Bamboo Construction Technology for Housing in Bangladesh

Opportunities and constraints of applying
Latin American bamboo construction
technologies for housing
in selected rural villages of
the Chittagong Hill Tracts, Bangladesh

Shila K. de Vries,
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M. Sc. Thesis in Technological Development Studies
Faculty of Technology Management
Eindhoven University of Technology
The Netherlands

Supervisors:
Dr. Ir. E.L.C. van Egmond - de Wilde de Ligny
Dr. Ir. J.J.A. Janssen
Drs. H.C.J.J. Gaillard

In co-operation with:
International Network for Bamboo and Rattan, Beijing, China
Action Aid Bangladesh, Dhaka, Bangladesh

“The bamboo is literally the stuff of life. He builds his house of bamboo; he fertilises his fields with its ashes; of its stem he makes vessels in which to carry water; with two bits of bamboo he can produce fire; its young and succulent shoots provide a dainty dinner dish; and he weaves his sleeping mat of fine slips thereof. The instrument with which his women weave their cotton are of bamboo. He makes drinking cups of it, and his head at night rests on a bamboo pillow; his forts are built of it; he catches fish, makes baskets and stools, and thatches his house with the help of the bamboo. He smokes from a pipe of bamboo; and from bamboo ashes he obtains potash. Finally, his funeral pyre is lighted with bamboo. The hillmen would die without the bamboo, and the thing he finds hardest of credence is, that in other countries the bamboo does not grow.”

(Lewin, 1869)

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Executive summary

The subject matter of this thesis is Bamboo Construction Technology for Housing and the impact that the particular needs of a target group have on successful application of foreign developed technologies.

The country of Bangladesh faces a huge problem in the housing situation. There is a substantial lack of housing, particularly qualitative housing that is adequate according to both material and immaterial needs of the population. The role of bamboo in house construction has been substantial everywhere it grows naturally, including in Bangladesh, where over 70% of housing is made from bamboo. However, the technologies, originating from family tradition, are still very basic and temporary. Bamboo has many advantages though which has been the reason for other countries to invest in research on improving bamboo construction technology for housing. Making use of these experiences gained in other countries and introducing new, more durable and sustainable, bamboo technologies in Bangladesh may very well contribute to a solution of the housing problem in the country.

International Technology Transfers between bamboo growing countries are amongst the points of interest for INBAR (International Network for Bamboo and Rattan). Although they have developed practical methods to facilitate these technology transfers, actual research into the practice of international technology transfers has not been executed yet. In consultation with the Eindhoven University of Technology and INBAR this research on technology transfer of two bamboo construction technologies from Ecuador and Costa Rica to selected villages of the Chittagong Hill Tracts (CHT), Bangladesh, has been formulated.

The *aim* of this research project was to determine the opportunities and constraints of the application of the two selected technologies in the CHT. Recommendations based on these conclusions can lead to providing for better housing opportunities for the *target group*: lower income households in selected rural villages of the CHT, Bangladesh.

The main question that has been answered through this research project is: **"What are the opportunities and constraints of applying two bamboo construction technologies for housing from Ecuador and Costa Rica in selected rural villages of the Chittagong Hill Tracts, Bangladesh, emphasising the particular housing needs of the target group?".** An analytical framework for studies on technology and socio-economic development is used in order to find the answer to this main question. In this model an attempt is made to integrate all factors on international, national, sector, and technology level that are of importance when introducing a new technology.

This model formed the base for the actual research which consisted of several sub-studies. Through a *literature study* the two technologies (Viviendas Hogar de Cristo from Ecuador and Proyecto Nacional de Bambú from Costa Rica) and their national and sector setting as well as the Bangladeshi national setting and part of the sector setting are mapped. In Bangladesh *case studies* have been executed on the particular qualitative housing needs as well as the present technology stock (products and processes) of the target group. These case studies have been executed through observations during fieldtrips and through interviews with the target group as well as with local construction experts. The technology from Ecuador and its setting is described in chapter 2, chapter 3 contains the technology from Costa Rica and its setting, and in chapter 4 the Bangladeshi national and sector setting are described including the qualitative housing needs of the target group.

The results of these sub-studies have led to the following *conclusions*. There are some major constraints towards technology development resulting from the national setting of Bangladesh. Basically, the country lacks a solid base for initiatives regarding technology development. This constraint will have to be overcome by time. Besides that, any national effort for investment in the CHT may form a problem as these people take a marginal position in the country. For development of bamboo construction technologies in general, a huge constraint is formed by the fact that bamboo has low status as a building material for houses.

Overall can be said that the house of Viviendas Hogar de Cristo pretty well matches with the present houses of the research area, but as for meeting the needs that the target group expressed for qualitative improvement, the VHC house is quite inadequate. The particular requirements of the target group regarding functionality and durability and status of materials is decisive.

The house of Proyecto Nacional de Bambú is far too expensive for the target group. It is obviously designed for a somewhat higher-income group. Some of the elements of the PNB house that add much to those costs are not needed though by the target group of this research. On the other hand the PNB house has some elements that do meet the qualitative needs that the target group expressed.

The *recommendations* following from these conclusions are summarised in the following table:

Actions	***Time frame****		***Actors *****			
	ST	LT	Inbar	local NGO	local actor	GoB
Application of VHC:						
▪ Do not apply this technology in the research area.	x		x			
▪ Consider (ST*) applying VHC in urban areas (or disaster affected areas) of Bangladesh. If it is proven to be successful, then apply (LT*).	x	x	x	x	x	
▪ Consider (ST*) setting up a production plant in the CHT. If it is proven to be successful, then apply (LT*).	x	x	x	x	x	
Application of PNB:						
▪ Do not apply this technology in the research area.	x		x			
▪ Take some elements of the PNB house and incorporate them into a new design (ST*). If it is proven to be successful, then apply (LT*).	x	x	x	x	x	
▪ Consider (ST*) applying PNB in higher (urban) income group. If it is proven to be successful, then apply (LT*).	x	x	x	x	x	
Bamboo for low-cost housing in general in Bangladesh:						
▪ Promote this issue to local actors.	x		x			x
▪ Invest in R&D on this issue.	x					x
▪ Provide for subsidies adequate for the low-income group.	x					x
▪ Adapt foreign technologies to local environment.	x		x	x	x	
▪ Introduce bamboo for housing for higher income groups.	x		x	x	x	

* ST: short term, within 5 years; LT: long term, above 5 years.
** INBAR: international networking organisation; Local NGO's: work in Bangladesh on various development projects; Other local actors: those that are active in the field of low-cost housing in Bangladesh, the CHT in particular. GoB: Government of Bangladesh.

Some issues that came up in these studies that require further research are:
- The CHT are in general quite neglected in development studies regarding Bangladesh.
- Bamboo as a construction material for housing has such a low status in Bangladesh that research into its present state as well as development is lacking.
- The specific attitude regarding bamboo in Bangladesh and ways to change this attitude.
- The actors that are engaged in housing in Bangladesh and exactly in what way they (co-)operate.
- Possibilities of applying VHC in urban marginal areas of Bangladesh, and placing the production plant in the bamboo growing areas, like the CHT.
- Possibilities of applying PNB in higher income (urban) areas of Bangladesh.

An evaluation of the methodology used in this research leads to the following recommendation:
- The theory used in this research is quite extensive as it is based on the thought that there are many aspects related to the success of a technology.
  - The advantages in this are that it provides for the possibility of executing an explorative – initial- research where all possibly relevant aspects are examined and problems can be identified for further (more detailed) research.
  - The disadvantages are that it is very extensive and within a limited time frame it is not possible to deal with all aspects in detail.
- The research area, the CHT, however suitable for this research being a bamboo growing area, is in a politically unstable position and this makes research quite difficult at the moment. As bamboo is available throughout the whole country on homesteads or imported from the forests, there are plenty of other areas suitable for bamboo development projects.

List of abbreviations

AAB	Action Aid Bangladesh
AABSR	Action Aid Bangladesh Southern Region
ADB	Asian Development Bank
BFRI	Bangladesh Forest Research Institute
CHT	Chittagong Hill Tracts
CR	Costa Rica
EC	Ecuador
EUT	Eindhoven University of Technology
INBAR	International Network for Bamboo and Rattan
LA	Latin America(n)
M.Sc.	Master of Science
NRI	Natural Resources Insititute
PNB	Proyecto Nacional de Bambú
TDS	Technological Development Studies
Tk	Taka, the Bangladeshi currency (1 US$ = 56.225 Tk[1], 1 Tk ≈ 0.02 US$)
US$	United States Dollar
VHC	Viviendas Hogar de Cristo

[1] For juni/july/august 2001.

