a growing food crisis across communities in the CHT. Through the UNDP's long-term development work in the CHT alongside the WFP, UNICEF and other stakeholders, a multi-agency joint-assessment mission was carried out to assess the food security situation in the CHT. This response was further followed up with detailed studies to assess the nutrition and health status of affected communities (see references Annex II) and with short-term distribution of emergency food rations. However, it is accepted that the response to the event so far does not reflect either a careful analysis of the broader long-term socio-economic consequences of bamboo-flowering and rat-related ecological disruption, nor do they represent a strategic, long-term, sustainable response to managing the rat problem or ameliorating it's long-term effects. What is popularly known is mostly rooted in poorly documented case studies, historical anecdotes, and media reports from the most recent historical rodent-crisis event which occurred in Mizoram State in the years 1958-60. This event is known to have produced a regional famine, and is widely credited with creating severe socio-political disturbances and being the trigger which led to the Mizoram Uprising in 1966, followed by a protracted 20-year armed insurrection against central Indian authority. As current understanding of the complex, long-term dynamics of this bamboo flowering-related rodent crisis is inadequate, the UNDP has commissioned this scientific report to provide all stakeholders with an academically grounded understanding of the rat flood phenomenon. The terms of reference for this UNDP-sponsored mission were to:

- Develop a comprehensive, practical, evidence-based understanding of the current scope and severity of the rat crisis across multiple sectors.
- Develop an academically grounded, evidence-based set of projections which reflect most-likely long-term negative impacts across multiple sectors, and which specifically will describe: a.) A likely scenario of how the problem will evolve; b.) Most likely long-term negative impacts; and, c.) Likely program impacts in the mid- to long-term.
- Develop a detailed list of programming options and recommendations for rodent management response rooted in a comprehensive analysis of the ecology and biology of rodents and the economic effects of severe rodent infestations, with specific emphasis on protecting the livelihoods and income-earning potential of people living in rat-affected areas.

Based on the above objectives and because of the complex ecological and socio-economic issues surrounding rodent outbreaks, a team of scientific experts was fielded from all the major academic and development institutions of Bangladesh with relevant expertise and experience to assist in the collection of information and in the writing of this report. The author list draws on expertise related to rodent ecology, bamboo ecology, community extension, agricultural economics, plant protection, pest management, sociology, anthropology and wildlife. Institutions involved in this report include the Plant Protection Wing of the DAE, the Vertebrate Pest Division of BARI, the Zoology Department of DU, the Agricultural Economics Department of BSMRAU and several NGOs including AID-Comilla that leads research and training programmes on community-based rodent management. This team of experts has been led by Dr Steven Belmain from the Natural Resources Institute in the United Kingdom who has spearheaded research and development actions on ecologically-based rodent management in Bangladesh since 2002.

Methodology

The information summarised in this report is based on two primary methodological sources:

1) A comprehensive collection and analysis of existing publications and written information (scientific, historical, current press, and "grey" institutionally-based literature) from all global sources related to bamboo flowering and rodent outbreaks.
2) A field-based mission by the joint authors of this report from 17-31 October 2008 to meet as many of the relevant stakeholders with knowledge on the issue as possible.

Detailed summaries of information collected can be found in Annexes 1-6.

For the field-based mission the objectives were to speak to a number of stakeholder categories including:

1) Local government
2) Local NGOs
3) Local DAE officers
4) Regionally-based academics
5) Local community representatives and community members
6) International agencies and NGOs

In most cases, information was collected through informal discussions and interviews with the project team meeting stakeholders in meetings held in Dhaka, Rangamati and Bandarban (see Annex IV). Additionally, the team was split in two, with a small group going to Thanchi Upazilla and a larger group going to Ruma Upazilla, Bandarban District. These areas were selected based on existing knowledge related to the status of bamboo flowering and rat floods as well as being reached in practical terms within the mission time frame.

Ruma was selected as an area where bamboo is currently flowering on a large scale, with some flowering having occurred last year. In addition to interviews with community members, information was collected using Focus Group Discussions and Participatory Rapid Appraisals. There was an expectation to target village elders who may remember previous bamboo flowering events and key people who may know about rat floods and bamboo flowering from the communities. The information collected by the mission team around village-level activities was related to:

1) Cropping calendar and patterns and crops grown
2) Bamboo flowering and fruiting calendar
3) Calendar of rat damage and severity – to crops
4) Rat damage to everything else – food store, possessions, structures, clothes, blankets. etc.
5) Rat control actions taken by communities and perceived results
6) Family members recently bitten by rats – who, where on body, when
7) Food availability – how often and how much are family members eating
8) Economic and social cost of rat problems

Additionally, the team were to take notes and to collect photographic and video documentation of the:

1) Forest environment – bamboo taxonomy and physiology
2) Rat damage - field crops, house, food stores, personal possessions, rat bites
3) Rat activity – runs, burrows, traces, actual rats

Thanchi was selected as an area currently experiencing high rodent damage. In addition to collecting all the information as above, this team brought with them 150 rat traps and associated equipment to carry out a systematic collection of rodent specimens. Rodents that were captured would be typed, sexed and weighed. External information on the individual's breeding condition (i.e. level of maturity) was recorded for all specimens captured. All female specimens captured were additionally dissected to collect internal breeding condition data (e.g. uterine condition, presence of uterine scars and embryos). Representative samples of rat types were to be preserved in 70% alcohol and returned to base for taxonomic confirmation.

Findings

Awareness about the bamboo flowering and rat flood phenomenon in the CHT was high among all CHT stakeholders with whom the project team met, including communities, local government officials, local NGOs, DAE officials, international agencies and within the CHT Ministry. All stakeholders accepted that the phenomenon is real, that is has occurred previously 50 years ago and will occur again in the future in another 50 years' time. This bamboo flowering cycle is unequivocally accepted across the scientific community as are the rodent population outbreaks that subsequently arise.

Despite this awareness, detailed systematic surveys and documentation about the scale of the problem, the localities affected and the extent of field crop and other rat damage are limited. This lack of information is partly due to the remoteness and lack of communication into many areas of the CHT. It is also partly due to the nature of the ecological phenomenon, where the effects are patchy, highly localised events occurring over a period of years. For example, communities which are relatively nearby each other (e.g. 5-10 km apart) can experience very different outcomes, with some communities badly affected last year, some this year and some to be affected next year. Local understanding within communities and historical literature confirm that synchronised bamboo flowering proceeds in waves. As yet, we do not know for certain if the food crisis will extend beyond 2010; however experience from Mizoram suggests further flowering in the CHT is likely in 2009, leading to rat floods in 2010.

Understanding the scale of the problem is, furthermore, affected by a general lack of understanding of the ecological processes that underpin the rat floods. For example, our short mission to the CHT identified at least one previously undocumented rodent species that is not found elsewhere in Bangladesh. It is not yet clear whether this is a totally new species of rodent with unknown behaviours and habits or related to species more commonly found in Myanmar. The generally accepted hypothesis within the scientific community is that bamboo seeds are eaten by rats, promoting an improved nutritional state for rats that can go on to produce larger and more frequent litters of young. The severity of impact will be related to how large the rat population grows in a given area, which itself will vary based on the abundance of flowering bamboo, and the timing and abundance of bamboo seed that is produced in the forest. Thus, impacts on people's livelihoods will also be based on the quantity of bamboo growing in proximity to jhum fields and community households. A summary of what is scientifically known about the bamboo flowering and rat flood phenomenon can be found in Annex I.

Knowledge and information collected on the effects of rat floods has largely focussed on field crop loss. The general consensus across all stakeholders is that many jhum fields can be totally destroyed during rat floods with harvests during rat floods being 10-20% of normal harvests in comparison to non-rat flood years. All food crops grown are badly affected including rice, maize, pineapple, potato, beans, and all other vegetable and fruit crops grown. Farmers anticipate such losses when the bamboo starts to flower and have evolved various coping strategies. These include 1) planting alternative non-food crops such as ginger or turmeric instead of rice and maize; 2) ceasing to plant jhum fields altogether; 3) building trap-barriers around their jhum fields to keep rats out of their crops; 4) diversifying their incomes through the production of handicrafts and selling non-agriculturally based products in order to buy food during the time of rat floods. However, the small-scale subsistence agriculture practiced in most of the CHT, and their remoteness from established markets means that most CHT communities are left with little alternative but to plant their jhum fields, knowing that they will experience high yield losses due to the imminent rat floods.

Outside of communities, knowledge and information on other effects of the bamboo flowering (besides field crop damage) is not routinely recognised by most stakeholders. CHT communities report that a range of problems become more severe during bamboo flowering events, including much higher loss and contamination of stored food, damage to clothes, blankets and other personal possessions stored at the household level, increased incidence of rat bites, increased disease outbreaks (particularly increased dysentery and fevers of unknown origin) and increased field crop damage due to wild pigs and birds. During rat floods, many households have to stand guard over their stored food through the night to ensure it is not all eaten by rats by the morning.

These multiple effects on their livelihoods are then followed by several years where bamboo resources become extremely scarce as the bamboo must regenerate from seed. As this regeneration

process is accepted to take 5-6 years, the supply of bamboo for house construction/repair, for manufacturing household goods and for selling at local markets is severely affected. A summary of what is known about the socio-economic consequences of bamboo flowering and rat floods is summarised in Annex II.

As is commonly found within all societies around the world, there is a strong sense of fatalism among CHT communities when dealing with their rodent pest problems. Many believe that very little can be done to stop the rat floods and mitigate the damage caused to their livelihoods. Apathy arises through this belief that "nothing can be done" as informed through repeated personal failures to effectively manage rat problems using local knowledge and resources. Although rat floods are certainly a challenge to manage, experience from elsewhere in Bangladesh and from around the world indicates that communities can be empowered to effectively control their rodent pest problems. Improving the knowledge and capacity of rural agricultural communities and arming them with better rodent management tools has been shown to be highly effective in the flood plains of Bangladesh as well as within many other agro-ecological contexts stretching from Southeast Asian countries such as Vietnam and Indonesia and African countries such as Tanzania and Namibia. A knowledge extension programme for community-based rodent management is currently ongoing in several areas of Bangladesh. Further information on this programme is available through http://www.nri.org/bandicoot. Adapting this community training programme to the agro-ecological and cultural conditions found in the CHT would be relatively easy. As their priority need related to external assistance, all CHT community members spoken to during the mission strongly expressed their desire for training and the provision of improved/new technologies.

Conclusions

The likely economic impacts that the rodent crisis will have on household livelihoods are severe across the short-, medium- and long-term. The immediate direct effects of the rat floods on food security and health effect individual households over at least two years as the flowering event proceeds in waves that have differential affects on the jhum fields used by each household. Lack of food over such a prolonged period of time is likely to affect the physiological development and brain development of children, and itself lead to health problems for all age groups through weakened immune systems. Food-aid relief to affected communities must remain a priority issue and continue for 2-3 years or until socio-economic stability can be re-established. We can confirm that many communities will be affected with rat floods in 2009. It can not be confirmed whether further bamboo stands will flower in 2009, but it is likely based on how the event recently transpired in Mizoram State and in historical contexts. Food security is likely to remain an important issue for many households across the CHT for at least another 3 years due to ongoing rat floods as well as through the recovery period where households try to rebuild their livelihoods, replace rat damaged essential goods and deal with consequences of prolonged bamboo regeneration.

The risks of rodent-borne diseases (zoonoses) remain unquantified, and it is not possible to separate confounding factors of nutritional state and potential rat-borne diseases as explanatory factors for the reported increased incidences of dysentery and fevers of unknown origin (FUOs). Rat-borne diseases such a leptospirosis and typhus are well-known to occur throughout South and Southeast Asia. Clinical recognition and diagnoses of rat-vectored diseases are not routinely carried out in Bangladesh through low awareness and symptomatic confusion with more recognised diseases such as dengue and malaria. Evidence from elsewhere in Southeast Asia has highlighted that many rat-diseases go undiagnosed and account for 30-50% of all FUOs.[1] We do know that the prevalence of rodent-borne diseases becomes high within outbreaking rat populations. This is because transmission of viruses and bacteria between rats is facilitated through higher rat numbers, which means that rats come into contact with each other more frequently. Without further evaluation, it will not be possible to understand which rat-borne diseases are present, and, indeed, whether these diseases are highly communicable among people (e.g. hantaviruses, arenaviruses, bubonic plague) or limited in their communicability (e.g. leptospirosis, typhus, salmonella). Diseases such as leptospirosis can be highly debilitating, taking several months to recover. Hence, there are mid- to long-term issues related to rat-borne diseases that debilitate and significantly reduce household productivity levels at key times of the year.

Bubonic plague deserves a special mention as the most famous of all rat-borne diseases. Plague continues to cause severe socio-economic consequences in endemic countries out of proportion to its mortality rates. Disproportionate resources are spent on the control of plague because of the highly contagious nature of plague and because its WHO notifiable status requires strict quarantine procedures. Currently, Bangladesh remains free of the plague. However, Myanmar is known to have endemic foci where the plague bacteria circulates, causing human cases almost annually. As the bamboo flowering event is also occurring in Myanmar, the chances of large populations of rodents dispersing with plague bacteria into Bangladesh remains a serious threat to national security. India faced a similar problem in 1994 where an unexpected outbreak of plague in Surat led to widespread panic and an international quarantine and embargo imposed on the entire country. This was estimated to have cost India more than $3 billion dollars through lost tourism, exports and other business. A poorly managed outbreak of plague in Bangladesh would be treated by the international community in a similar way with long-term negative public health and economic consequences for the entire country if human plague cases were to occur in the CHT.

Rat damage to household possessions such as clothes, blankets, mosquito nets, furniture, metal and plastic utensils is severe to extreme. Households will need to repair and buy many damaged items

[1] Peacock, S.J. and Newton, P.N. (2008) Public health impact of establishing the cause of bacterial infections in rural Asia. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 102: 5-6.
Phongmany, S., Rolain, J.M., Phetsouvanh, R., Blacksell, S.D., Soukkhaseum, V., Rasachack, B., Phiasakha, K., Soukkhaseum, S., Frichithavong, K., Chu, V., Keolouangkhot, V., Martinez-Aussel, B., Chang, K., Darasavath, C., Rattanavong, O., Sisouphone, S., Mayxay, M., Vidamaly, S., Parola, P., Thammavong, C., Heuangvongsy, M., Syhavong, B., Raoult, D., White, N.J. and Newton, P.N., (2006) Rickettsial Infections and Fever, Vientiane, Laos. *Emerging Infectious Diseases*. 12(2): 256-262.

after the rat floods, draining limited household finances and potentially diverting cash away from education and income diversification initiatives in the mid- to long-term.