1 Research design

1.1 Introduction

The subject matter of this thesis is Bamboo Construction Technology for Housing and the impact that the particular needs of a target group have on successful application of foreign developed technologies.

1.1.1 Housing as condition for development

Amongst humanity's basic needs shelter, or housing, ranks quite high. In literature it usually follows after water, health, and food [1]. As Nabi states, "to maintain a good quality of life, a household or an individual should own a good house" [2]. For a very long time however, housing has been considered as being merely consumptive rather than contributing to a national economy. Therefore housing has pretty much been neglected by policy makers. These days especially the low income countries suffer a huge housing problem. Supply is insufficient for the lower income families in particular, and therefore many of them live in houses of inferior quality or even in slums (where shelter is no more than some cardboard and plastic sheets and cloth). In other words, besides a huge quantitative housing need, there is also quite a qualitative housing need.

Also Bangladesh has to cope with a huge problem in the housing situation being one of the world's poorest and most densely populated countries. Issues as rapid growth of its population, unequal social structures, topographic limitations, resource constraints and an unclear governmental perception of housing (leading to inadequate policy making) have all contributed to the problem [3]. According to a UN report [4], most of the housing facilities in Bangladesh lack proper construction, with about 85% of rural dwellings having inadequate protection from wind, rain and floods. The situation is hardly better in urban areas where 84% of the houses are temporary or semi-permanent constructions.

1.1.2 Bamboo for housing

The role of bamboo in house construction has been substantial everywhere it grows naturally[2]. It has strength, flexibility and versatility and therefore it is a suitable material for practically every part of the house – when treated and used properly. The advantages of using bamboo for construction do not end with technical advantages only. It is very economical because it is a local product and therefore amongst the cheapest building materials. Prices have been increasing lately though due to over extraction from forests and lack of plantations that are well managed. Cultivating bamboo can have very high yields if managed properly. Moreover, bamboo can be used as a substitute for timber in many applications, and compared to the trees used for that timber, bamboo grows substantially faster. It can contribute to a solution for the deforestation that is at the present causing concerns for the environment.

One major disadvantage of bamboo is its poor resistance to fungi and bacteria. Without preservative treatment and proper use, the material has a very short life. With the rise of the more durable brick and concrete, bamboo became inferior to those construction materials and its social status is considered very low. In fact, as soon as they can afford to, people tend to replace their bamboo buildings with masonry or concrete. With new technologies of constructing with bamboo, more durable constructions can be achieved as well as better appearance of the house - making it more socially acceptable. This is very well worth while bearing in mind all the advantages bamboo has as a construction material. Huge development efforts are taking place in Latin America, where different new building systems have been developed for low-income, middle-income as well as high income households.

In Bangladesh, where over 70% of housing is made from bamboo, the applications are still very traditional. The technologies stem from family tradition and bamboo needs replacing every other year or so. Research into the subject of bamboo in Bangladesh has been restricted to botanical issues rather than applications in for example housing. Making use of the experience gained in other countries and introducing new, more durable and sustainable, bamboo technologies in Bangladesh may very well contribute to a solution of the housing problem in the country.

[2] In tropical and subtropical areas, ranging from 46 N to 47 S latitude, reaching elevations as high as 4,000 m. www.inbar.int

1.1.3 Research project on bamboo construction technology for Bangladesh

The issue of bamboo for the development of the housing sector in Bangladesh corresponds with the vision of INBAR (International Network for Bamboo and Rattan). INBAR is an intergovernmental organisation with twenty member countries, Bangladesh being one of them. Their mission is to improve the social, economic and environmental benefits of bamboo and rattan, and they support and co-ordinate programs in scientific research, technology generation and sustainable development programs providing bamboo and rattan solutions for people and the environment[3].

One of the points of interest for INBAR is international technology transfers between bamboo growing countries. Although they have developed methods to facilitate these technology transfers, actual research into its practice has not been executed yet. In consultation with the Eindhoven University of Technology and INBAR this research on technology transfer of bamboo construction technologies from Latin America to Bangladesh has been formulated. This report contains the results of that research. INBAR is currently setting up a bamboo development project in the Chittagong Hill Tracts (CHT), Bangladesh. This project area is used for the field work of this research.

1.1.4 Contents of this report

The *first chapter* of the report introduces the design of the research. In the first section of chapter one, this introduction, the background of the research is laid out as well as the contents of the report. This is followed by the theoretical design of the research containing research questions and models. The first chapter concludes with the empirical design of the research, describing the research methods and execution.

The following three chapters present the results of the research. *Chapters two and three* present the bamboo construction technologies of respectively Ecuador and Costa Rica (of which opportunities for transfer to Bangladesh are considered in this research). *Chapter four* presents the situation in Bangladesh, including the housing needs of the target group.

The final chapters discuss conclusions and recommendations. In *chapter five* the opportunities and constraints of transferring the bamboo construction technologies from Ecuador and Costa Rica to Bangladesh are assessed – in other words, an answer to the main research question is given. *Chapter six* gives recommendations for transferring bamboo construction technologies to the relevant actors involved in housing for low income households, as well as an evaluation of the research methodology.

1.2 Theoretical part

1.2.1 Aim of the research

The introduction of the foregoing section leads to the aims of this research. The direct aim of this research is to determine the opportunities and constraints of the application of Latin American bamboo construction technologies for low income households in the CHT, Bangladesh.

Recommendations based on these conclusions can lead to the indirect aim of this research: providing for better housing opportunities for the target group: lower income households in selected rural villages of the CHT, Bangladesh.

1.2.2 Research questions

In order to attain the above mentioned aim, one main question is formulated. This main question is answered in this research by subsequently answering a number of sub-questions.

Research question

What are the opportunities and constraints of applying two bamboo construction technologies for housing from Ecuador and Costa Rica in selected rural villages of the Chittagong Hill Tracts, Bangladesh, emphasising the particular housing needs of the target group?

[3] see also www.inbar.int

Sub-questions
1. Which theory is most appropriate to use in order to answer the main research question?
2. What is the nature of the bamboo construction technology from Ecuador and what are the factors that have influence on its success?
3. What is the nature of the bamboo construction technology from Costa Rica and what are the factors that have influence on its success?
4. What are the particular housing needs of the target group and what are the factors that influence those needs?
5. Do the two bamboo construction technologies match with housing needs of the target group?

The first sub-question is dealt with in this first chapter of this thesis. The remaining sub-questions as well as the main research question are answered in the following chapters (see section 1.2.5).

1.2.3 Relevance

Scientific
The scientific relevance of this research is gaining more insight into the different factors and actors involved in international technology transfers. This research focuses on the particular needs of the target group that are considered to have impact on successful application of foreign developed technologies.

Practical
This research is practically relevant by contributing to the achievement of the above mentioned indirect aim of this research: providing for better housing opportunities for the people of the CHT, Bangladesh. Moreover, this research can contribute to the so-called South-South transfer of technology benefiting the more disadvantaged groups in society.

1.2.4 Theoretical background

In search of a model for technology and development
In the search of aspects influencing international technology transfers (ITT's), literature on technology development has been consulted [5,6,7,8,9,10,11,12,13,14,15]. In a country there will always be a certain need for technologies to meet the ongoing changing demand for products and production processes. The options for meeting this demand are: a) develop the technology locally, so-called indigenous technology development, or b) acquire the technology from abroad: international technology transfer [16].

In the past decades many studies on this issue have been carried out. After World War II political and academic concern for the role of technology in societal development increased. The various theories that emerged were mostly mono-disciplinary, failing to integrate relevant disciplines such as economy, sociology and engineering. The classical theories of development are based on traditional classic economic principles. Although these studies have been useful, they still give no insight into the level and nature of production performance from technological point of view which is very much of importance for this research. Other theories have emerged but none of them seems to be able to integrate all aspects concerned though. In an attempt to find such an all-integrating methodology for her studies on technology mapping, Van Egmond [5] has developed an analytical framework for studies on technology and socio-economic development. In this model an attempt is made to integrate the major factors on international, national, sector, and technology level that are of importance when introducing a new technology.

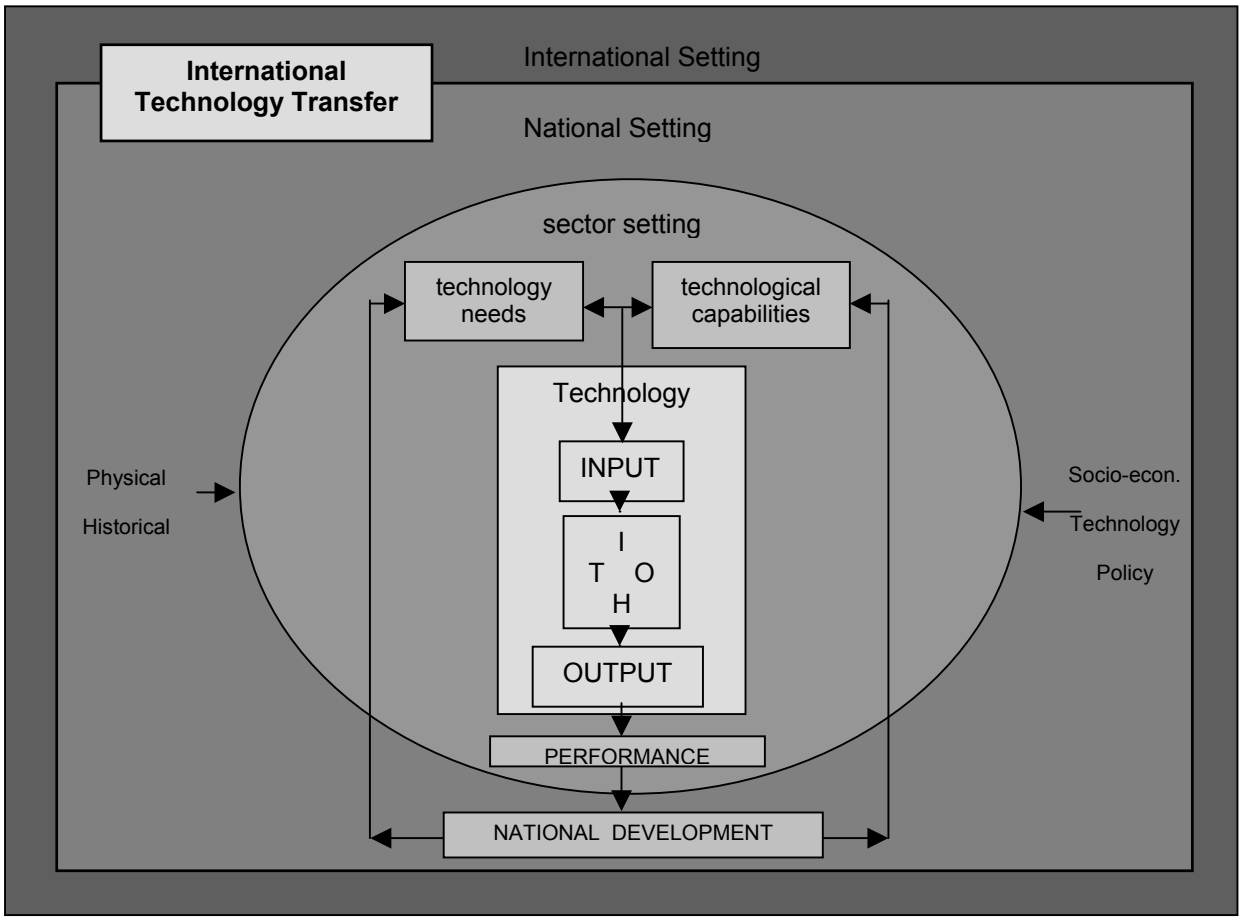


Figure 1.1: An analytical framework for studies on technology and socio-economic development.
Source: Van Egmond, 1999 [5].

In the following an elaboration of Van Egmond's model, which is slightly adjusted for this research, is made. In section 1.2.5 the translation of this model into the actual research is made. Section 1.3 describes the empirical aspects of that research.

Explaining the theoretical model: conceptual definitions
The explanation of the theoretical model presented in figure 1.1 starts from the centre of the model, at technology level. Sector, national, and international setting, by which 'technology level' is enclosed in the model, are supposed to form preconditions for the technology level.

This central part of the model can be used to describe the bamboo construction technologies. A construction technology, as well as any other technology, consists of a product and a process, so we can speak of a product technology and a process technology [5]. **Product technology** refers to the complex of attributes embodied in the *output* of the production process. These attributes can be classified as (1) functionality, (2) geometry, (3) materialisation, (4) production, (5) costs, and (6) physical performance. **Process technology** refers to the *transformer* applied for the production of goods and services in the context of transformation of inputs in production processes into outputs. A process technology can be divided into four main components: Technoware (T): equipment, tools, etc.; Humanware (H): manpower; Infoware (I): documented facts; Orgaware (O): the organisational framework.

The outcome of the application of technologies in a certain sector will become evident in the **performance** of the sector. This performance will either enhance the **national development** or not.

The model shows how the national development status forms the base for **technology needs** and **technological capabilities**. The term *technology needs* refers to the psychological, material or immaterial, desires of a certain population regarding technology. Technology needs consist of quantitative needs on the one hand, and qualitative on the other. The concept of *technological*

capabilities refers to the total stock of national resources that can be committed to the production system in the country (technologies, human resources, natural resources and technology infrastructure), giving the necessary inputs for efficient and effective production.

Van Egmond considered two main systems in the **national setting** that are of significance for studies on technology and socio-economic development. First the *physical system*: geography, climate, occurrence of natural disasters, vegetation, etc. Secondly the *social system* which consists of a whole of institutions that can be considered as representatives of the necessary functions that need to be fulfilled in that social system. The institutions considered of importance for this research are: (1) socio-economic institutions, which is a combination of different institutions –economy, demography, health and education- which are individually less significant for the purpose of this research and are therefore combined; (2) technology, which in this case is considered as the totality of sectors in a country; and (3) policy making. Apart from this, also the history of a country will be dealt with, as it explains the present status of the national setting of a country.

The aspects of the **international setting** that are important when dealing with international technology transfers include the countries where technology is being transferred from as well as for example international trade agreements. When talking about **international technology transfer**, basically one refers to a purchasing process. There is a buying and a selling party and of course a good or service to be sold. Roughly the phases of an ITT process are:

(1) pre-investment phase (preparation);
(2) investment phase (implementation);
(3) post investment phase (evaluation).

The first step to be taken in the pre-investment phase is to identify a possible technology project to be transferred, by executing a technology audit or needs assessment. In this research the focus is on this **needs assessment**, keeping in mind not the whole process of ITT, but only the fact of **application** of a foreign technology in a new environment.

1.2.5 Application of theoretical model in this research project

In this research a needs assessment is carried out, keeping in mind the actual application of the foreign technologies. The opportunities and constraints of application of these technologies (two Latin American bamboo construction technologies for housing) are examined by comparing them with the needs of the target group. Because of the impact of national and sector settings on successful application of technologies, and the fact that these settings are different for the LA countries and for Bangladesh, national and sector settings are also taken into account in this research (see figure 1.2).

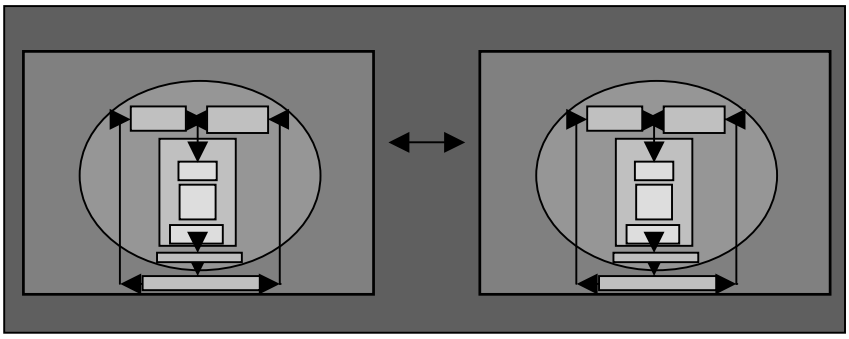


Figure 1.2: Comparing technologies in their setting

In this research the theoretical model is used to: 1) describe the LA bamboo construction technologies and the extent to which these technologies are related to their national and sector setting, and 2) to establish the national and sector setting of Bangladesh in order to draw conclusions on the opportunities and constraints of applying the LA technologies in Bangladesh.