The lack of bamboo over several years will have mid- to long-term impacts through limiting the amount of bamboo which can be sold. Households that heavily rely on selling bamboo to support their livelihoods will be severely affected for five to six years. Construction and repair to households and other goods made from bamboo is likely to limited, particularly affecting households who make and sell woven bamboo materials as one of their main livelihood activities. Commercial production of paper and other bamboo-derived products is likely to be severely affected. The lack of bamboo will affect national supplies, and Bangladesh may need to consider importing bamboo from elsewhere in the world to meet local demand.

Recommendations

There are several components to a potential intervention programme that is directed at protecting livelihoods and household level economic security from rat floods and other ecosystem changes caused by gregarious bamboo flowering. These components need to work in parallel with each other and require a degree of cross departmental coordination to be most effective. In this regard, we believe there is much to be gained by attempting to replicate the efforts of Mizoram State. In order to deal with the rat floods and avert a potential famine as experienced 50 years ago in Mizoram, the government of Mizoram developed a comprehensive strategy involving activities across 15 government departments. This five-year spending plan called the Bamboo Flowering and Famine Combat Scheme (BAFFACOS) of Mizoram State started in 2004, spending 4-6 million USD per year. Results from the first two years of this programme are available and can be downloaded through the following hyperlink[2] Government of Mizoram Achievement Reports on BAFFACOS during 2004-05 and 2005-06

The authors of this UNDP report advise Government to develop a similar cross-department strategy that at least involves the Agriculture, Health, Forestry, Environment, Education and CHT Ministries. Nearly all of the actions recommended below are relatively short- to medium-term actions that need to be implemented over the next 1-5 years. All the actions described below need to start in parallel and be implemented as quickly as possible. However, several of the actions should have longer-term timeframes, namely actions 1, 3, 5 and 6. The full effects of these four actions are likely to take longer than five years to deliver as they are dealing with the longer-term impacts of the rat floods on forest ecology and people's livelihoods that may only become apparent over more than five years.

1) Training and Capacity Building Programme: This programme could easily tie on to an existing funded programme (by DFID's Research Into Use Programme) on community-based rodent management. The programme is led the by NGO AID-Comilla and involves partnerships with the DAE, BARI and several regional NGOs working in different areas of the plain lands of Bangladesh. This well-established network has the existing infrastructure and experience to assist CHT communities to effectively manage the rat floods. The aims of this DFID-funded project are to train institutions, train communities, promote public-private partnerships with the rodent control industry, manufacture and distribute new traps and technology and build awareness about rodent pest problems and their sustainable control. Communities in the CHT have expressly asked for such training, and we believe the training and extension model developed over years of research in the plains of Bangladesh is the right one and can easily be adapted for the different agro-ecological and cultural contexts of the Hill Districts. Through the DFID programme, we ultimately expect a sustainable extension programme can operate without external input, with the investments required provided by communities and the private sector with delivery by the NGO sector. The UNDP has already taken the first step in such a programme by funding an institutional capacity building programme to train CHT leaders, NGOs and other institutional stakeholders on the concepts of ecologically-based rodent management. Further funding would be required to develop a community-based training programme. More information about the ongoing DFID programme is available at Rat Management for Rural Communities in Bangladesh [3] As highlighted in Annex I, effective rodent management options exist. Delivering the rights tools and knowledge to communities to deal with the rat floods and mitigating the damage caused to people's livelihoods is possible. We expect this will involve several actions, such as optimising the technology of rat flood barriers already used by some households, proofing food stores, intensive trapping with new-design rat traps, targeting control efforts at the right time and place and ensuring that communities understand that they must act together to make their actions ecologically-effective and cost-effective. Such a community-based programme should be implemented immediately with investment spread over at least two years.

2) Ecosystem Research: Bamboo forest ecology is entering a period of large-scale disruption. Many unexpected events are and will continue to occur within the food web and forest ecology for many years to come. Unfortunately, very little research has been carried out on this phenomenon in the past or, indeed, elsewhere in the world where such events happen. There is an urgent need to collect information and carry out research on 1) rodent population dynamics and efficacy of control strategies in the CHT, 2) the socio-economic impacts of rat floods and the loss of bamboo, and 3)

[2] http://www.nri.org/projects/bandicoot/docs/mizoram_gov_report.pdf
[3] http://www.nri.org/bandicoot

monitoring the timing of bamboo seed production and abundance and the underlying causes in order to develop a sampling strategy leading to targeted, prioritised actions. Such a programme should be implemented immediately with investment spread over three years so that the phenomenon can be accurately tracked. This will not only inform responses to the current crisis but ensure that stakeholders are better prepared when the event occurs again in 50 years' time.

3) Formation of Bubonic Plague Action Committee: There is no evidence that plague cases have occurred in Bangladesh to date as a result of the rat floods. However, there is a serious risk of the disease entering the country over the Myanmar border during this time of large rodent population outbreaks and large-scale migration of rodents. Myanmar is a plague-endemic country, and the bamboo flowering event occurring there will result in large populations of dispersing rodents in the years to come. This committee should be trying to establish links with the government of Myanmar and its plague-monitoring activities and with the WHO's Epidemic Readiness and Response Team. The committee should be focussed on putting systems in place to ensure early detection and recognition of plague cases, establishing chains of command, communication protocols and quarantine procedures in the event that plague cases do arise. A poorly managed outbreak of plague in Bangladesh could result in international quarantine procedures being put in place at a national level as occurred in India during the Surat plague outbreak of 1994.

4) Fire Prevention: Forest fires are not a usual phenomenon within the Hill Districts. However, the bamboo flowering event will result in large stands of dead bamboo, particularly in protected areas such as forest reserves. Lightning strikes within such stands could result in forest fires which spread out of control. At minimum, a risk assessment should be carried out to establish where and when forest fires might occur, taking remedial action by cutting down dead bamboo stands where necessary.

5) Economic Reconstruction: Livelihoods will be severely affected, and it is likely that CHT communities will be put back in development terms by several years. Although the cropping cycle will recover after the flowering cycle completes, the rat floods will have damaged livelihoods in more longer-lasting ways. For example, severe rat damage to clothes, blankets, mosquito nets, utensils and other personal essential goods will require replacement and household expenditure. Furthermore, it is widely accepted that the bamboo will take 5-6 years to regenerate. As the two species which have flowered, *Melocanna baccifera* and *Dendrocalamus hamiltonii*, comprise more than 80% of the bamboo grown, there will be severe impacts on bamboo supply and household livelihoods which depend on the harvesting, manufacturing and marketing of bamboo products. Efforts on the diversification of household incomes will need to be redoubled to take account of the loss of a major livelihood income stream.

6) Health Research: There have been increased reports of dysentery and fevers of unknown origin (FUOs) during rat floods. It is possible that a number of rodent-borne diseases are outbreaking, e.g. hantaviruses, arenaviruses, murine typhus, leptospirosis, gastro-enteric bacteria, haemorrhagic fevers. As yet, we do not know which diseases are responsible for this increased incidence. Nor do we understand the health impact of rat floods in the short- or long-term. Some diseases may cause prolonged debilitation, others may continue to persist even after the rat floods cease, others may spread their endemicity outside of initially affected areas of the CHT. In this regard, there is an urgent need to investigate the underlying causes of disease outbreaks, rodent zoonoses and disease identification.

7) Law & Order and Emergency Relief: There are increased reported cases of petty theft, larceny and child trafficking related to food shortages. The lack of food and the rat floods are leading to organised protests to local authorities, the holding of press conferences and increased international attention to the issue. As the rat floods are confirmed for 2009 and likely in 2010, there is a danger of escalation if food shortages are not adequately addressed, potentially leading to mass migration and/or increased inter-cultural tensions. To help preserve livelihoods in the short-term and avert disaster, there is an urgent need to increase food assistance programmes in rat flood affected areas.

8) Publicity and Awareness Campaign: There is an urgent need to raise awareness among the general public across Bangladesh society about the phenomenon. Although there have been several stories in the press, some of these are questionable in their accuracy, with both sensationalism and misinformation unintentionally occurring due to the difficulty of ensuring factual information is

accurately presented. We propose that a documentary film is professionally produced and broadcast in local language on rodents and bamboo flowering that includes surveys and interviews with farmers, scientists, footage of the rat floods, the damage caused and the potential solutions.

Annex I: Bamboo/Rodent Ecology

Executive Summary

Rodent population outbreaks following gregarious bamboo flowering is a real and scientifically accepted phenomenon occurring in the Bengal Bay eco-region as well as in other parts of the world where bamboo naturally grows. Expansion of the rat population occurs through the provision of large quantities of bamboo seed, which the rats eat and use to fuel their reproductive rate. The large amount of food in the environment means the rats can have larger litters more frequently over a longer period of time. When the bamboo seeds eventually become scarce, the rats move out into agricultural fields and rural communities in search of food, eating everything they can find.

Damage to people's livelihoods is severe. Rodent damage levels in the CHT are conservatively 4-5 times greater than that seen in the flood plain areas of Bangladesh. In addition to the destruction of nearly all field crops, the rats get into people's houses, eating stored food and damaging all sorts of personal possessions and biting people while they sleep. Higher incidence of "fevers of unknown origin" and increased dysentery is documented in affected communities and most likely attributed to several different rodent-borne diseases known to be present in Bangladesh. However, the causes of the increased incidence of disease have not been clinically confirmed.

Mitigating the effects of rat floods upon livelihoods is possible by empowering communities to more effectively manage the rat outbreaks through a combination of training and demonstration programmes that provide knowledge and better technology and tools for dealing with the outbreak.

Further research to understand the ecology of rodent outbreaks is urgently required. An increased understanding of the population dynamics and ecosystem changes would help the development of ecologically-based rodent management strategies, optimising indigenous knowledge systems and lead to better targeting of actions where rodent outbreaks are predicted to be most severe.

The rat floods are likely to continue for 1-3 more years in localised areas of the Hill Districts where bamboo forests are found. This will be followed by a 5-6 year period of bamboo regeneration during which time bamboo resources will be limited at a national level.

Introduction to Bamboo Ecology

Gregarious flowering and mast seeding of bamboo is a well-accepted phenomenon throughout the world. Bamboo flowering intervals are genetically triggered and range from less than 10 years to more than 120 years (Janzen, 1976). Mast seeding is an evolutionary strategy found across the plant Kingdom, most notably studied in oak, beech and other temperate zone tree species (Clotfelter et al., 2007; Kelly & Sork, 2002). Plants have evolved these strategies in order to ensure that not all of their seed is eaten and destroyed by seed predators (Stenseth, 1999; Wolff, 1996; Silvertown, 1980). By periodically flooding the environment with tremendous amounts of seeds, it is not possible for seed predators to eat it all, thereby ensuring that sufficient seed remains to germinate and produce new trees/bamboo. In other words, the plants are taking their predators by surprise so that predator populations are easily satiated.

The timing of seed masting events are species-specific and usually follow highly regular cycles. Climatic cues may inform and assist the synchronisation of flowering and seeding, but the process is strongly linked to the plant's genome. For this reason, bamboo flowering and seeding can not be "switched off", and it is not possible to stop bamboo from flowering. For example, if the bamboo is cut down before it flowers, it will flower immediately upon its regrowth.

There are well more than 30 species of bamboo growing throughout the Bengal Bay eco-region which stretches from Mizoram and Tripura States in India, through the CHT and into Chin State in Myanmar. The two dominant species of bamboo found within the Chittagong Hill Tracts (CHT), *Melocanna baccifera* and *Dendrocalamus hamiltonii*, flower on an approximate 40-50 year cycle and are responsible for the current flowering event. These two species comprise greater than 80% of all bamboo grown in the CHT region. The flowering event initiates in the north-eastern part of its home range and proceeds in south-westerly waves of flowering over a 3-4 year period in a given area. Hence the current flowering event started in Mizoram in 2004, reaching Bangladesh in 2007. The

flowering event is now largely over in Mizoram, where the flowering occurred over 4 years. Based on this and established understanding of the way bamboo flowering events proceed, we can expect the flowering cycle to continue until 2010 in the CHT. The event is also occurring in Myanmar, where it has started later and will carry on later, perhaps until 2012.

From historical records we know that previous flowering events involving *Melocanna baccifera* and *Dendrocalamus hamiltonii*, started in 1958 and 1910. Accounts of flowering events throughout history can be found in Daniel Janzen's 1976 review. The outbreak in 1958 and subsequent famine in Mizoram is widely accepted to have led to the Mizoram Uprising and the 20-year civil war that led to the creation of Mizoram State in 1987. This historical context resulted in a strongly proactive approach by the Mizoram State government during the 2004 outbreak, with the government developing and implementing a Bamboo Flowering and Famine Combat Scheme (BAFFACOS). This cross-departmental, five-year investment programme established in Mizoram was able to lessen the impact of the rat floods and improve community coping strategies.

Bamboo flowering and seed masting are followed by a mass die off of the bamboo and its regeneration from the seed over 5-6 years thereafter. When dominant species of bamboo undergo such events, bamboo resources are, therefore, diminished for several years, causing various socio-economic impacts; these are discussed further in Annex II. These relatively rare flowering events cause widespread ecosystem changes that have not been properly studied and analysed anywhere within the Bengal Bay eco-region (India, Bangladesh, Myanmar) nor, indeed, anywhere else in the world where this phenomenon occurs. The most notable ecosystem change resultant from the bamboo flowering is a dramatic rise in rodent numbers.

Introduction to Rodent Ecology

Rodent outbreaks following bamboo flowering are a well-accepted scientific phenomena reported to occur in several countries including Argentina, Peru, Brazil, Chile, Madagascar, Japan, Laos, Myanmar, India and Bangladesh (Douangboupha, et al., 2003; Jaksic & Lima, 2003; Chauhan & Saxena, 1985; Numata, 1970; Rakotomanana, 1966). Rodent outbreaks in other countries where bamboo is found in abundance are also found in historical literature. However, the long intervals between flowering events for many bamboo species, e.g. 130 years for the main species of bamboo in China, *Phyllostachys bambusoides*, means that proper scientific surveys and ecosystem analyses are, indeed, extremely rare. As yet, no longitudinal surveys of rodent population dynamics during bamboo flowering events are available from any part of the world. Any references to bamboo flowering and rodent outbreaks are usually "snap shot" surveys that offer no insight into rodent breeding potential, immigration and recruitment. Linkages between bamboo flowering and rodent outbreaks have not been proven, and the causes of rat floods are mere speculation. The impact of rat floods is well documented with several historical documents referring to widespread famine and mass migration of people living in affected areas during such events (Douangboupha, et al., 2003; Jaksic & Lima, 2003; John & Nadgauda, 2002; Nag, 1999; Philippi, 1879).

Although it is not scientifically confirmed, it is assumed that the rodents eat the bamboo seeds, using the abundant food resource to increase their breeding potential and expand their population. It has also been purported that bamboo seeds may contain potential estrogenic compounds that stimulate reproduction, which again is not confirmed. Farmers in the CHT also note other ecosystem changes, such as higher crop damage by birds and pigs, but it is not known whether these animals have been driven out of the forest because of a breakdown in the food web or because of similar population expansions through eating the abundant bamboo seeds.

Rodent population outbreaks, resultant from other causes, are more precisely understood. Several studies can link rodent population outbreaks to variation in rainfall, with unusually high rainfall leading to rat floods due to increased vegetative matter on which rodents feed (Holmgren et al., 2001; Lima et al., 1999a & 1999b). This is particularly common in southeastern Australia, southwestern USA and semi-arid regions of sub-Saharan Africa and South America. Like locusts and other plague-predisposed species, rodents are able to breed very quickly and can increase their populations rapidly under the right conditions. Similarly, rodent population outbreaks are well-documented from seed masting events in temperate forests with oak, beech and other tree species (Clotfelter et al., 2007; Hongjun & Zhang, 2007; Schnurr et al., 2002).

Some limited studies have been carried out in Mizoram during the recent outbreak. These studies have yet to be formally published, but suggest rodent population expansion is directly linked to the timing and abundance of bamboo seed produced (pers. com. Dr Ken Aplin, CSIRO). It is hypothesised that variation in the timing and abundance of seed produced in a local area can dictate the severity of the rodent outbreak, e.g. earlier season seed production gives the rodent population longer to expand, with higher amounts of seed also causing larger-scale outbreaks. This variation may explain why flowering events do not always lead to rat floods of the same severity. Evidence from Mizoram also suggests that bamboo flowering occurs synchronously over quite small patches. Nearby hills may not flower in the same year, leading to a mosaic flowering outbreak that proceeds over 3 to 4 years. The evidence collected during our CHT mission and discussion with CHT communities confirms this patchiness of flowering events, which effectively prolongs the damage, allowing the rat population to build with each progressive season.

The limited data derived from rodent captures in Mizoram and during the CHT mission suggest that the majority of adult rodents are in optimal breeding condition. In other words, abundant food in the form of bamboo seed means that rodents are very healthy and large, allowing them to produce large, frequent litters of young rats. One surprise from the CHT mission was the capture of at least one unknown species of rodent that has not been captured elsewhere in Bangladesh. Further taxonomic work will be required to determine whether the specimens belong to *Berylmys bowersi* or whether the specimens are a new species within the genus *Berylmys* or indeed within another genus more commonly found in southeastern Asia.

Rodent Impacts on Livelihoods

Like many countries, Bangladesh has a poorly documented problem with rats. Facts on crop yield losses caused by rats under true field conditions are hard to come by. Prevalence of rodent-borne diseases, such as leptospirosis or typhus, is unknown. And information regarding the impact of rodents on stored food through loss and contamination is simply not collected. What we do know is that nearly all agricultural crops grown in Bangladesh are attacked by rodents, and they are known carriers of more than 60 life-threatening diseases. Reducing crop damage by rodents not only improves food security and nutrition, but can lead to increased income. Reducing post-harvest loss and food contamination by rats improves health and nutrition, as well as lowering disease transmission. One of the big problems in developing better rodent management strategies is to understand their true impact on people's livelihoods. Although many farmers will understand that rodents are a problem and damage their field crops, stored food and personal possessions, awareness among farmers about the level and scope of damage is often underestimated. For example, many rodent diseases have symptoms that are easily confused with other diseases about which awareness is higher (e.g. malaria or dengue). It is, therefore, important to raise awareness and generate accurate information about the multiple damages caused by rodents, producing information that correctly shows levels of loss and contamination, and disease risks. Providing people with the true cost of rodents on their livelihoods allows them to consider how much they can invest (traps, poisons, labour) in controlling rodents.

Since 2002, research on rodents, their biology, damage and management has been carried out with the help of rural communities in the Comilla and Feni regions of Bangladesh and funding from the UK Department for International Development. This research was led by NRI, UK with partners including BRRI, BARI, AID-Comilla, and CSIRO, Australia. Although there was much anecdotal evidence of rodent pest problems cited by communities, there was a need to show the actual impact of rats on people's livelihoods. Research activities showed that 5 to 10 percent of stored paddy rice was lost to rodents over each 3 month storage period, with each farming household losing an approximate of 200 kg of stored paddy per year. In common with most of Asia, most Bangladesh farmers stated they plant about 2 rows of rice for the rats for every 8 rows sown. Our assessments showed pre-harvest losses from rats ranged from 5 - 17 percent in irrigated and rain-fed rice fields. Significant damage to all other fruit and vegetable crops grown was noted, with loss and damage ranging from 10 to 50 percent over the entire range of vegetables cultivated. Farmer damage assessments highlighted some of the more overlooked impacts of rodents, namely physical damage to houses, personal possessions, roads and fields. Rat bites while people sleep occur at relatively stable levels throughout the year with around 5 percent of households noting family members have been bitten in any given month.

Systematic rodent damage and livelihood assessment surveys have not been carried out in the CHT, but it is likely that CHT communities experience the same "baseline" of rodent damage in normal non-rat flood years as anywhere else in Bangladesh as described above. The impact of rats on people's livelihoods during the bamboo flowering increases at least by an order of magnitude in direct relation to the relative magnitude increase in the rat population. In the absence of scientific surveys we can not say precisely how much is lost during rat floods; however, based on previous research that shows most communities underestimate the true loss of rats on their livelihoods, we can reliably extrapolate minimum damage levels from surveys carried out within affected communities. In this regard, our discussions with communities from Ruma, Thanchi and Alikadam Upazillas present a bleak picture on levels of damage and loss caused by rodents in rat flood years. From this we can gather that nearly all jhum fields experience much higher levels of rat damage, and rat floods severely affect the amount of food that can be harvested. The minimum amount of damage experienced to field crops is 50 to 90 percent in years when rat floods occur. Thus severe food insecurity over 1-2 seasons in a community is normal during rat floods where households are lucky if they can harvest 10% of their crops. Food insecurity caused by the rat floods has been documented by several organizations that have carried out systematic studies, including the UN World Food Programme which has been delivering food aid assistance to affected communities over the last year. Damage to the few cash crops grown such as pineapple was also severe and observed during the CHT mission. Damage to stored food and household goods (e.g. blankets, clothes, utensils) was also observed and was much higher in comparison to "baseline" levels of rodent damage commonly observed elsewhere in Bangladesh. Our mission to the CHT was too short to provide systematic assessments of rodent damage. However, based on team member experience working elsewhere in Bangladesh, rodent damage levels are conservatively 4-5 times greater than that seen in the flood plains of Bangladesh. Photographic examples of damage were taken in the CHT can be found at the end of this Annex.

Rodent Management

A common problem when dealing with rats is that there is often no clearly expressed demand for rodent control. Many rodent problems are not well understood by villagers, and the traditional methods of managing rodents are rarely adequate, so that villagers often just accept the situation. Providing communities with appropriate management tools and knowledge about the rodent pests affecting their livelihoods, allows them to successfully manage their rodent pest problems in a cost-beneficial way.

However, in the case of rat floods and large rat population outbreaks, there is always a clearly expressed demand for rodent control with stakeholders appealing for knowledge and tools to more effectively manage the situation. Our mission to the CHT highlighted the strongly expressed demand for rodent control through several pathways, including local government, DAE officials and by affected communities, themselves. This strong consensus for rodent control has yet to be realised through large-scale training and capacity building programmes. However, a first step has been taken via the UNDP with AusAID funding to provide training to local leaders and NGOs operating across the three Hill Districts. This "training of trainers" will help raise awareness and knowledge levels, but significant further funding will be required to deliver knowledge and capacity building programmes to affected communities.

There are three basic steps in developing a sustainable, ecologically-based rodent management (EBRM) strategy for rural agricultural communities.

Step one: Know your enemy

As with any IPM strategy, the main principle is to "know your enemy". Not all rodent species are the same; each species has different breeding rates, habitats and species-specific behaviours. These factors will affect their pest status and the methods of control. For example, some rats like to live up high in trees or the roofs of people's houses, while others like to burrow in the ground or the walls of mud-brick houses. Knowing where rats live is important when targeting control actions. Rodents are also highly adaptable, and the same species may exploit different foods or habitats when found in different environments. Once armed with the basic knowledge about the rodents, where and when they cause damage and the types and extent of damage caused to different crops, stored food and health, it becomes possible to address all the problems rats cause in an integrated way. This information improves peoples' understanding of the costs of doing nothing about rats on their

livelihoods and allows an assessment of potential cost-benefits when developing a management strategy.

Step two: Know your end user

In addition to understanding the local rodent biology and ecology, EBRM must also consider the knowledge, attitudes and practices of the people affected. Effective rodent control practice must be based on the financial and time constraints of the people suffering from rodent pest problems. Rodent-human interactions can be complex, with rats seen as food, pests, and even involved in witchcraft or religious beliefs. Understanding existing practices and knowledge helps in the design of a strategy that will be locally acceptable and sustainable. For example, few small-scale farmers understand the difference between acute and chronic rodent poisons, and will often choose acute poisons as they see dead bodies in the morning, which they rarely see when using chronic poisons. However, chronic poisons can work well and effectively reduce pest populations, but the effects are not so clearly seen as the poisoned rodents die in their burrows. In the case of the CHT, rodents are widely consumed, so advocating the poisoning of rodents would have severe consequences for human health.

Step three: Know your technology

Because rats are mobile, moving over large distances in their daily foraging, the main principle of EBRM is that farming communities must act together. Individuals acting on their own in their house or crop field will have little impact on the overall rodent population, with rats quickly migrating back into areas from where they have been removed. This implies that communities must coordinate and communicate effectively over a large scale, and it is important to encourage high levels of community cohesion for EBRM to be successful. This can be a challenge, particularly in more peri-urban situations. The cost-benefits of working together for rodent management means that individual investment costs are low, as the overall effort is shared by many. EBRM must therefore be a community-based effort.

Reducing the rat population through intensive trapping is labour intensive, but requires a smaller financial investment compared to the continual purchase of rat poisons (as traps can last for many years). Nearly everyone is familiar with the principles of rat trapping, and often several indigenous trap designs can be found locally. However, not all traps are the same, with some designs working far more effectively than others. Good quality traps may not be locally available, and this may need to be addressed at market and policy levels to rectify. The main principle of intensive trapping is to remove rats from the population faster than their breeding rate. Because rats breed very quickly, this means that intensive trapping must continue on a daily basis over a long period of time, with traps spread over a sufficiently large area. Research activities in the Comilla region of Bangladesh showed that we could dramatically reduce the rat population by more than 80 percent. This was largely achieved by communities managing a system of daily rat trapping throughout their village with about 50 percent of households trapping daily with one or two high quality kill traps. The position of the traps would rotate around the village so that every household would be involved. With continual daily trapping, the rat population crashed after 2 months and remained low as long as daily trapping continued across the village. Intensive trapping during rat floods should also work as long as trapping is carried out at the right times and places and on a sufficiently large and coordinated scale.

Another trapping technology that has been developed and used effectively in small-scale agriculture is called a Trap Barrier System. CHT communities are already employing such technology, surrounding their jhum fields with bamboo fences interspersed with rat traps. Such technology could be improved to make the barriers even more rodent-proof and effective. Photographs of this technology can be found at the end of this Annex.

Rat populations can also be reduced by permanently changing the environment and the availability of food, water and nesting places that rats need to survive. These actions are commonly referred to as environmental management. They can be particularly effective when aiming to stop rodents sheltering near to human living areas, and eating stored food and water meant for immediate human consumption. For example, this may involve rodent proofing on-farm grain stores, or ensuring that locally stored water is adequately covered to prevent rodents eating, drinking and contaminating food and water with their urine and faeces. Many diseases carried by rodents occur through contamination of food and water, so environmental management must be accompanied by local education programmes to raise awareness about the risks of rodent diseases. Environmental management can

also involve activities that reduce places that rodents can eat and live around villages, e.g. by ensuring that rubbish is cleared away, and removing rubble or vegetation far away from human living areas. Good sanitation can really make a major difference in the number of rodents living close to people, reducing rodent impacts on livelihoods.

Consequences of Rat Floods

The likely short- and long-term negative consequences of the rat flood can be extrapolated from first-hand evidence gathered from the CHT mission, discussion with many stakeholders (Department of Agriculture Extension, affected communities, WFP, local government) and the existing scientific and historical literature on the subject.

Localised rodent population outbreaks will occur wherever bamboo flowering events occur. There is a 7 to 12 month time-lag between the start of flowering and the subsequent rodent outbreak. The severity of the rat flood is likely to be related to the timing and abundance of bamboo seed produced and the relative proximity of bamboo forest to communities.

Bamboo flowering was observed in abundance in several localities during October 2008 in Bandarban District. Communities in these areas will be facing food insecurity in 2009/2010 as will any other communities where the bamboo has flowered over October/November 2008.

We do not know for certain if further bamboo flowering will occur in 2009 and 2010, but further flowering events are considered likely within some localised areas of the Hill Districts. This is supported from evidence gathered in Mizoram State and from historical literature which shows that flowering events occur in waves over a period of 3-4 years.