When using this model for both Bangladeshi and Latin American situations the research becomes quite extensive. In order to keep the research within time limits some restrictions are made. Firstly, two technologies from Latin America have been selected and in describing these technologies the emphasis is on the technology-level. Secondly, in the section on Bangladesh the emphasis is on the

technology needs which is part of the sector setting, but because of its emphasis, it will be dealt with separately. These two restrictions are explained in the following.

Emphasis on technology needs

In the previous section the importance of a needs assessment in the process of ITT has already been mentioned. Several authors underpin this importance of assessing the needs of the target group [6,9,10,12,17]. They all mention a needs assessment or market exploration as one of the first steps to be taken in the process of technology development/technology transfer. Stewart [in 1] for example states that:

"*Choices of product should be done on the basis of felt needs. […] In many cases, products developed for rich countries possess characteristics unnecessary and sometimes even undesirable for poorer nations. The government could –and should- play a prominent part in establishing the desired characteristics. Frequently, however, it will not only be significant but also necessary to make an inventory of the demands of the target-group, that is the group of people which are supposed to use the product, and to establish the priorities of this group.*

The field research of these studies evolve around this aspect of technology needs. The housing needs of the target group, low-income families in the CHT, Bangladesh, are examined in the field.

Selection of the two Latin American technologies

The two technologies selected for this research have gained quite some success in being internationally recognised. They both received Habitat's Best Practice award and have been mentioned in many different publications. Therefore INBAR was interested in including these technologies in this research. And as a literature study is used for examining these technologies (see following section), sufficient literature was available as well. The two selected technologies are:

1. Viviendas Hogar de Cristo, Ecuador
2. Proyecto Nacional de Bambú, Costa Rica

Research model

The research model (figure 1.3) shows the aspects from the theoretical model that are considered in this research and the connection between them. This model can be seen as a 'working model' for the execution of this research.

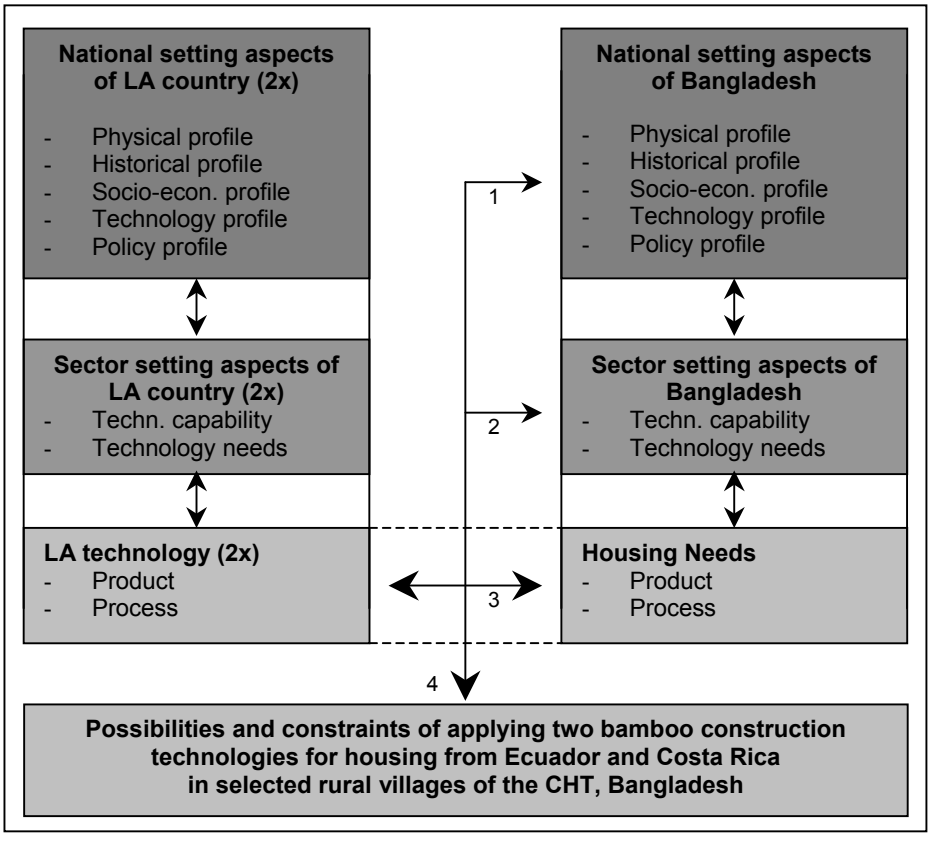


Figure 1.3: Research model.

The boxes show the sub-studies carried out in this research. The three upper left boxes refer to Ecuador (chapter 2) and Costa Rica (chapter 3) giving the answer to sub-questions 2 and 3. The three upper right boxes refer to Bangladesh and provide for the answer to sub-question 4 (chapter 4). Within these sets of three boxes, the vertical arrows show how the sections are interrelated. The rest of the model refers to the conclusions of this research (chapter 5). This conclusion can be divided in four steps (1,2, 3, 4 in figure 1.3).

1. Comparison between LA technology and National setting, particularly the policies
2. Comparison between LA technology and Sector setting, particularly the technology capabilities
3. Comparison between LA technology and Housing needs
4. Opportunities and constraints of applying LA bamboo construction technologies from LA in B.

Step 1,2, and 3 show how the LA technologies are compared with the different aspects of Bangladesh, according to sub-question 5. Step 4 is a conclusion of steps one to three, giving an answer to the main research question. Finally recommendations can be made to the different actors involved in housing for low income families in the CHT, Bangladesh (chapter 6).

1.3 Empirical part

1.3.1 Type of research

This research is of an explorative, descriptive kind. Therefore the results should be considered as preliminary results, and following from this research further studies are identified. This research is split up into a number of sub-studies. Two types of research have been used: literature studies and case studies.

Literature studies
These were carried out to gather data on:
- Latin American technologies, their sector setting, and national setting
- National and (part of) sector setting Bangladesh

Case studies
Village case studies
In order to examine the *housing needs* as well as the present *housing stock* of the target group, four comparative village case studies were executed. The villages differ significantly which made it preferable to take several comparative case studies. These case studies are set up in the form of a survey. The population of the village case studies consists of the households of the villages (approximately 150 households per village) with the head of the household (or following most important person in household available at the moment of interview) as research unit. Of each village, a random sample of 30 households is interviewed, making a sample fraction of 1/5. There may be a bias in the sample as during the research, it is likely that not all of population was available and/or willing to participate.

The four villages are selected from the list of seven villages that are possibly involved in the future INBAR project on bamboo development. It is important to note that these villages may very well not be representative for all rural villages of the CHT. Those villages that are most accessible have been chosen for this research. The number of households included in the survey (the sample) is determined according to the assumption that 10 interviews can be taken per day, and the fact that in one week, the interviewer would be able to work 3 days. The interviewer would stay in the villages during those days, so it was preferable that all interviews of one village would be taken in one week (3 days together). Resources for more than four village case studies were not available. A total of 120 interviews has been taken.

Maji case study
Local experts [18] indicated that the *construction processes* in the CHT are generally carried out by a particular group of small scale local contractors, called maji. Interviews have been taken from this main group of actors. Population of this case study consists of all majis from the four villages, and a random sample of five majis is taken. Also in this sample there is the possibility of a bias as the research depended on the availability of majis during the research and their willingness to co-operate.

1.3.2 Operationalisation and research instruments

In order to execute above mentioned sub-studies, the variables of the research model are transferred into a checklist of measurable terms (operationalisation: see appendix A1.1). This checklist is used directly as instrument for the literature studies. The instrument used for both case studies is a questionnaire that is derived from the checklist and pre-tested by discussing it with BFRI researchers that have experience in the research area amongst others with taking questionnaires (see appendix A1.2 and A1.3 for both questionnaires). These questionnaires are taken from the population by means of an oral interview where the interviewer fills in the questionnaire.

1.3.3 Methods of data collection

As for the case studies, due to political unrest in the CHT as well as the difficult access to the research area, the author has not participated in taking the interviews herself. She visited the area on field trips (three day-long fieldtrips). *Observations* of the housing situation have been made during these field trips, and more insight into the construction process has been gained. A BFRI research assistant has been hired as interviewer for the case study *interviews*. He is very well known in the area and with the population and had experience there with conducting research for BFRI. This interviewer spent in total approximately 15 days in the research area to take the interviews.

1.3.4 Methods of analysis

The methods of analysis used in this research are all either descriptive or basic descriptive statistics. The data resulting from the research do not allow for more sophisticated types of analysis.

2 Ecuador

This chapter presents the first bamboo construction system that is considered for application in Bangladesh: Viviendas Hogar de Cristo (VHC). As national and sector setting are considered to give preconditions for the success of the application of a technology for low-cost housing, both national and sector setting will be discussed first in order to see the context of VHC.

2.1 National setting Ecuador

2.1.1 Physical profile

Geography

Ecuador is one of the smallest countries in South America. The country comprises three well-defined geographical zones: the sparsely populated Amazon region in the east ('oriente'), the Andes highlands in the centre ('sierra') and the coastal area at the western side of the country ('costa'). Besides the main land, Ecuador also consists of the Galapagos Islands. Quito is the administrative and cultural centre as well as the country's second largest city. The largest city is Guayaquil which is also the economical centre being the main port.

Figure 2.1: Map of Ecuador. Source: www.mapquest.com

Climate and natural disasters

Both 'costa' and 'oriente' have a tropical climate. In the 'sierra' the climate is cooler though as a result of it being a mountainous region. The natural disasters Ecuador has to face are earthquakes ('oriente' mainly), landslides, volcanic activity ('sierra') and periodic droughts (mainly south part of 'costa') [1,2].

The varying characteristics of the different regions also have their effect on house construction in those regions. Whereas houses in both costa and oriente may correspond, the sierra with its cooler climate will have a different housing pattern. The three regions all have other more or less frequently occurring natural disasters with which one has to count when designing a house.

2.1.2 Historical profile

History obviously had its impact on different aspects of Ecuador today. It has established Ecuador's land volume, and as for house construction, the different rulers that Ecuador had have put their mark on the architecture of today. Moreover it led to the current housing crisis for low income families (see also appendix A2.1.1).

2.1.3 Socio-economic profile

Ecuador is a relatively poor country and the government faces enormous debts that cannot directly be solved due to the unfavourable economic situation. Its population is growing quite rapidly which is particularly posing a problem in urban areas where nowadays approximately 60% of the population lives. The economic situation also has its impact on the health and education situation. Health and education level are quite according to Ecuador's status of a lower middle income country. Not very high, but also not extremely low. The present housing situation as well as innovations in the housing sector were obviously influenced by this.

2.1.4 Technology profile

The overall status of technology in Ecuador is also quite according to its status of a lower middle income country. For housing this implies that not too much development was encountered in literature (see appendix A2.1.2 for socio-economic and technology indicators).

2.1.5 Policy profile

Housing policies
Since recently the government has been working on a new housing program with main objective to reach the population that needs the most assistance. These programs are especially directed at families from rural areas and marginal urban areas who are not able to obtain credits from banks or co-operative societies. The reality though is that the poorest population still isn't served by these programs [3].

Bamboo related policies
No policies related to bamboo have been found in literature.

2.1.6 Conclusion on national setting Ecuador

Ecuador's current housing crisis is a direct result of its national history, social classification, economy and policy making. The low income part of the population, the largest part, does not have sufficient and adequate housing and has to rely on the traditional building material in traditional applications, bamboo.

2.2 Sector setting Ecuador

The sectors concerned in this research are the bamboo and the housing sector. The technology needs and capabilities of these sectors are discussed in this section.

2.2.1 Bamboo sector

Technology needs
At present, the supply of bamboo products as well as the availability of bamboo processing technologies is sufficient to meet the demand. The prominent position that bamboo has in the Ecuadorian culture (see appendix A2.2.1) implies – based on the role that bamboo generally has in those countries where it grows naturally - that it is used as a traditional low-cost and low-status material for housing and that therefore bamboo is considered a poor man's timber [3].

Technology capabilities
1. Technology stock

Product technologies
Bamboo is mostly used for construction of rural and marginal houses in and around all coastal cities of Ecuador. Other uses are supporting of conventional methods of construction, supporting bananas at plantations, and for an endless amount of artefacts that farmers and city dwellers use and without which their lives seem impossible to imagine. Bamboo in construction is used in two different ways. Firstly in the form of *poles* for structure of walls, floors and roofs. The second application of bamboo is split bamboo, used in walls and ceilings. In Ecuador split bamboo is known as 'caña picada' or 'tabla de caña'. The technologies (also in construction) are traditional, and the bamboo used is extracted from forests [4,5].

Process technologies
Tools and equipment, skills and knowledge, information and documentation, and organisation structure of the bamboo sector are traditional and therefore very simple. Bamboo in Ecuador is harvested by hand from natural forests at relatively low cost.

2. Human resources stock

Specific data on the human resources stock in this particular sector are not available. Reference is made to the human resources on national level as mentioned in the 'technology profile' in the first section of this chapter.

3. Natural resources stock

Guadua Angustifolia (guadua in this report) is the most frequent bamboo species of Ecuador. Other species found in Ecuador are "bambusa aculeata" and "bambusa vulgaris". Most of Ecuador's guadua is gained from natural forests (about 95%), but these forest resources are currently limited so there is a problem in supply to be foreseen in the future. Only in the past half decade some reforestation programs have started - all of them privately organised. Commercial plantations have not been set up yet [3,4]. The country has unique opportunities though for plantation development. Land costs are

cheap, labour costs are appropriate for sustainable hand-extraction of bamboo, and there is a sizeable existing domestic market for bamboo [6].

Guadua prospers on well-watered volcanic and alluvial soils. It is a fast growing plant. Culms attain their maximum diameter (15-18 cm) soon after the growing process has started. Internodes are 20-30 cm apart and the maximum plant height (18-20 m) is achieved in less than 6 months (appr. 80-110 days). Plant maturity is reached 3 to 6 years after planting. [7]

4. Technology infrastructure
The International Network for Bamboo and Rattan (INBAR) is starting a project for small-scale farmers to cultivate bamboo in the area around Santo Domingo, Ecuador. Together with a United States financed plantation, these would be the very first commercial bamboo plantations in Ecuador. No data are available on other activities and/or actors.

2.2.2 Housing sector

Technology needs
In 1996 an estimated deficit of 1,328,000 houses has been calculated. A large amount of houses in this deficit consists of the existing housing stock that lacks quality: 980,000 houses (74%) [6]. Gilbert [8] gives the following 1995 figures: permanent dwellings: 2.136.000; total deficit: 1.505.000, of which 18.1% is quantitative and 52.3% is qualitative.

A basic home is considered to have 36m2 on a 72m2 plot, but for Guayaquil it was estimated that only 20% of the population can afford that without financial assistance. The government of Ecuador has implemented a subsidy program, but still this program excludes the low-income families. The same can be said for mortgage systems and credit facilities.

Most of the low-income houses in Ecuador are built with self-help construction (*autoconstruccion* in Spanish). Although this is seen by some [8] as an inferior construction method leading to the deterioration of the housing stock, the municipality of Guayaquil acknowledges the 'autoconstruccion' as a solution to the housing deficit. They started the project "Mucho Lote" which has the objective of delivering 15,000 low-income plots with services for the low-income families. The owners of the plot can construct their own house on the plot. At the same time this solves part of the illegally occupied land problem that the municipality has to face [3].

Technology capabilities
1. Technology stock
The two most occurring construction technologies in Ecuador are concrete and bamboo construction technologies. Because of the difference between these two systems both product– and process technology of these two construction systems are described separately in this section.

A. Concrete:
Product technologies
In all parts of the country concrete block construction is the most preferred form of construction today. The houses available *cost* about US$ 5000 for 36 m2. The credit systems that come with the projects are mostly aimed at middle income families with incomes starting from 800 dollar per month. These houses have a living room, two bedrooms, and a fully-equipped kitchen and bathroom. The advantages of the concrete system as for *physical properties* are: large durability against a.o. humidity and fungal attacks; security against crime. Besides that it is a symbol of status. The fact that they have poor thermal resistance is a major disadvantage.