Damage to livelihoods is and will be severe for many communities, going well beyond severe food shortages due to unusually high field crop loss (i.e. 80-100%). Damage to personal possessions, buildings, and household goods is and will be very high, requiring significant expenditure to replace basic possessions such as clothes and blankets. Increased incidence of disease within affected communities is reliably reported. Although disease outbreaks may be confounded by lowered physiological resistance due to food shortages, it is highly likely that rodent-borne diseases account for a significant proportion of the increased disease burden that has been noted. It is not known whether these disease outbreaks are due to communicable pathogens that are carried by rodents such as hanta or arena viruses that could spread from human to human, or from relatively non-communicable bacterial diseases spread through food and water contamination (e.g. leptospirosis, salmonella) or direct contact with rodents (e.g. rat bites, aerosolised rat urine), and/or intermediate vectors (e.g. rat fleas, ticks spreading typhus).

Zoonotic rodent-borne diseases, particularly haemorrhagic fevers such as leptospirosis and typhus, are known occur in Bangladesh. Such diseases could become more endemic and prevalent within the CHT and spread to other areas of the country through pathogen transfer via dispersing rodent populations. High rodent populations will have higher disease prevalence than is normal.

As the bamboo flowering is occurring in Myanmar, a country with endemic bubonic plague, it remains a possibility that rodents dispersing from Myanmar could carry the plague pathogen into Bangladesh. Plague remains a WHO notifiable disease subject to quarantine procedures during new outbreaks. The pneumonic form of the disease is highly contagious, with rapid progression to mortality if left untreated.

CHT communities are aware of the consequences of the bamboo flowering, with information on the phenomenon passed down through the generations. Indigenous coping strategies exist, but these are widely accepted to be inadequate by CHT communities. Increased knowledge, training, optimisation of indigenous rat management tools and the introduction of new tools are all possible interventions to improve community coping strategies which are environmentally and financially sustainable.

A large-scale bamboo die off will occur, directly related to the habitat dominance of the two bamboo species that are flowering. It will take approximately 5-6 years for the bamboo to regenerate, and a

shortage of bamboo materials will occur with socio-economic consequences felt across the country. This is further discussed in Annex II.

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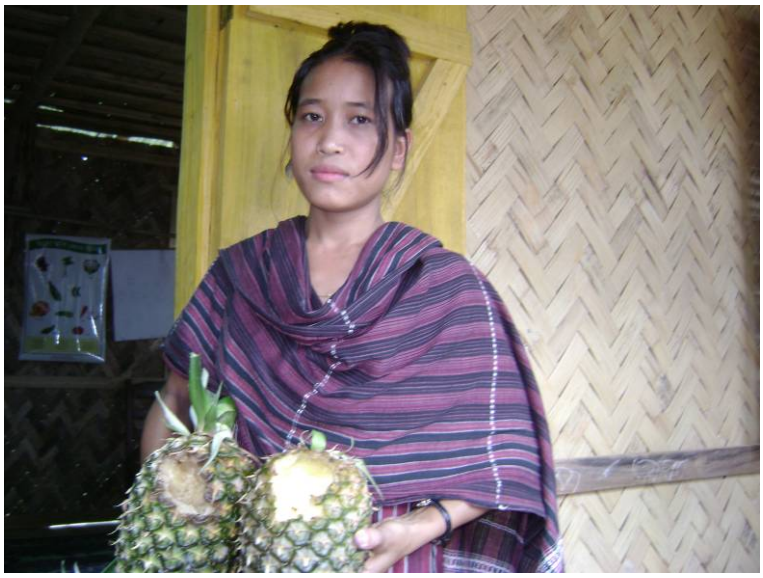
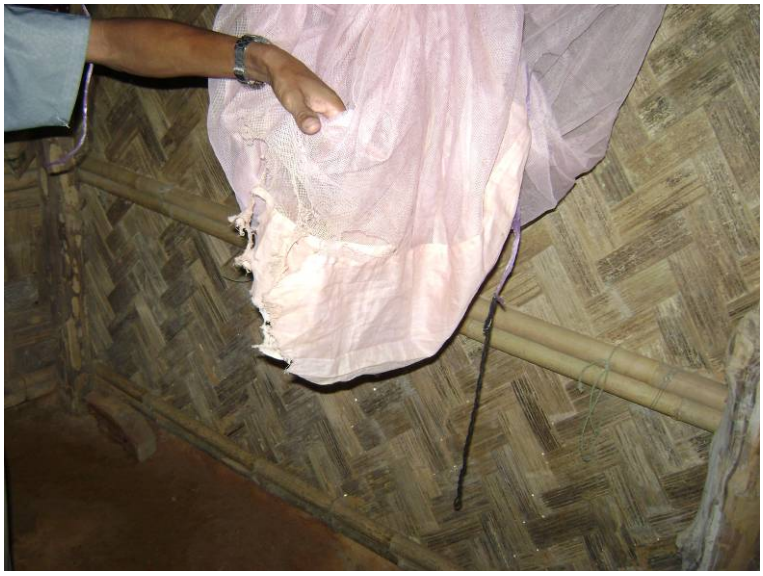
Photographs from the CHT highlighting evidence of rodent damage and indigenous rodent management technology

Rats have partially eaten these maize cobs, causing at least a 50% reduction in yield. However, damage is certainly much higher than this as many cobs are entirely eaten by rats before they can be harvested.

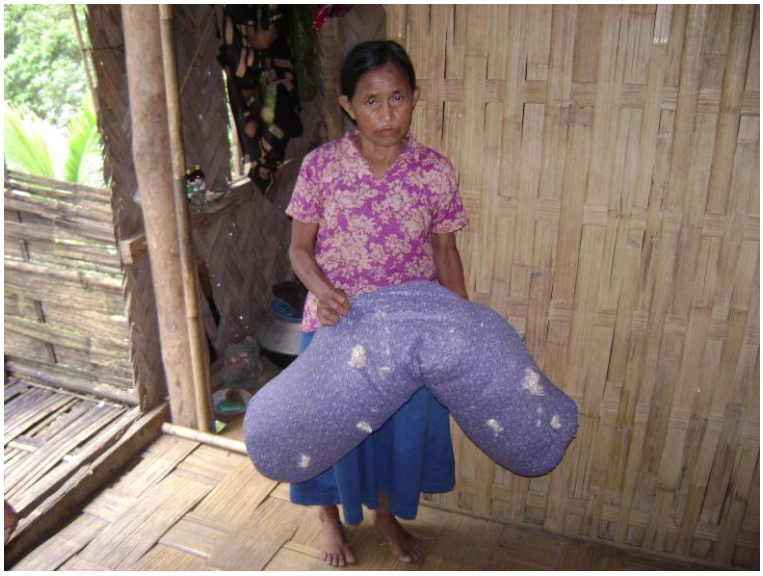


Pineapple was one of the few cash crops grown on a significant scale in Ruma Upazilla. Farmers consistently said they have lost 20% to rats in the current season. This is expected to be greater than 80% next year.

Rodent contamination and damage is extremely high within CHT household-level stores. What is not possible to see is the amount of rice that has been physically removed and eaten by rats. Studies in Comilla have indicated that 5-10% of rice is lost from stores similar to those used in the CHT. The much higher levels of contamination in CHT stores suggests losses are 2-3 times higher than this.



Rodent damage to mosquito nets can render the nets useless for protection against malaria. Households will need to spend money to purchase new ones.



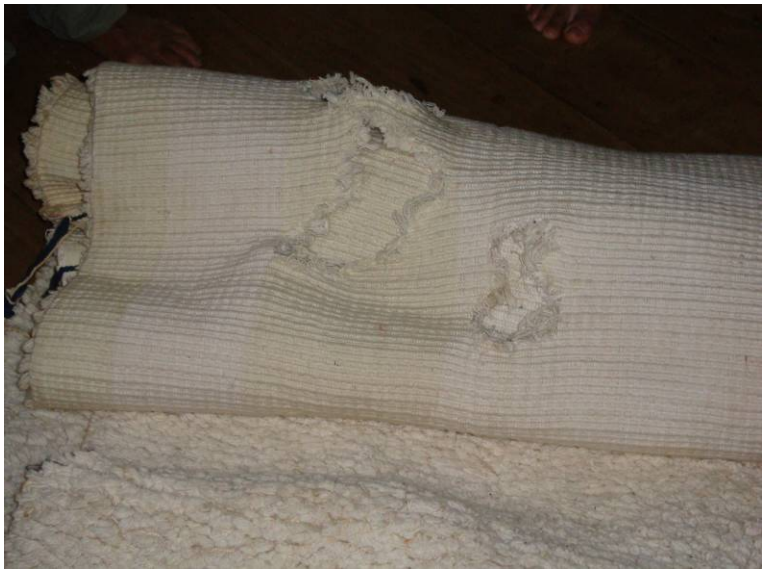
Rodent damage to clothes, blankets, pillows and all other soft furnishings was observed to be very severe. Many items are ruined beyond use or repair and will need to be re-purchased.

Damage to bananas is reported to be on the increase. Many bunches are entirely destroyed through rodent attack soon after the flowering stage. This late stage damage is expected to increase over the next year.

More damage to pineapple in a different village of Ruma Upazilla

Damage to rice store structures and bagged rice was very common across all households visited

Rat damage to pumpkins, gourds and squash can destroy the entire fruit and lead to reduced shelf life and marketability through minor damage to the skin in several places.



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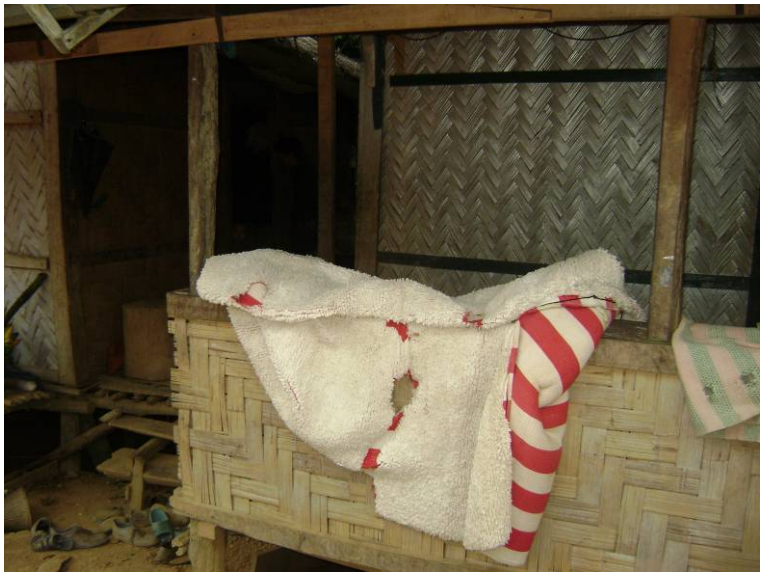

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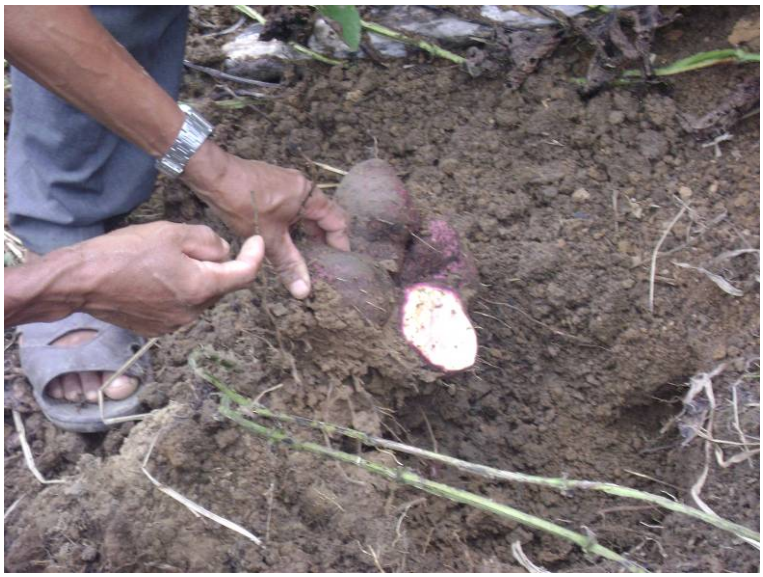
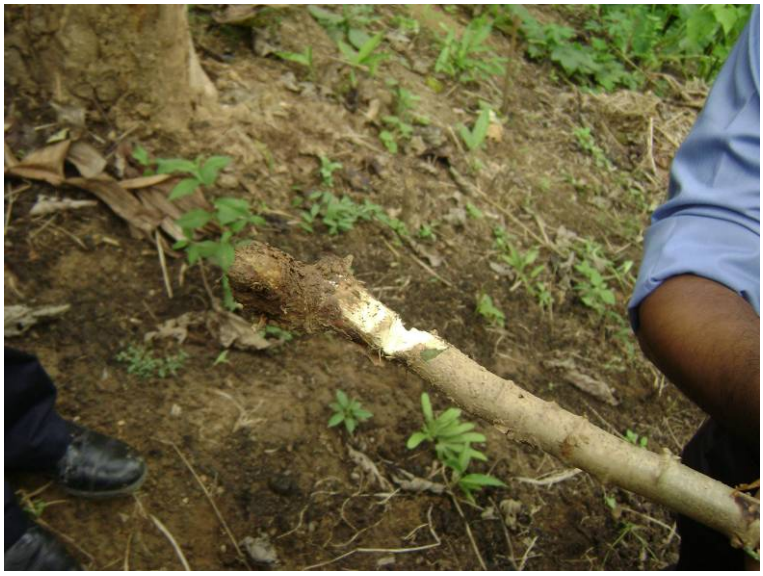


Rat damage to potatoes was common across inter-cropped jhum fields.



Rat damage to cassava stems leads to entire plants dying.