Process technologies
No data available.

B. Bamboo:
Product technologies
The traditional bamboo construction method is called 'bahareque' (see appendix A2.2.2) and in the city of Guayaquil many old houses can be found that are made of bamboo bahareque. Out of the two types of bahareque, solid and hollow, the hollow one is used in Guayaquil. These structures provide solid and secure walls and greatly improves the aesthetics, durability and suitability of the structure. Unfortunately, the costs of the mortar used in this construction method are rather high, and nowadays,

if those financial resources are available, a concrete block system is preferred. Another more affordable construction method uses uncovered bamboo. Mangrove wood is used for columns and the walls consists of panels made of wooden frames covered with split bamboo. The production of these constructions is simple and often used for self-help construction (see appendix A2.2.3 for more on Ecuadorian bamboo housing).

Process technologies
Bamboo is still used as a traditional building material. Therefore tools and equipment, skills and knowledge, information and documentation, and organisation structure of the bamboo sector are traditional and therefore very simple.

2. Human resources stock
Specific data on the human resources stock in this particular sector are not available. Reference is made to the human resources on national level as mentioned in the 'technology profile' in the first section of this chapter.

3. Natural resources stock
Natural resources for house construction, building materials, are in principle available in the country. Concrete is the predominant construction material, and cement is produced locally. Forests for the extraction of wood are also available, but as in many other countries, deforestation is a problem in Ecuador (see appendix A2.2.4). The same goes for bamboo, as all bamboo used in construction is extracted from forests.

4. Technology infrastructure
The network of actors supporting low-income housing in the city of Guayaquil consists of: government and public sector agencies, commercial private agencies, NGO's, community based organisations, and households [3].

2.2.3 Conclusion on sector setting Ecuador

Bamboo sector
Although at present supply seems to fulfil the demand, a problem in supply is foreseen in the nearby future. Technology capabilities are based on a very traditional use of bamboo.

Housing sector
The need for low-cost housing is not very well met at all. The market is more focussed on middle-income families. The most common form of housing is using concrete blocks. Bamboo housing is also quite common, but in the lower-cost area. Bamboo for housing is used both in a covered as an uncovered way. Capabilities seem to be quite promising for the development of the lower-cost area of the housing sector.

2.3 Construction system: Viviendas Hogar de Cristo

2.3.1 Introduction

In 1973 "Viviendas Hogar de Cristo" (VHC) was founded in order to provide a housing solution for the outskirts of Guayaquil, Ecuador. Here one can find one of the worst housing conditions in the world. The objectives of VHC are to give shelter to the homeless, strengthen the family unit and promote human and spiritual values at home. Aware of the lesser status of bamboo, VHC's principle is "better to give a bamboo shelter today than a concrete house in five years". Shelter offers more than just a roof above the head. It is the beginning of the social and economic development of the family. It offers stability and health for the family, a place to do homework for the children and it gives better chances of obtaining work. Families are stimulated to improve their house in time. The bamboo house is just the first step in acquiring a solid, long lasting and decent home.

The traditional housing in the rural and urban-marginal areas inspired the applied technology for the construction of the houses of VHC. It is a logic response to the physical, social and economical conditions of this environment around Guayaquil and it enables to produce low-cost housing which is socially accepted and easily maintained [4, 9, 10].

2.3.2 Product description

1. Functionality
As there are no facilities whatsoever incorporated in the house, the space can be used for any purpose needed. The house consists of only one room.

2. Geometry
The VHC bamboo house is rectangular of shape, with a surface varying from 20.5 to 41 m² (there are three types available, varying in size). It is elevated on poles so that later a ground floor can be added. It has a gable roof (two slopes) and the roof has some overhang. Overall appearance is that of a traditional, low-cost bamboo house (see appendix A2.3.1 and A2.3.2).

3. Materialisation
The materials used are bamboo, wood, some smaller metallic components, and zinc sheets for roofing. Bamboo is used in the form of 'esterilla' (split bamboo) as cover of the wall panels. The bamboo is extracted from the forests and the culms are processed directly into strips or bamboo mats. This process is done manually with the aid of axes and machetes. The immediate processing has the advantages of employment generation for the rural population as well as allowing the transport of larger quantities of bamboo.

The wood, mangrove for the pillars and tropical hardwood for the other parts, is extracted from the forests in coastal areas. Certificates are given by forest institutes to guarantee the sustainability of the exploitation of the forests. In Esmeraldas the tropical hardwood is sawed into planks and transported to the Hogar de Cristo plant. The wood will be classified and dried for 1 to 2 months. In the plant the wood is further processed for floor elements, frames for the bamboo panels, doors, windows or roofing support beams. The mangrove wood for the pillars is bought from small merchants who exploit it from the mangrove forest in the estuary and bring it with a boat or canoe to the small river port of the factory.

The smaller metallic components are for example nails. The zinc sheets are used for roofing. These inorganic materials represent 60% of the total costs of the house.

4. Production
Basically, when a family wants to obtain a house from VHC, they go to the corporation and based on their socio-economic and family situation, VHC decides on a suitable housing type and financing (cost and monthly payments). When everything is confirmed and the initial payment is made, the building package can be acquired and transported to the building site.

The building package consists of 8 panels for the walls (see appendix A2.3.3), wooden boards for the floor, 1 door and 3 windows, 9 wooden pillars, roofing sheets and nails. The package comes with a manual which makes it possible to assemble the house without supervision. This is usually done with the help of friends, family or neighbours. It is possible though to hire a construction expert to help. At the building site, the house can be constructed in 4-5 hours.

The whole process of obtaining and constructing the house takes about 10 to 15 days, depending on the productivity of the plant where the building packages are fabricated.

5. Costs
The VHC bamboo house is sold as a package that families can buy for about $380. According to the household's socio-economic characteristics, they can get subsidies. Usually, the payment is done over a period of 3 years, in monthly payments. Excluded from this price are the transportation costs of the packages and the costs of hiring an expert for constructing the house.

6. Physical performance
As mentioned in the introduction, the VHC bamboo house is designed following the traditional rural houses. The tradition has developed into a house that is fairly well secured against earthquakes (light structure), fungal attacks (wood instead of bamboo is used in direct contact with the ground), humidity and warmth (bamboo used for walls performs well in humid climate and its open structure allows for ventilation). The zinc roof protects the house from tropical rains, but for regulation of warmth it is not suitable at all. As for security against cyclones, as they don't occur in the area, no special attention is given to this.

2.3.3 Process description

Technoware
The VHC house is prefabricated which allows for a process using modules, serial production and high levels of productivity. The high number of units per day can, in cases of natural disasters, double or even triple.

The construction of the panels is organised as follows:
- Metal moulds are used to make the different panels in series
- Storage of raw material is at one side of the moulds, storage of finished panels is at the other side
- Fabricating the panels goes as follows:
  - Making of wooden frames
  - Placing esterilla on the frames and attaching it to the frames
  - Cutting off the esterilla that is sticking out of the frame
  - Stacking of the panels

In an eight-hour day (with necessary breaks) one labourer can make approximately 18 panels, sufficient for 3 houses a day. In general, a VHC house, with all its components of bamboo and wood, is fabricated in about 2,5 hours. This results in a daily production of 50 houses at the VHC production plant. All components are put in a package, ready to be transported to the construction sites.

The vehicles used for transportation of the packages are owned by private organisations or individuals. They have agreed on a uniform cost of US$6 to transport the packages from the plant to any site in Guayaquil. In case of emergencies due to disasters, the packages (in larger quantities) are transported by truck of even boat.

Humanware
The labour needed for producing VHC house is:
- Panel production plant workers
- Transportation workers
- Professionals to help construction on-site

Orgaware
The organisation of Viviendas Hogar de Cristo can be described as follows:
- Selecting of beneficiaries
- Acquiring the inputs
- Producing building packages
- Transportation
- On-site professional help
- Or: autoconstruccion

Infoware
- Manuals
- Publications containing basic drawings

[4,11,12,13,14]

2.3.4 Conclusion on construction system Ecuador

VHC has responded to the housing situation of a specific area in Guayaquil, where there is a lack of housing for the lowest income groups. This has determined the present success of VHC.