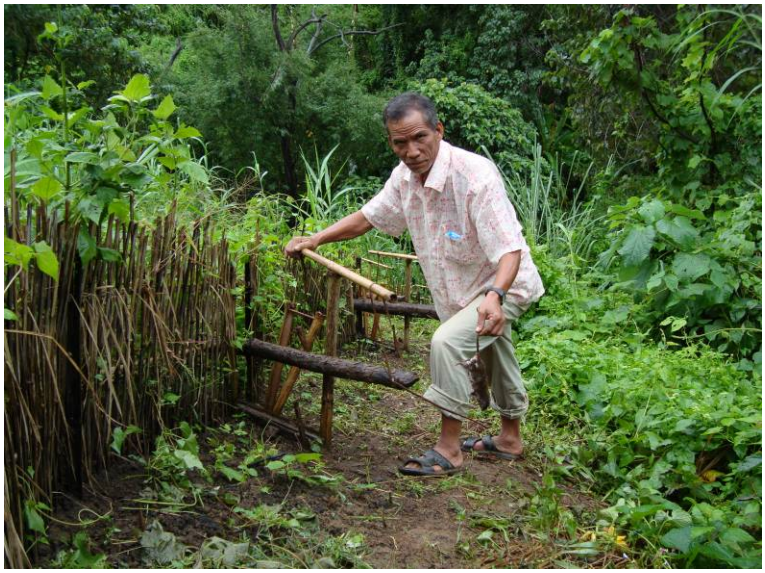
Rat damage to rice is the most widely noted affect by CHT households. Current damage in the villages visited in Ruma indicated at least a 20% loss. This is expected to increase to greater than 80% next year.

Bamboo seed production normally starts around May, following on from flowering in the previous year in October. The seeds drop to the ground over the months of May to July. The photograph shows that some seeds have already started to germinate by the following October. The bamboo forest regeneration process is widely accepted to take about 5 years, related to the bamboo's development of mature root systems.

Flowering bamboo was noted in abundance. The photo of the bamboo seeds shown above was taken in the same locality as this picture, emphasizing the issue that flowering events occur in waves across the area over a period of years.

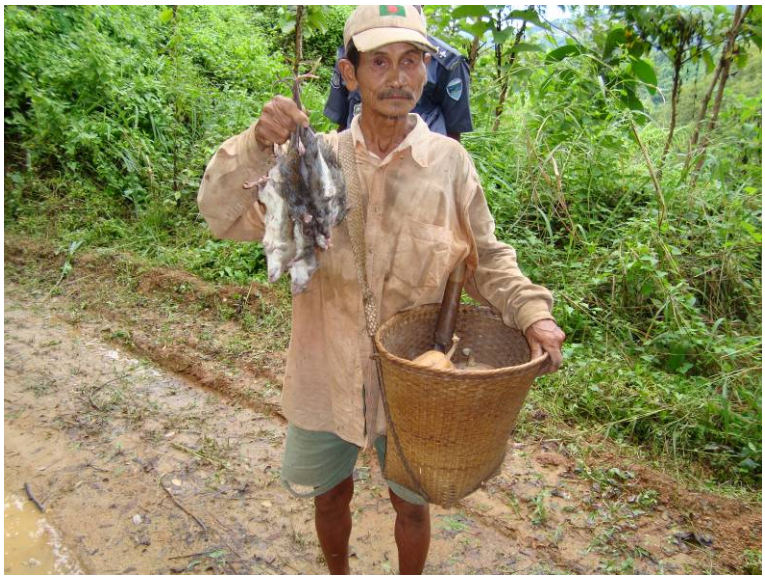
Large stands of bamboo can be found growing adjacent to many jhum fields. Fields next to large areas of bamboo are expected to suffer much more extensive crop damage than fields with relatively less bamboo nearby.

Indigenously designed snare traps are used to capture rats. However the intensity of trapping carried out is low and uncoordinated so is unlikely to significantly impact the numbers of rats in the environment.



Many households build bamboo fences around their jhum fields which are regularly interspersed with rat traps. These barriers are a highly appropriate technology for dealing with rat floods, and there is much scope to improve their efficacy through optimising their design and the construction materials used.

Rat burrows are abundant in jhum fields, an indicator of very large rat populations in the area.



Different species of rodent are found in the CHT that are not found elsewhere in Bangladesh. As yet, we do not have the taxonomic identification of the species. This will be important to understand the rodent's breeding capacity and behaviour so that management strategies can take such knowledge into account.

Annex II: Food Security Crisis and Socio-economic Impacts of Rat Floods in the CHT

Executive Summary

Detailed studies on the health and nutrition status of rat flood-affected communities in the CHT have recently been carried out by various organisations including Helen Keller International, Save the Children UK and Medecins sans Frontieres-Holland. These studies provide baseline information on the food security and health status of communities living within areas where the rat population has dramatically increased in response to the bamboo flowering/seeding event. All of these studies confirm that severe crop damage has occurred, with households experiencing significant shortfalls in food, which is manifesting itself through increased disease, malnutrition, low body mass indices and poor child growth rates. These affects on CHT communities will continue in areas where the bamboo continues to flower. These institutional reports indicate that emergency relief efforts need to be significantly increased in order to meet local community needs and to prevent permanent damage to childhood development.

Income generation through the marketing of agricultural produce has been severely curtailed. Not only are the rats eating significant amounts of rice, vegetables and fruits, the way in which rats feed means that they usually don't eat the entire fruit. For example, the rats will chew a small hole in each pineapple, pumpkin or gourd, causing the entire fruit to rot. In this way rats damage far more than they actually eat. Even slight superficial rat damage to potatoes, pumpkins, etc. significantly reduces the shelf life and marketability. The impacts on agricultural production also have major impacts on household incomes for those who engage in casual labour, assisting farmers with the maintenance and harvesting of crops. Rat damaged crops means there is little need to employ casual labourers.

The rat floods are not only damaging field crops but affecting livelihoods in many other serious ways. For example, communities that have diversified their incomes through weaving and handicrafts are being affected by the rats which are destroying their yarn and blankets, and many yarn stocks have been completely destroyed by rats. Damage to furniture, blankets, clothes and other personal possessions is extremely high in affected communities. Although no systematic survey has been carried out on rat damage to household possessions, buildings and structures, it is at least an order of magnitude higher than such damage normally found in rural communities elsewhere in Bangladesh. The financial implications of household damage by rat floods will be long-lasting and severe for CHT communities as they will need to use money to buy essential goods such as clothes that have been damaged by rats.

The loss of bamboo during its prolonged regeneration will directly affect the incomes of all households in rural communities of the CHT. It is estimated that each rodent-affected upazilla could lose a minimum of 100 to 150 million Taka each year over a 4-5 year period. Local cottage industries such as bamboo weaving and commercial manufacturing of paper and other bamboo products will be severely affected. Export of bamboo from the CHT throughout Bangladesh and internationally will be seriously curtailed for 5-6 years. Importation of bamboo may need to be considered to meet national needs.

General Description of the Study Area

Location

The Chittagong Hill Tracts (CHT) is the main mountainous area of Bangladesh and lies across the Tropic of Cancer between $21^0$11' to $23^0$45' North latitudes and $88^0$01' to $91^0$45' East longitudes. With an area of 2699.55 km^2, it is bounded by the Chittagong and Cox's Bazar Districts stretching along the Bay of Bengal on the West, by the foothills of the Indian states of Tripura and Mizoram on the North and East and by the Akyab District of Myanmar on the South and Southeast. The CHT is administrated under three individual districts, namely Rangamati, Khagrachari and Bandarban (Figure 1). The hills of this region are comprised of folded sedimentary rock. Notable hill ranges are Alu Tila, Bhanga Mura (416.66 m), and Matai Pukhiri (213.36 m).

Climate

The climate of the CHT is a tropical monsoon climate characterized by heavy seasonal rainfall from May to October, moderately warm temperatures and high humidity. The annual average temperature

is maximum 34.6^{0}C and minimum 13^{0}C; annual rainfall is 3031 mm, relative humidity is around 91% from September through December and around 65% from December through February. The area has an erratic monsoon climate, with periodic flooding in the valleys and drought in the mountains, hot rainy summers and a pronounced dry season in the cooler months. Natural calamities such as floods, tropical cyclones and tornadoes affect the area almost every year.

Soil condition

The physical characteristics of the mission study areas in Ruma and Thanchi Upazillas are similar to other hilly districts of the CHT. The landscape presents a scenic view of hills and valleys, fresh water springs and lakes and patches of tropical green forest. The valley soil is mainly acidic, reddish-brown loam. The condition of the topsoil is a relatively thin sandy loam to silt loam. pH levels range between 5.5 and 6.5, which is less acidic than the subsoil. Most of the available nutrients are in this organic matte-enriched topsoil. Non-eroded topsoil usually has markedly less clay than the subsoil. The main limitation for agriculture is the relatively steep slopes which are vulnerable to erosion when the native ground cover is removed and cultivated. Some of hill inclines are utilized for hill slope cultivation, locally called jhum agriculture. This form of cultivation is widely practiced throughout the hilly areas of Bangladesh, Myanmar, India and Laos and is characterised by rotational slash and burn cropping cycles. (Banglapedia, Vol. 6, pp 49).

Land use pattern

The total cultivable land in Khagrachari district is 40174 ha of which 52.13% is single cropped, 35.38% is double cropped and 12.49% is triple cropped. The amount of cultivable land under irrigation is 6138.4 ha. The area under fallow is about 8289 ha (Banglapedia, Vol. 6, pp 49).

Rivers and water bodies

There a few rivulets, springs and khals flowing through the district. The names of these rivers and khals are Myani khal, Kasalong khal, Cangachara, Mala, Nava, Chingri, Khurang khal, Mani Khara, Feni and Palakchara. These rivers and khals have little importance in navigation. They occupy an area of 215 sq. km (83 sq miles) which is 8.3% of total area of the district.

Demographic and Socio-Economic Characteristics

The population density of the CHT region is lower than the other parts of Bangladesh due to its hilly nature and relative lack of a road communication network. The total CHT population enumerated in the 1991 census was 1.042 million of which 562,597 were male and 479,776 female. Demographic details below are provided across an example set of four Upazillas as accurate information is not available for all parts of the CHT. The percentages of men are always higher than that of women in all sample Upazillas (Table 1).

Table 1 Population of the sample upazillas

Upazilla	Total population	Percentage	
		Male	Female
Khagrachari Sadar	61,306	54.02	45.98
Dighinala	50,933	51.50	48.50
Matiranga	71,949	52.38	47.64
Ramgarh	44,217	53.01	46.99
All Upazillas	228,405	52.72	47.28

Source: Banglapedia, Vol. 3, 6 & 8

On an average 28.3% population are literate in the sample Upazillas. The overall literacy status of men is higher compared to women in the example areas (Table 2). The populations of Khagrachari Sadar Upazilla have access to all kinds of municipal facilities and partly explains why literacy is highest compared to the other Upazillas.

Table 2 Literacy status of the sample Upazilla (percentage figures)

Upazilla	Male	Female	All
Khagrachari Sadar	42.3	23.2	33.7
Dighinala	32.1	20.3	26.2

Matiranga	33.4	13.6	24.1
Ramgarh	38.9	17.8	29.1
All upazilla	36.7	18.7	28.3

Source: Banglapedia, Vol. 3, 6 & 8,

The occupational status varies across the four example Upazillas. On an average 39.83% are engaged in agriculture, 19.54% are engaged in agricultural labour, 12.40% are engaged in wage labour and the remaining 14.40% are engaged in other occupations. In Matiranga upazilla the highest percentage of population is engaged in agricultural labour; whereas wage labour is the highest occupation in Sadar Upazilla due to business, construction and official works. The people of Ramgarh Upazilla are highly engaged in the commercial sector compared to other areas (Table 3).

Table 3 Occupational status of the people of sample upazillas

Upazilla	Type of occupation (%)					
	Agriculture	Agricultural	Wage	Commerce	Service	Others
Khagrachari	34.69	17.73	25.74	5.81	5.84	10.19
Dighinala	52.26	16.17	6.47	6.36	5.90	12.84
Matiranga	39.24	24.67	8.32	8.95	6.05	12.77
Ramgarh	33.14	19.57	9.09	10.00	5.90	22.30
All upazilla	39.83	19.54	12.41	7.78	5.92	14.53

Source: Banglapedia, Vol. 3, 6 & 8.

Modes of communication

Sadar upazilla: The communication facilities in the Sadar Upazilla are more developed than the other upazilla of this district. There are both pucca (brick cobble) and kutcha (mud) roads in this district. It has 52 km of pucca road, 63 km semi-pucca and 118 km of kutcha road. There are various transport facilities in the Sadar upazilla. The modes of transports are bus, rickshaw, horse carriage, bullock cart, jeep (chander gari) and human porterage.

Matiranga upazilla: The roads of this upazilla are mostly kutcha. There are 81 km pucca, 50 km semi-pucca and 270 km of kutcha roads in this upazilla. Transportation facilities are found to be very poor. The modes of transports are boat, bullock porterage, human porterage, van (kind of rickshaw) and bus (very rare).

Dighinala upazilla: The main mode of transport in the Dighinala upazilla is jeep (*Chander gari*) and human porterage. It takes a long time to get a bus for moving one place to another. It is due to unavailability of bus and the scarcity of roads.

Ramgarh upazilla: The communication system in this upazilla is more or less good due to its urban area with plain land and a highway is passing across this upazilla. There exists 12.5 km pucca road, 11.5 km semi-pucca and 165 km mud road. Bus, tempo, rickshaw, and van are available in this area.

Major crops and fruits

Different types of crops and fruits are grown in the CHTs (Table 4). The farmers of Sadar upazilla only cultivate some of the more common crops. In the case of fruit, they cultivate all kinds of fruits that are generally grown in the CHT. On the other hand, the cultivation systems of the other upazillas are more diverse.

Table 4 Major crops and fruits grown in the sample upazillas

Upazilla	Major Crops	Major Fruits
Khagrachari Sadar	Paddy, potato, brinjal, nut and cotton	Mango, black berry, jackfruit, pineapple, papaya, banana, litchi and sofeda
Dighinala	Paddy, potato, brinjal, marpha, nut and cotton turmeric, ginger, arum, sesame, hilly potato and vegetable	Mango, jackfruit and banana

Matiranga	Paddy, arum, sugarcane, potato, brinjal, marpha, cucumber, turmeric, ginger, arhar (kind of	Mango, black berry, jackfruit, pineapple, papaya, banana, litchi, lemon, jongli kul, guava, kamranga (kind of sour fruit), wood-
Ramgarh	Paddy, sweet potato, brinjal, sugarcane, cucumber, turmeric, ginger, kachu (varieties of arum),	Mango, jackfruit, pineapple, papaya, banana, litchi, lemon, guava, and jambura (shaddock)

Source: Banglapedia, Vol. 3, 6 and 8

Ethnicity

Ethnicity in the CHT is dominated by the Mongolian group. The major Mongolian tribes are Chakma, Tipra, Murong and Magh (Table 5). The CHT hosts thirteen different tribes who are divided into nearly a hundred different sects. Buddhism is followed by Chakma and Marma, Hinduism by the Tripura and Christianity by Mizo and Bawm.

Table 5 Different tribes in the CHT

Tribal group	Main religion	Census 1956	Census 1981
Chakma	Buddhism	140,000	230,000
Taungchengya	Buddhism	15,000	20,000
Marma	Buddhism	80,000	120,000
Sak	Buddhism	2,000	1,500
Khyeng	Community religion	1,000	1,500
Tripura	Hinduism	30,000	40,000
Riang/Brong	Hinduism	7,000	10,000
Mru	Community Religion	17,000	20,000
Khumi	Community Religion	2,500	1,000
Bawm	Christianity	3,500	8,000
Pangkhua	Christianity	1,500	2,000
Lushai/Mizo	Christianity	500	1,000
Tribal total		*300,000*	*455,000*
Bengali	Islam	30,000	290,000
CHT Total		*330,000*	*745,000*

The pattern of human settlement throughout the CHT shows much territorial intermingling among tribes. Some groups dominate in certain parts of the CHT (e.g. the Chakma in the centre, and Marma in the tract between the Karnafuli and Sangu rivers) and others are concentrated in specific areas (e.g. Tripura in the north, Mru in the south). There is also a distinction between groups living in hill valleys and groups living on the ridges of the hills. Nevertheless, in many places local settlement patterns are highly complex. For example, seven different groups could be found living in close proximity in an area of about 15 by 10 km around the township of Ruma on the Sangu River in the southern CHT. Average family size of the CHT household is reported to be 6 with 4 children per family.

Natural Resources

Government managed forest: The reserved forest constitutes the most important category of government-owned forest areas in the CHT, covering about a quarter of the region. This category of land is administered by the Forest Department. The reserve forest covers about 15018 acres (Webb and Roberts, 1976).

Community managed forests: The most important category of community managed forests is the mauza forest commons or village common forest. These are mostly small (average 50-300 acres), consisting of naturally grown or regenerated vegetation, and are traditionally managed and utilized by village communities under the leadership of the mauza Headman.

Swidden grazing and other common land: This type of land is owned and managed by the community, such as grazing land, graveyards, churches, schools, etc. Communities regard these as common property to manage or use as the community collectively decides or as decided by the community headmen.

Water bodies: All water bodies are considered as state property. Some parts of the Karnaphuli reservoir have been leased out for fisheries.

Privately owned tree plantation: There are two major categories of privately owned tree plantation in the CHT. These lands belong to indigenous farmers and town-dwellers.

Other privately owned lands: These are the land owned by the tribal people used for fruit orchard and jhum cultivation.

Table 6 Categories of land grants given by the government in the CHT

Use of land	Identity of Leases	Nature of Grant	Granting authority	Amount (Acres)
Homestead (rural)	Hill people	Freehold	Headman	0.30 acres
Homestead (rural)	Any person	Leasehold	Deputy Commissioner (DC)	Unspecified
Homestead (urban)	Any person	Leasehold	DC	Up to 0.30 acres
Plough cultivation	CHT residents	Freehold	DC	Up to 5 acres
Orchard plantation	CHT residents	Freehold	DC	Up to 10 acres
Commercial plantation	Any person	Leasehold	DC	Up to 25 acres
Commercial plantation	Any person	Leasehold	Commissioner	Up to 50 acres
Commercial plantation	Any person	Leasehold	Government	Above 100 acres
Industries	Any person	Leasehold	DC	5-10 acres

Bamboo flowering

Bamboo flowering events in the CHT have a long history (see Annex I). Since 1908 three bamboo flowering events have occurred in CHT (Table 7).

Table 7 Documented bamboo flowering in the CHT over the last century

Bamboo flowering year	Inter-mast period (years)
1908-1912	42-49
1958-1959	46-51
2006-10	47-51

In the current outbreak, bamboo flowering and rodent infestation in the CHT was first reported in April 2007 by a national daily. It raised concern with possible rat infestation as a result of bamboo flowering and on subsequent crop damage and famine that were locally anticipated to follow. A number of agency studies recently reported about the food security impact of bamboo flowering in affected areas of the CHT (supplied on request from CHTDF, UNDP). In these reports, it has been assumed the flowering started in 2007 and would continue up to 2010, with a new area affected each year. Initial reports of bamboo flowering were received from the state of Mizoram in India in December 2005. Historically, bamboo flowering begins in the Mizo region and travels southward into the CHT and Myanmar over several years.

Bamboo flowering has been reported and/or observed primarily along two terrains running North to South. The first bamboo flowering was observed in the high hills that run along the Mizoram and Myanmar borders (Baghaichari, Barkal, Ruma and Thanchi), much of which are under reserve forest. The second bamboo flowering occurred along the Chimbuk Hills that lie in between the Sangu and Matamuhari Rivers, much of which is non-classed forest leased out to the communities or within the jurisdiction of community land. Widespread bamboo flowering in Khagrachari District has also been reported in 45 villages in eight upazilla. Of these, 15 villages are in Dighinala, 10 in Laxmichhari, 5 in Matiranga and 5 in remote Panchhari upazilla.

While there may have been some sporadic bamboo flowering, reports from all places along the terrain running south from Baghaichari to Barkal, Roangchhari, Ruma and Thanchi, suggests that flowering of the 'Muli' bamboo occurred with seeds developing first in 2007. Most reports suggest that about one-fourth of the total bamboo flowered during this period. Another half flowered during 2008. It is expected that the remaining quarter will flower in the coming years 2009 and 2010.

Impact on jhum cropping

jhum cultivation is an old-age traditional crop cultivation system of the people in the hill areas of India, Bangladesh, Myanmar and Laos. This system is different from normal cultivation practiced in the plain areas of Bangladesh. After cultivating crops, farmers generally leave the hill for rejuvenation of top soils and rotate back to the same hill after 3-10 years for crop production. This cultivation system is, therefore, called shifting cultivation. Slashing and burning of native vegetative cover are carried out before jhum cultivation and, hence, the system is also often called slash and burn agriculture.

The jhum land is prepared during March – April. They sow seedlings in May. Seeds of different crops are sown at the same time and such intercropping is widely practiced. The important mixed crops cultivated in jhum lands are rice, brinjal, turmeric, chilli, sesame, arum, sweet-gourd, white gourd, pepper, cucumber, and cotton. The other crops are maize, gourd, teasel-gourd, yard-long bean and tree potato. Harvesting of crops depends on crop maturity, with each harvested as they mature. The harvesting schedule for different crops is shown in Table 8. They harvest jhum crops for a long period that starts from June and ends in December depending on the maturity of crops.

Table 8 Generalized jhum calendar of the study areas

Particulars	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Site selection											
Slashing & burning											
Seeding, broadcasting, or dibbling											
Weeding, basal fertilizer dose											
Weeding, thinning, insecticide use											
Top dressing (if any)											
Crop Harvesting											
Vegetable, marpha harvesting											
Melon harvesting											
Cucumber, gourd harvesting											
Maize, rice harvesting											
Chilli harvesting											
Pumpkin, cheena harvesting											
Brinjal harvesting											
Sesame harvesting											
Cassava harvesting											
Cotton, turmeric, ginger, arum											

The character of jhum agriculture has changed in the last several decades in the CHT as intense land pressure has occurred, affecting productivity. Rotational cycles have shortened to 3 years from the traditional 10-15 years, and land shortages and competition have forced people to stay longer or permanently in a smaller area.

Profitability of jhum cultivation in the CHT is presented in Table 9. The gross return from one acre of land is TK 44,257 with a gross cost of production of Tk 13,515, providing a gross margin of Tk 35,764 and a net return of Tk 30,742.

Table 9 Profitability of jhum cultivation on different fallowed cycles (Tk/acre)

Items	Category of hill farm fallow period				All categories
	3 years fallow	4 years fallow	5 years fallow	6 years fallow	
1. Gross return	28,070	38,291	51,147	59,522	44,257
2. Gross cost	11,349	13,137	17,359	12,217	13,515
(a) Fixed cost	6,217	4,754	6,436	2,683	5,022
(b) Variable cost	5,132	8,383	10,923	9,534	8,493
3. Gross margin (1-b)	22,938	29,907	40,224	49,988	35,764
4. Net return (1-2)	16,721	25,154	33,788	47,305	30,742
5. Benefit cost ratio (BCR)					
Over variable cost	5.47	4.57	4.68	6.24	5.21
Over gross cost	2.47	2.91	2.95	4.87	3.27

Source: Islam et al., 2006.

During the rodent outbreak of 2007-08, the total number of rodent-affected households was 9,910 with an affected jhum crop area of 5,658 hectares. Crop losses were 5,092 MT amounting BDT 12.85 million (Table 10). It was found that jhum crops were damaged seriously (80-100%) because of the rodent outbreak.

Table 10 Extent of damage of jhum crop due to rodent outbreak during 2007-08 crop season

District	Upazilla	Union (No.)	No. of HH affected	jhum area damaged (ha)	Loss	
					Crop (Mt)	Tk
Rangamati	Baghaichaari	1	2,909	1,912	1,836	45,900,000
	Bilaichhari	3	480	434	432	10,775,000
	Borkal	5	1,731	115	110	2,750,000
	Jurachhari	4	720	114	112	2,800,000
	Longgodu	1	45	39	38	950,000
	Total	14	5,885	2,763	2,528	6,3175,000
Khagrachari	Khagrachari Sadar	11	327	1,7285	145	3,631,250
	Panchhari	5	35	661	6	150,000
	Dighinala	12	74	57	57	1,425,000
	Matiranga	8	244	20,785	192	4,800,000
	Mohalchhari	4	330	170	158	3,950,000
	Lakkhichaari	4	95	70	68	1,700,000
	Total	44	1,670	1,374	1,218	30,456,250
Bandarban	Roangchhari	4	1,250	888	780	19,500,000
	Roma	2	542	417	405	10,125,000
	Thanchi	3	295	27	27	675,000
	Lama	1	39	54	50	1,250,000
	Bandarban Sadar	2	229	135	134	3,350,000
	Total	12	2,355	1,521	1,346	34,900,000
All districts Total		70	9,910	5,658	5,092	128,531,250

Source: DAE, Rangamati

Figure 1 Illustration of jhum cultivation practices in the CHT

Shifting cultivation (jhum)

Selection of jhum land: Choosing land for agriculture is not only based on various practical criteria but also on religious beliefs. Several local communities of the CHT will follow traditions such as taking a bath, wearing clean clothes and offering prayers before they go out in search of a likely jhum site. Farmers will collect a lump of soil from the site for a "dream test". If the farmers dream well, they select the land for cultivation. If the dream is unfavourable, they reject the site and look for another area.

Slashing and burning: After selecting a hill, farmers will invite all their neighbours for a party and go together to the field and start slashing down the vegetation in January. When dry, this will be burned in February and sowing of seeds usually commences on particular holy days. Farmers plant different crop seeds at the same time.

Figure 1 continued

Jhum crops: The important jhum crops are rice, brinjal, turmeric, chilli, sesame, marpha, arum, sweet-gourd, and cotton. The other crops are maize, gourd, teasel-gourd, yard-long bean and tree potato.

Crop harvesting: Jhum crops are harvested over for a long period that starts from June and ends around December depending on the maturity of the different crops.

Impact on livelihoods
Various livelihood activities of the CHT people include jhum farming, cutting bamboo and other forest products, collecting wild potato, arum, fruits, working as casual labourers, weaving of cloths, bamboo crafts and off-farm services.

Bamboo and other forest products are harvested and sold. Cash sale of bamboo, teak, firewood, rattan and other bamboo products are a supplementary part of income that is very important to the jhum farmers' livelihoods. It is estimated that 15 million bamboo stalks valued at BDT 10 per stalk are extracted every year from Baghaichari Upazilla alone. However, bamboo dies off after flowering and takes several years to regenerate. **Considering this annual bamboo harvest, a total of BDT 150 million will be lost in this one single rodent-affected upazilla as production plummets. The impact of bamboo regeneration across the CHT economy will be measured in hundreds of millions of Taka per year over 4-5 years.**

Weaving is an important livelihood activity of the women of the CHT. Such cottage industry fulfils clothing needs of the hill people. In addition, such products are also sold at various hill district towns and have a growing demand from other regions of Bangladesh. It is reported that rats have destroyed most yarn stocks in the affected area and most weavers have no cash reserves to replace lost yarn.

Bamboo crafts are important cottage-made products in the CHT. All kinds of household items such as baskets, fishing traps, hunting traps, fencing, housing, etc. are made from bamboo. As bamboo die off following flowering, many CHT households will loose this source of income.

Casual labour includes working in jhum fields for crop cultivation, cutting and carrying wood, and bamboo. The normal wage rate ranges from Tk 60 to Tk 80 per day without food. Damage of jhum crops has greatly reduced employment opportunities of the casual labourers.

Impact on food security
Rice is the single common staple food of the people of the CHT. Rice is harvested once a year as a jhum crop. During field visits, the CHT households reported that production of rice in the normal year could meet their food grain requirements throughout the year. However, their food security condition became alarming in the severely rodent affected areas where 80-100% jhum crops have been damaged. The second most important food items that come from jhum are vegetables such as cucumber, pumpkin, white gourd, and these are also affected. Most of the families have food shortages for a period of 6 to 8 months. It was reported in a recent joint-agency study that crop destruction has led to severe food insecurity for 25,880 households (Table 11).

Table 11 Vulnerability assessment result in January, 2008

District	No. of Upazilla	No of Union	People affected	Families affected
Rangamati	4	12	78,400	15,680
Bandarban	3	8	50,000	10,000
Total	7	20	128,400	25,680

Source: joint WFP/UNDP/UNICEF internal food security report, 2008

Prices of rice, vegetables and other food prices have increased in the CHT in relation to the price of food products across Bangladesh and globally. Such price increases compounded the problem for affected communities as their purchasing power is further reduced. From the field studies, it was found that rice, shrimp paste, dry fish and vegetable oil are substantially not accessible and these commodities are used at reduced rates or not at all by most households. Another dimension of food insecurity of the rodent affected CHT households is that they are physically cut off from access to food due to their remote locations and the lack of local supply of food caused by the rodent crisis.