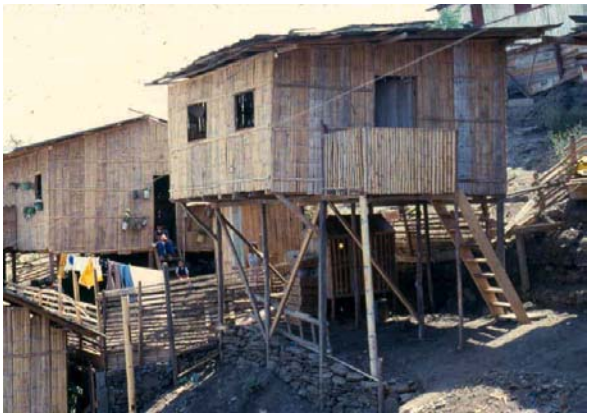
Product
The only obvious disadvantage of this construction system is the lack of facilities. No facilities whatsoever for water, electricity, cooking and bathing are provided for. Besides that, the system has a number of advantages considering the fact that it is designed as a house for low-income families. The design is made based on the traditional rural bamboo houses. Social acceptation therefore does not pose any problems, the appearance of it blends into the Ecuadorian landscape. Materials used and physical properties take very well advantage of both sector and national conditions. Costs and production also cater well to the target group.

Process
The process is designed in such a way that the costs of the house can be kept this low. This is an obvious advantage. It is a serial production process, so there has to be enough demand for the houses in order to work at full capacity though.

Picture page Ecuador

Above (3x): Viviendas Hogar de Cristo. Model house, production plant, and inside detail.
Source: Gutierrez, 2000.

Above: rural bamboo house in Ecuador.
Source: Moran, 2001.



Above (2x): Bastion Popular slum, Guayaquil.
Source: Moran, 2001.

Picture page Costa Rica

Above left and right: PNB houses.
Source: Gutierrez, 2000; Janssen, personal collection.

Above: PNB house, detail of unfinished wall.
Source: Janssen, personal collection.

Above: PNB house under construction.
Source: Gutierrez, 2000.

3 Costa Rica

This chapter presents the second bamboo construction system that is considered for application in Bangladesh: Proyecto Nacional de Bambú (PNB). Both national and sector setting will be discussed first in order to see the context of the PNB as this context is considered to give the preconditions for the success of a technology for low-cost housing.

3.1 National setting Costa Rica

Figure 3.1: Map of Costa Rica.
Source: www.mapquest.com

3.1.1 Physical profile

Geography

Costa Rica's land consists of coastal plains separated by mountains with a maximum altitude of 3,810 metres ('Cerro Chirripo')[4]. The country is relatively small (its area is about 0.4 times the total area of Bangladesh) with more than half of its population living in the Central Valley with an altitude between 800 to 1,500 metres above sea level. In this valley the country's capital, San José, is located, as well as three of the other four important cities of the country: Alajuela, Heredia, and Cartago (Limon is the fourth).

Climate and natural disasters

The climate is tropical with a high rate of humidity along the coast and lower humidity and more cooler temperatures in the Central Valley. Amongst occurring natural disasters are volcanic outbursts, earthquakes and hurricanes along the Atlantic coast.

For house construction this means that in this Central Valley there may be a shortage of housing (because of 'overpopulation'), and that in design one has to count with a tropical climate and the occurrence of natural disasters as volcanic outbursts, earthquakes and hurricanes.

3.1.2 Historical profile

Costa Rica's history (see appendix A3.1.1) had its impact on for instance the production structure, the basic infrastructural system, urban structures and housing styles. The changing of administrations every four years causes a somewhat unstable base for technology development in general [2,3].

3.1.3 Socio-economic profile

The socio-economic characteristics (see appendix A3.1.2) show that Costa Rica is a middle income country. It has quite a stable economy and the health and education situation is pretty good, but compared to modern countries it is still lagging behind. This is expressed in the present housing situation.

3.1.4 Technology profile

Technology in Costa Rica favours development in housing in a way that there is quite a base for technology development in general. (see appendix A3.1.2 for technology indicators)

3.1.5 Policy profile

Housing Policies

Already since the beginning of the 20th century the Costa Rican government has been involved in different public housing projects [3]. In the early 1980s the housing situation found itself in somewhat of a crisis though, with a chronic housing shortage and a deteriorating and substandard housing stock

[4] All figures in this section 3.1 are World Fact Book 2001 estimates [1], unless otherwise indicated.

[4]. In 1986 the government launched the “National Housing Program 1986-1990” aiming at the provision of 80,000 housing units by the end of the four year period. Besides delivering houses, the plan also aimed at finding solutions for the increase of income and employment for the families concerned. To what extent these programs favour the low-income families is not clear from literature.

Bamboo related policies
The PNB was supported with policy action by the government of that time. With the changing of that government, no special attention goes out to bamboo in policy making.

3.1.6 Conclusion on national setting Costa Rica

The Costa Rican government has clearly acknowledged the housing crisis that exists especially for low income families in the country. The political situation, where governments change every four years, does not favour a solution of this housing crisis though. Besides a somewhat unstable political situation, other conditions like the socio-economic situation as well as the technology profile do seem to be favourable in the light of a solution of the housing crisis for low income families.

3.2 Sector setting Costa Rica

The sectors concerned in this research are the bamboo and the housing sector. The technology capabilities and technology needs of these sectors are discussed in this section.

3.2.1 Bamboo sector

Technology needs
In this section we will consider the demand for bamboo in house construction. According to the technology mapping studies that Van Egmond did [3], 6% of the housing construction is made of prefab bamboo elements.

Technology capabilities
1. Technology stock

Product technologies
The applications in which bamboo is used are construction, handicraft, water piping, fencing, furniture, and decoration (see table 3.1). Up to the initiation of the PNB, not much attention has been given to this sector though. The technologies (also in construction) are traditional, and the bamboo used is extracted from forests. Since the PNB has been set up, bamboo plantations have been set up and the technologies for housing became more developed, even into prefab bamboo construction systems. Also furniture has undergone new developments under the PNB. In section 3.3 the PNB is described for further information.

Table 3.1: Bamboo species of Costa Rica. Source: Leijdekkers, 1999, p. 53 [5].

Species	*Location*	*Application*
1. Bambusa textilis	Turrialba	Construction
2. Bambusa tulda	Turialba, Guapiles	Handicraft
3. Bambusa tuldoides	Aiquirres, Alajuela, Guapiles	Handicraft
4. Bambusa vulgaris	Costa Rica	Handicraft
5. Dendrocalamus giganteus	Alajuela	Construction, handicraft
6. Gigantochloa apus	Turrialba	Construction, handicraft
7. Guadua aculeata	Guapiles, Golfito, Paquita	Construction, water, fencing
8. Guadua amplexifolia	Costa Rica	Construction
9. Guadua angustifolia	Guapiles, Golfito, Paquita	Construction, Furniture, decoration
10. Melocanna baccifera	Turrialba	Construction, handicraft
11. Phyllostrachys aurea	San Jose, Alajuela	Furniture, decoration

Process technologies
Up to the initiation of the PNB, tools and equipment, skills and knowledge, information and documentation, and organisation structure of the bamboo sector have been traditional and therefore very simple. In section 3.3 the process technology of the PNB is described.

2. Human resources stock
Specific data on the human resources stock in this particular sector are not available. Reference is made to the human resources on national level as mentioned in the 'technology profile' in the first section of this chapter.

3. Natural resources stock
In the table 3.1 one can see the bamboo species that occur in Costa Rica, their location, and their application. Besides these naturally occurring bamboos in Costa Rica, the government has also set up plantations of Guadua angustifolia in the country (table 3.2 gives the planning for these plantations). The aim of this was to provide construction material for the low-income housing project "Proyecto Nacional de Bambu". The revenues of these plantations have been considerably less than planned however.

Table 3.2: Guadua plantations in Costa Rica.
Source: Leijdekkers, 1999, p. 55 [5].

Plantation	*Surface (ha.)*	*Future expansion*
Ciudad	300	-
Guapiles	240	900
Guacimo	60	2000
Arenal	60	260
Puntarenas	50	-
Paquita	40	-
Golfito	36	-
Total	786	

4. Technology infrastructure
Up to the start of the PNB, the Costa Rican universities and research centres knew little about bamboo and its various applications. But the project's plans include a 'Research and Development Program' to provide technical support to the entire project. Three projects had been defined at the beginning of the PNB that deal with physical and mechanical properties of bamboo, bamboo preservation techniques, and structural components and joints [4].