Usually the CHT people consume three rice meals per day which has been reduced in terms of number, quantity and quality. Every meal no longer includes rice, with substitutes such as boiled banana, wild potato and yam becoming more common. Some tribal communities eat rat meat, but it is unknown whether this helps offset the grown food insecurity situation for affected households.

Impact on health
The CHT has generally poor and inaccessible health services. The three most common illness reported were diarrhoea, malaria and respiratory tract infections. Increased reports of diarrhoea, especially among children and women, are attributed to the consumption of wild food (which may contain toxins), rat-contaminated drinking water and other rat-born diseases. There is also increased reports of malaria-like fever which is nearly double over what communities normally expect. It is not known if this is due to rat-borne diseases and this issue needs scientific investigation.

Recommendations for Mitigating Socio-Economic Impacts of Rat Floods

The recent rodent outbreak in the CHT first started in 2006-07 and will be continue up to at least 2010. It has created multidimensional problems such as crop damage, food shortage, food insecurity, adverse effects on livelihoods, health and ecological problems. In order to develop sustainable socio-economic coping strategies, different types of short, medium and long term programme interventions will be required. These are as follows:

Short Term
Emergency food aid: The provision of food rations for the households of the affected area will be required until the harvest of normal yielding jhum crops. Pregnant women and children are the most vulnerable groups and would suffer from food insecurity and malnutrition. So they would require supplementary food items as emergency aid to meet their nutritional gap.

Distribution of inputs: In order to rehabilitate the jhum farmers there is a need to give them assistance in terms of distribution of agricultural inputs like seed, fertilizer and saplings of fruit and nut trees. Rice, vegetables and turmeric seeds should be provided for the next season as many seed stocks have been destroyed.

Health Care: Strengthening of primary health care facilities at the community level and opening of Para Centres is recommended. Training on basic hygiene, promotion of sanitation through the Para Centres and providing basic health care information would be useful.

Medium Term
Training and capacity development: Community based rodent management has been found to be very effective in the plain lands and can be replicated in the CHT also. The CHT people would require training on rodent biology, the harmful effects of rats on human health, livestock health and crop damage, effective control mechanisms, and the distribution of trapping technology and materials. NGOs could play an important role for motivation and capacity building of the CHT people through arranging community based rodent management training.

Promotion of weaving and handicraft production: The women would require assistance to purchase yarn stocks as most weavers have no cash to replace lost yarn damaged by rats. There is also a necessity to develop effective supply chains to distribute their handicraft products in urban areas so that they can get better prices for their products.

Livestock production and poverty reduction: Poverty reduction through livestock production has been found to be useful in the plain lands can be also replicated in the CHT. The CHT has grazing land and natural vegetation, has good stocks of fodder and plant leaves and can be an ideal place for beef fattening and goat rearing. Initially CHT people would require cash assistance to purchase cattle and goats and training for beef and goat fattening.

Long Term
Research programme: A research programme should be implemented on crop diversification, improving jhum cultivation, variety development, soil erosion, ecosystem, biodiversity, forest management and socio-economic impact assessment study, supply chain development and value addition, climate change and livelihood adaptations.

Infrastructure development: Developing schools, health centres, markets, roads and communication network would be required to foster economic growth and development of the livelihoods of the CHT people.

Sharing Mizoram experience: Mizoram has relatively more experience of successfully handling the rat flood problem during the current outbreak. Lessons can be learned from the Mizoram model to develop a multi-departmental coordinated approach in the CHT.

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[5] Citations which are underlined can be downloaded from the internet from the electronic version of this document. An electronic copy of the current document can be found from the following website:- http://www.nri.org/projects/bandicoot/docs/bamboo.pdf

Annex III: Address List of Mission Team Members and Co-authors

Md. Sayeed Ali Director, Plant Protection Department of Agriculture Extension (DAE) Khamarbari, Farmgate, Dhaka-1207 Phone # 0088-02-9131295 (office) 0088-02-9561488 (Residence), 0088-01670424098 (Mobile) Fax # 0088-02-9111554	Dr. S.M. Fakhrul Islam Professor Department of Agricultural Economics Bangabandhu Sheik Mujibur Rahman Agricultural University Salna, Gazipur Phone # 0088-02-9206310-14 Ext-2110 (Office); 0088-02-9334677 (Residence), 0088-01715132408 (Mobile) 0088-02-9205333 (Fax), E-mail: fakhrulsm@dhaka.net
Abul Kalam Azad Logistics Manager Rat Management for Rural Communities Project (DFID Funded) AID-COMILLA Village: Raghupur, Post Office: Rajapara, Union: Jagannathpur, Comilla 3500 Phone # 0088-081-72003 (Comilla) Fax # 0088-081-62444 (Comilla) Mobile # 0088-01728129159 e-mail :aidazad@btcl.net.bd	ATM Hasanuzzaman Scientific Officer Vertebrate Pest Division Bangladesh Agricultural Research Institute (BARI) Joidevpur, Gazipur Phone # 0088-02-9261511 (Office) Fax # 0088-02-9261415 Mobile # 0088-01711149837 e-mail: hasanbari@yahoo.com
Dr. Nazira Q. Kamal Formerly: Head of Entomology, with positions as Director of Research and Director of Administration at Bangladesh Rice Research Institute (BRRI) Currently: Field Operation Manager Rat Management for Rural Communities Project (DFID Funded) Contact details as above	Dr. Noor Jahan Sarker Professor Department of Biology (Wildlife) University of Dhaka Phone # 0088-02-8611023 Mobile # 01819505387
Dr. Santosh Kumer Sarker Formerly: Chief Instructor (Rodent Specialist) at DAE Currently: Training Manager for Rat Management for Rural Communities Project (DFID Funded) Contact details as above 01714222157, 7161864	Mr. Lalit C. Chakma Executive Director Strategic Actions Society (SAS) Kallyanpur Area, Rangamati-4500 Chittagong Hill Tracts Bangladesh Tel & Fax: 88-0351-62237, Mobile: 01712-276408 E-mail: info@sasbd.org, sas_lalit@yahoo.com Website: www.sasbd.org
Md. Nazmul Islam Kadry Community Extension Specialist Rat Management for Rural Communities Project (DFID Funded) Contact details as above	Dr. Sohrab Uddin Sarker Professor Department of Zoology (Wildlife) University of Dhaka
Mohammad Harun Rodent Extension Specialist Rat Management for Rural Communities Project (DFID Funded) Contact details as above	Mr. Udayan Dewan Director, Program and Communication Organization for the Poor Community Advancement, Mirsarai, Chittagong 0088-01914848380 (mobile) E-mail: dewanudayan@yahoo.com
Dr Steven Belmain Natural Resources Institute, University of Greenwich Central Avenue, Chatham Maritime, Kent ME4 4TB United Kingdom E-mail: s.r.belmain@gre.ac.uk +44 1634 883761	

Annex IV: List of Stakeholders, Account of Discussions and Information Collected

This Annex provides a complete account of all the stakeholders involved in team discussions during the mission and a summary of the issues and outcomes discussed. Each team member took their own personal notes during these meetings, and these have been amalgamated into a combined synopsis that all co-authors accept as a true and accurate representation of each discussion held.

Date: October 19, 2008
Place of visit: Ministry of Chittagong Hill Tract Affairs, Bangladesh Secretariat
Persons met: Raja Devasish Roy, Special Assistant to the Chief Advisor
Summary of discussion: We met with the Raja to outline our mission objectives and receive his advice and wisdom on the rat flood phenomenon.

Date: October 21, 2008
Place of visit: UNDP Rangamati Field Office
Persons met: Head of UNDP Rangamati Field Office
Summary of discussion: We met with the Head of the UNDP Rangamati Office, Rob Stoelman. He briefed us on the itinerary of the program in Rangamati on the following day and we discussed our priority objectives for the overall mission, deciding to break into two groups in order to visit areas at different stages of the flowering event.

Date: October 22, 2008
Place of visit: SAS Office, Rangamati
Persons met: Mr. Lalit Chandra Chakma, Executive Director of SAS. Mr Nanda Kishore Chakma, SAS. Mr. Tanay Dewan, Consultant Hile-Hilly. Mr. Bhuban Kanti Chakma, Executive Director, Hile-Hilly. Mr. Udayan Khisa, CIPD (Center for Indigenous People Development). Mr. Shokin Chakma, Assistant Advocacy Officer, RDA (Rangamati Development Associate). Mr. Biplop Chakma, Executive Director, ASHIKA.
Summary of discussion: There was a discussion with the local NGO representatives on the attack of rats in Sajek, Barkal, and Jurachhari areas of Rangamati Hill District. The local representatives reported that they are aware about the rat invasion and the problems that they have caused on the life of the tribal people in the affected areas. The are aware of the historical context in Mizoram and worry that such events could happen in the CHT. They have reported that cases of malaria-like diseases, vomiting diseases, jaundice and rat bites are increasing. They reported that many children are being given away as families can not feed them. Crop damage to all crops, damage to house roofs, killing of chickens were all mentioned as commonly suffered damage by households due to the rat floods. The meeting attendees reported that UNDP is providing rice and other essential food stuffs. They felt a strong necessity of supporting the affected people, so that they could survive. They also demanded to train the people with appropriate mechanisms so that they could combat the situation. The meeting attendees also demanded the official recognition of jhum cultivation as a means of livelihood for the indigenous community, highlighting that people can not get bank loans or appropriate technical support related to jhum cultivation.

Date: October 22, 2008
Place of visit: Zillah Parishad, Runagate
Persons met: Jagot Jyoti Chakma, Chairman Rangamati Zilla Parishad, Mr. Golum Rahman, Chief Executive Officer.
Summary of discussion: There was a cordial discussion with the Zilla Parishad Chairman about the rat attack and he related that he furnished a report to the Honourable Minister of the Chittagong Hill Tracts Ministry, Raja Devasish Roy, depicting the total scenario of the affected areas. The Chairman also related that they helped the affected people from the Parishad, but it was quite insufficient as per the needs of the locality. The Chairman felt the need of providing training to the local community so that they could manage the issue and save their crops from similar rat attacks in the future. In the meeting, we came to learn that there have been some adverse situations created in the locality, such as:

- Theft and petty larceny increased
- Children given to others as unable to feed them
- Acute food shortage prevailing in the locality

- People migrating to neighbouring Mizoram, India

Date: October 22, 2008
Place of visit: World Food Program (WFP), Rangamati
Persons met: Two officials represented WFP on behalf of Ms. Rita Chakma who is the Head of the Rangamati Office.
Summary of discussion: The UNDP officials reported that they are quite aware about the rat attack. Field staff who are working in remote areas have visited some affected places of the Hill Districts. They reported that they have provided food assistance to 25,850 households in 7 Upazillas of Rangamati and Bandarban district. They also provided high energy biscuits to the affected communities. During discussion some interesting learning issues were:

- The Chairman of Sajek Union anticipated the rodent invasion, and he informed the district administration to be alert on this natural phenomena
- Diseases such as diarrhoea, dysentery have increased and even doubled in some places
- Some people have died, possibly because of lack of food or eating contaminated food
- The community people have shared the rations given to them with those who did not receive rations
- Many people are skipping meals and eating wild plants
- Most households have to guard food aid received to ensure it is not eaten by rats during the night
- People eat rats, sometimes prepared through drying and it is not known if this could promote some diseases
- Menace of wild pigs and birds have increased along with the rat attack
- Some community people know about the occurrence of rat floods and when some anticipate a rat invasion, they stop cultivating the jhum fields.
- Funding for food relief activities of WFP ended in October 2008, with a need to find further funding

Date: October 22, 2008
Place of visit: UNICEF Rangamati Office
Persons met: Mr. Mong Yai, Program Officer, Rangamati Office.
Summary of discussion: The UNICEF officer reported that they are aware about the rat attack and that they have been involved in the joint agency assessment of rat attack, but they do not have funds to support the affected people with food and other essential items. They were not aware of any studies carried out in relation to increased disease in connection to the rat flood. Information on disease in communities will be collected by Hill Districts, but these data are not standardised, their reliability was called into question

Date: October 22, 2008
Place of visit: DDAE Office, Rangamati Hill Tracts
Persons met: The Deputy Director of Agriculture Extension and Training Officer, DDAE Office.
Summary of discussion: There was a long discussion on rat attacks in Rangamati and Bandarban Hill Districts. The DD related to us that they are quite aware about the rat attack and they instructed their local officials (SAAO) to ascertain the damage. Mr. Kajal Talukdar, Training Officer, read out a long report describing detail description of the incidence and the measures taken by the Department of Agriculture Extension. In the discussion some important issues were came out as follows:

- Most affected areas are Sajek of Baghaichari Upazilla and Farua and Bilaichhari of Bilaichhari Upazilla
- 95% of jhum cultivation in remote areas has been affected by rat floods, losing 90-100% of their normal yield.
- Farmers were trained on rat management
- 29,775 tails were deposited in DAE as the management measure of rats
- Introduction of traps
- Ensure rodenticides were available in the market
- DAE is considering improving the jhum cultivation
- DAE is introducing drought resistant rice varieties for jhum cultivation
- DAE is encouraging jhum farmers to use intercropping as a way of preventing erosion and increasing productivity.

Date: October 23, 2008
Place of visit: UNDP Bandarban Office

Persons met: Seventeen community leaders from Alikadam Upazilla
Summary of discussion: There was a long discussion about the intensity of the rat attack with the affected people of Alikadam in the UNDP Bandarban office who came to Bandarban to apprise the District Chairman and the local media reporters of their situation and damage caused by the rat flood. The affected people brought approximately 10 kg of rat tails from their own area as evidence to show to the local administration and the media. They expect the flowering to take four years and feel helpless and hopeless to deal with the rat floods. They want to be able to control the rats and very much want to receive training and knowledge on how to do this and about new technology that could help them.

Date: October 24, 2008
Place of visit: Ruma Munlai Para
Persons met: The local community of the village including local leaders (Ex-Chairman) and people from all walks of life of the affected village.
Summary of discussion: There was a discussion on rat attack with the affected people of Munlai Para. They briefed us about the attack of rats that have been taken place over the last few months. We visited some affected places adjacent to the village where there were signs of rat damage in jhum fields.

- The community people are fully aware about the attack and its consequences
- The community people know the history of the attack that have taken place in Mizoram in 1960
- Some jhumia families stopped cultivating jhum in apprehension of attacking rats in their crops
- Some farmers have cultivated turmeric and ginger instead of rice
- The community sought training to combat the rat crisis
- They sought assistance to improve their traditional handicraft and looms
- They know about the re-generation of bamboo following its flowering, which they expect to take 3-4 years to flower and 4-5 years to regenerate
- They estimate losses to pineapple and rice at 20%, and 20-30% for all other crops grown. They expect this to increase to greater than 80% damage next year.
- Some people use poison to kill rats around the house, but it is not commonly available or used, particularly as many people eat rats
- They hope they can sell handicrafts to good markets to get themselves through the major food crisis next year
- They are not interested for short-term relief; rather they are interested to have training on rat management

Date: October 24, 2008
Place of visit: Basatlang Para, Ruma
Persons met: The local community of the village including local leaders i.e. school teacher, karbari, students etc.
Summary of discussion: There was a discussion on the rat attack with the affected people of Basatlang Para of Paildu Union. They briefed us in detail on the problems encountered and the expected severe problems they will face next year due to the large amounts of bamboo currently flowering. We visited some affected places far away from the village. We witnessed the damage done by rats and was severe with farmers losing most their crops by rats. However, some of the places had virtually no damage, with the expectation that these will be badly hit next year.

- They are expecting more attack in next year. This is from their previous experience which they gained from their fore fathers. Some flowering happened last year in small amounts, affecting some households severely where it happened. Most bamboo is currently in flower now, so they expect very serious problems next year.
- In an average, 50% of the jhum crops have been damaged across their community
- Flowering generally takes place after 50 years interval
- Some wild animals also damaged their crops i.e. wild pigs, porcupines, squirrels and birds
- In some areas badly affected they have seen rats out in their fields in the daytime
- The community has devised bamboo fencing around the jhum fields placing some local traps in strategic positions to save the crops from rat attack. It is a very appropriate and sustainable technique.
- They are very worried about their children getting enough to eat over the next few years
- The community have put their opinion that crops damage by pigs occurs when there is a shortage of bamboo shoots as it is the very delicious food for the wild pigs

- The community sought training on rat management not government assistance

Date: October 25, 2008
Place of visit: Bandarban Zilla Parishad
Persons met: Mr. Thansama Lushai, Chairman, Bandarban Zilla Parishad, Chief Executive Officer.
Summary of discussion: Dr. Steven Belmain, the team leader of study group broached the discussion. He was assisted by his team members during the discussion. Dr. Steven explained the scenario of the rat attack in Mizoram, South Africa and Australia. This helped them to understand the total scenario of the globe. After that the Chairman put his opinion about the issue. He related that he sent a letter to the Honourable Minister of CHT Affairs apprising the situation and it's remedial measure. The following are the synopsis of the discussion:

- The Chairman related that the community people have got full knowledge on rat attack which they experienced from their forefathers
- They received 500 MTs of food grains from WFP
- The community should be involved in training to tackle the crisis
- The bamboo variety affected is locally known as *paya*
- The Chairman sought rodent management techniques from the team

Date: October 23-25, 2008
Place of visit: Remakri Bazar Para of Remakri Union and Tindu Village of Tindu Union of Thanchi Upazilla of Bandarban Hill District
Persons met: various members of the communities including: Apru mong Marma, Chairman, Remakri UP, Thanchi, Bandarban Hill District; Maliram Tripura, Member, Remakri UP, Thanchi, Bandarban; Sathijong (Mro) Chairman (Acting), Tindu UP, Thanchi, Bandarban; Medungma Marma, Inhabitants of Remakri, Thanchi, Bandarban; Thangpang Mro, Karbari, Remakri UP; Mongsanu Marma; Pangya Mro
Summary of discussion: All bamboo has already died. Some crops of jhum fields (10%) have been collected. Five indigenous groups live in the area. Khumi and Mro have a habit of eating the meat of rats. Different 'new' rat species collected and breeding information collected. Socio-economic status is very low due to rat damage in their jhum field crops. In general, people live in extreme poverty. People told us most damage occurs by rats near in jhum fields nearest to bamboo forests. The remoteness of target villages and bad weather limited the amount of rat trapping and capture rates within the time allowed.

Annex V: Alikadam Mro Community Leader's Representation to Bandarban District Council

During our mission to Bandarban, we met with a group of community leaders from Alikadam Upazilla who had travelled to Bandarban to speak with leaders and inform the press about the rat outbreak and its effects on their people. Our discussions with this group are summarised in Annex IV. In support of this, the below is an English translation of a document produced by the Alikadam Mro community leaders themselves which presents data on the effects of the rat flood on their livelihoods.

Press Conference 2008 on account of Massive crop damage due to Rat invasion and economic crisis in Mro community of Alikadam Upazilla

Dear Journalists
We would like to welcome you from the Mro community of Bangladesh. We are living in Alikadam Upazilla since time immemorial in Alikadam Upazilla of Bandarban Hill District.

Dear Gentlemen
Massive crop damage has been taken place in the hilly areas of Alikadam Upazilla due to rat invasion and the economic condition of the Mro community is at stake. So we invited you to put this issue to the people and the nation as well. We know the reporters are the conscience and they are regarded as the fourth pillars of the nation. So we approach to you to apprise you our miseries and sufferings without letting it to our leaders and administration.

We hope you will realize our miseries and economic hardship and feel compassionate and uphold this issue to the nation.

Dear Media Friends
We are giving you a vivid description of 17 villages of 371 families in which about 1000 acres of jhum crops have been damaged due to the rat invasion. This is the season of happiness for the indigenous people for having new rice from the jhum, but the mishap has befallen on them due to the unfortunate rat attack. The sufferings of the people have been aggravated for not having the expected harvest.

Dear Friends-Mirror of the country and nation
We can boldly say that we are the primitive people who have been fighting the ferocious animals and natural adversity, leading a nomadic life doing shifting cultivation one after another hill from time immemorial. Our past life was very happy and glorious and the culture was enriched. The rat invasion starts when bamboo flowering starts. This year we have bamboo flowering and our prediction became true.

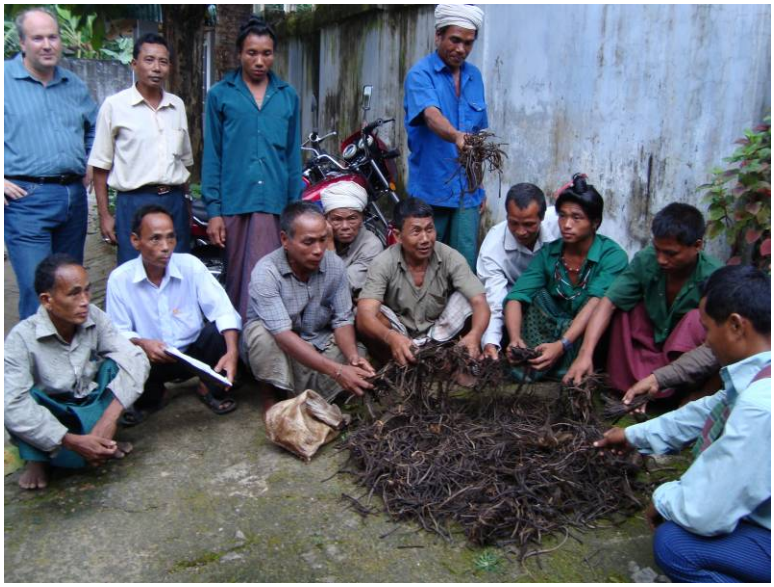
The area of jhum cultivation is becoming limited due to population explosion and the soil is getting infertile because of continuous jhum cultivation in the same hill. Nevertheless, we have to adopt this traditional profession for the sake of our existence. We have no alternative other than this jhum cultivation. We are deprived of education and we did not feel that we need to have settlement on our land. Even we do not know how to do settlement of our land. As a result, we do not have any recorded land of our own. As citizen of the country we have the right to receive loan from bank with minimum rate of interest. As we do not have the recorded land, we are deprived of the loan facility. We are still in the clutches of the traditional usurers who take high rate of interest from us. This year the unfortunate rat invasion in our jhum crop has made us nervous and put us at our wit's end. So we humbly appeal to you to come forward and extend your helping hand and uphold this issue to the relevant authority of Bangladesh. May the Almighty be with us all. Thank you.

Sincerely

On behalf of the Alikadam Mro inhabitants

List of affected jhum crop villages due to rat attack, 292 Chimpra Mouza, Alikadam, Bandarban

Sl. No.	Name of Karbari (local Headman)	Name of the village	Nos. of affected families	Total affected land (in acres)
1.	Khidu Mro Karbari	Khidu Karbari Para	47	100
2.	Ralai Mro Karbari	Ralai Karbari Para	30	80
3.	Parao Mro Karbari	Parao Karbari Para	22	48
4.	Kratlai Mro Karbari	Kratlai Karbari Para	08	40
4.	Yungcha Mro Karbari	Yungcha Karbari Para	16	40
6.	Chailam Mro Karbari	Chaolam Karbari Para	31	60
7.	Dangli Mro Karbari	KathalJhiri Karbari Para	13	48
8.	Mangrum Mro Karbari	Mangrum Karbari Para	17	56
9.	Menchar Mro Karbari	Menchar Karbari Para	16	40
10.	Thongpong Mro Karbari	Thongpong Karbari Para	14	80
11.	Menway Mro Karbari	Menlew Karbari Para	18	44
12.	Komchong Mro Karbari	Dolujhiri Karbari Para	16	40
13.	Renglot Mro Karbari	Renglot Karbari Para	14	40
14.	Dangku Mro Karbari	Dangku Karbari Para	14	40
15.	Rengbuk Mro Karbari	Rengbuk Karbari Para	07	20
16.	Chaklam Mro Karbari	Chaklam Karbari Para	11	40
17.	Dokhoin Mro Karbari	Dokhoin Karbari Para	07	20
	Total		**301**	**836**



Mission Team Leader, Dr Steven Belmain, together with the community leaders from Alikadam Upazilla named in the above table and the thousands of rat tails they collected over a few nights before travelling to Bandarban to tell others about the problems they are facing with rat floods.

Annex VI: Extracts of a letter prepared by the Deputy Director, Department of Agriculture Extension for Bandarban Hill District Council

The below are extracts of a report prepared by Mr. K.M. Lokman, Deputy Director, DAE, Bandarban Hill District Council. Memo no 1659 dated 12.10.2008 submitted to the Honourable Chairman of Bandarban Hill District Council.

The Honourable Chairman of Bandarban Hill District Council has sent a letter government, letter no 55 dated 15 October 2008 to the honourable assistant to the Chief Advisor, Ministry of Chittagong Hill Tracts Affairs of Bangladesh Government. The Chairman mentioned in his letter that under Remakri Union, 1400 households were affected and 75% of crops were damaged. At the Tindu Union Parishad, 50% of households out of 850 were severely affected with the rat flood. Moreover under Thanchi Upazilla, 125 hectares were affected, and in Ruma Upazilla, 90 hectares of jhum crops were severely damaged by the rat infestation.

Upazilla wise rat flood damage under Bandarban Districts

Name of Upazilla	Name of Damaged Crops	Damaged Crops Area (Ha)	
Thanchi	rice, maize, sesame, chilli	175.20	
Ruma	chilli, sesame, cucumber, rice	90.63	
Alikadam	rice	88.00	
Nakhyangchary		5.49	
Bandarban Sadar			no damage
Roangchhari			no damage
Lama			no damage
Total		**359.32**	

The Chairman of No. 1 Pyanda Union Parishad has sent a letter, dated 20.10.2008, to the Honourable Chairman of Bandarban Hill District Council providing data on jhum crops damaged by the rat flood and wild boar as per the below table.

List of crops damaged by Rat and Wild Boar in the year 2008 in Paingdu Union under Ruma Upazilla.

Name of Para	Number of affected Households	Rice (Kg)	Maize (Kg)	Sweet Gourd	Calocasia (Kg)	Cucumber (Kg)
Gonga Para	16	13750	5662.5	7050	10012.5	8362.5
Rownin Para	47	28600	8025	10912.5	9337.5	10387.5
Poli Prangsha Para	26	17090	4537.5	3450.0	3600	5812.5
Chandra Para	84	68240	10237.5	4350.0	33712.5	57187.0
Politong Para	25	26580	2550	3187.5	5100	2925
Sardalang Para	23	9030	4462.5	4837.5	3975	1387.5
Hapyhill Para	24	17600	11362.5	13237.5	14362.5	15900.0
Kyalungkhyang Para	15	11900	2212.5	900	6337.5	8287.5
Kyatai Para	26	14000	3525	1275	7312.5	1650
Segum Para	32	34940	4687.5	2700	13837.5	12412.5
Liangkhyang Para	49	34800	8587.5	13987.5	9337.5	7012.5
Jurdarang Para	40	23050	153375	154687.5	217312.5	186000
Chairagra Para	39	18810	20137.5	18787.5	17400	16800
Basatlang Para	35	24900	9487.5	10275	9487.5	7425
Kanan Para	9	7400	4012.5	4050	5212.5	4050
Line Para	7	3450	1575	1687.5	1050	2062.5
Chairagru Para	8	4900	2737.5	3300	2287.5	3262.5
Mualpi Para	86	58430	6901	6412.5	4762.5	6300
Munnuam Para	101	89340	10368.75	7650	7725	11925
Artha Para	48	22800	25050	18412.5	38887.5	2137.5
Sangnakra Para	24	15590	2325	2550	3525	3187.5
Nutan Para	21	16080	5812.5	9600	5437.5	5550
Debachara Para	21	14100	5437.5	8025	58877.5	6262.5
Paingdu Ujani Para	20	8870	7612.5	5250	2812.5	4275
Parao Para	22	11000	1725	1537.5	1312.5	712.5