3.2.2 Housing sector[5]

Technology needs
There is an increasing gap between housing needs and supply of housing in Costa Rica. The annual *deficit of houses* is increasing from some 85,000 units in 1973 up to 189,000 in the year 2000[6]. About half of the deficit is formed by uninhabitable houses, and half of a lack of supply. *Affordability* of houses at the same time has declined, especially for low income groups. At least some 20% of the lowest income population have no access to even a housing improvement loan, let aside a loan for the construction of a new house.

Nevertheless the number of housing units that are built per year is increasing (just not at all keeping up with the demand). The public sector provides for 66.8% of the total supply. This is done by financing housing projects which are executed by the private sector, since 1986, under a program called 'National Housing Program'. Not only are new houses constructed (56%), but also this financing system provided for the purchase of existing houses (28%), maintenance and repair of existing houses (10%), and purchase of a plot (6%). The rest of the housing supply originates in the private sector which supplies 30% of the housing, and 3.2% of the houses are constructed with private means.

[5] All data in this section are derived from Van Egmond, 1999 [3].
[6] Deficit = effective demand for houses – housing stock (excl. uninhabitable houses)

Technology capabilities

1. Technology stock

Product technologies

Most of the *housing types* in urban areas are modern single storey houses. The *materials* used most are concrete blocks or concrete prefab panels. More and more construction systems have developed into prefabricated systems.

As for the *functionality* of the houses, sufficient room for living and future expansion is provided for, as well as facilities such as piped water in-house, electricity and sanitation. The overall *physique technical quality* of the available construction systems for housing is reasonably good. Fire resistance and security against wind forces is good, when the constructions are built according to building regulations. However, earthquake resistance is questionable in most of the cases, and indoor climate needs attention.

Process technologies

The use of *tools and equipment* is directly linked to above described construction systems. Besides a few powered hand tools and simple electrical equipment (e.g.: the concrete mixer), the requirements for tools and equipment are limited to the use of hand tools only. The requirements for *skills and knowledge* are equally limited. Prefab construction can largely be executed with semi-skilled labour, or the houses can even be built as self-help construction project. *Information and documentation* is available to a large extent both on paper in documents and in computerised form. As for the requirements for the *organisational structure*, especially the mass construction projects require a higher level of project management. This level of project management is reasonably available in Costa Rica (small and medium scale contractors). The construction of individual houses requires only some managerial skills (tradesman type or small contractor) and usually rented powered equipment is used.

2. Human resources stock

The average percentage of people officially employed in the construction industry was between 1990 and 1995 6.5% of the total economic active population. Qualified labour for house construction is lacking. Construction process is very labour intensive still, so quite an amount of labour is required.

3. Natural resources stock

Natural resources for house construction, building materials, are in principle available in the country. Concrete is the predominant construction material, and cement is produced locally. As for wood, there is quite an amount of forests and woodlands in Costa Rica (34% of total land area), but over the past decades, there has been a lot of deforestation. In the eighties, when this was recognised as a problem by the government, some 28.000 ha new plantations have been established. Also the cultivation of bamboo has been introduced. This was done as part of the PNB, and in section 3.3 this will be discussed in more detail.

4. Technology infrastructure

The network of actors in the Costa Rican housing sector is similar to other countries. Professions and trades range from programming, planning, financing and design and engineering to tendering, contracting and the final realisation of the building. Communication and relationship between the actors is reasonable, but performance of the actors themselves is not optimal. Underlying reasons for this can be found in the national setting such as economic situation and policy structure.

3.2.3 Conclusion on sector setting Costa Rica

Bamboo sector

Under the Proyecto Nacional de Bambu, more attention has come to the use of bamboo in the country. Plantations have been set up and research into bamboo for housing has initiated. Where bamboo development stands these days is not clear though.

Housing sector

Costa Rica has to cope with a shortage on the housing market, especially in the low-cost area. Supply, although increasing, is not keeping up with demand. Capabilities evolve mostly around concrete house construction as this is by far the most frequently used form of construction. The only larger scale experience with bamboo housing appears to be in the Proyecto Nacional de Bambú.

3.3 Construction system: Proyecto Nacional de Bambú

3.3.1 Introduction

The Proyecto Nacional de Bambú (PNB) is designed to encourage and facilitate the use of bamboo in house construction. It was set up as part of a larger project: the National Housing Programme which was set up by the government as a response to the country's housing crisis in the mid 1980's. Besides that, the project is designed to prevent deforestation in Costa Rica.

The aim of the project is threefold:
(1) *Construction* of 760 demonstration bamboo houses in 38 rural communities nation-wide, ultimately resulting in a self-help programme building 7500 houses per year in the rural sector;
(2) *Cultivation* of 700 hectares of Guadua bamboo to provide necessary material for this future programme; and
(3) *Education* of over 1000 professionals, technicians and family elders in methods of cultivation, production and preservation of bamboo for use in construction.

The project started in 1986 and during the preparatory phase the pilot project was developed using the experience of bamboo construction technology in Colombia and Ecuador ('bahareque' technology: see chapter 2, section 2.2.2). In the following phases an intensive construction scheme in the rural areas was developed including technical training, bamboo cultivation, community labour organisation, environmental assessment of the technology and production of furniture and handicrafts for export [4,6,7].

3.3.2 Product description

1. Functionality

The PNB houses come in different sizes, varying approximately from 40 to 50 m², but each one has basically the same functions available. The house has one room that serves as living and dining room, a kitchen and a bathroom and some bedrooms. The bathroom contains a toilet, shower and sink. Each house has at least two bedrooms and a maximum of four. Depending on the layout of the house, it has the entrance right into the living room, or it has a separate entrance/hallway. In appendices A3.2.6 and A3.2.7 one can find the ground plans for some of the house types.

2. Geometry

All types of houses have a rectangular shape. They are single-storey and not elevated from the ground. Some of the types have a covered porch. The roof is two-sloped, with a small slope and some overhang. Overall appearance is that of a house more sophisticated and with more status than a traditional bamboo house (see appendix A3.2.7).

3. Materialisation

The foundation is a reinforced concrete strip foundation on top of which concrete blocks form the bottom layer of the wall. Like that, the bamboo walls are not touching the ground, and the bamboo is protected from deteriorating due to fungi and so on.

The walls are made of prefabricated timber and bamboo panels, finished with plaster. The bamboo is in the form of 'esterilla'. Esterilla is a form of split bamboo and is fixed on the timber panels with spikes. Instead of esterilla, also caña brava, a sort of reed, is used in its round form. It has a diameter of approximately 2.5 cm. The caña brava is placed on the panel with one cm in between and fixed with spikes. Furthermore, the caña brava or esterilla is tied together at the ends with galvanised metal cord.

The plaster is a mixture of cement and sand (3:1) and is put on each side of the panel for 2 cm. This plaster forms a rigid diaphragm, making it possible to eliminate diagonals and to permit the use of weaker sections of timber. The total weight of the walls is only about 100 kg/m2 which is about 35% of a concrete block wall. The roof consists of a timber joists, timber purlins and is covered with iron or tin sheets (see appendices A3.2.3 to A3.2.8).

4. Production

The houses can be built by 'self-help' or a team of professionals can come and build the house. The production process consists of the steps shown in table 3.3 which are placed in logical order of sequence. The construction process is quite complicated, and it takes about 45 days (see appendix A3.2.1 for more).

Table 3.3: Phases of the PNB production process.
Source: PNB, 1993 [8].

Phase	*Time (days)*
1. Ground preparation	2.0
2. foundation and substructure	5.0
3. Prefabrication of panels	4.0
4. Installation of panels	1.5
5. Roof structure and finish	3.0
6. Plastering of walls	8.5
7. Water installations	0.5
8. Floor	4.0
9. Doors and windows	5.0
10. Sanitary installations	1.0
11. Electricity	4.0
12. Septic tank and drainage	3.0
13. Final finishes	3.0
Total construction time	**44.5**

5. Costs

The costs of a PNB house are approximately 100 US$ per m². For a PNB house of 40m², the costs are US$ 4,000. Some of the more expensive parts of the house are the inside doors, electricity, concrete foundation, a sidewalk along the house, a concrete plastered floor, plastered walls, kitchen and sanitary supplies.

6. Physical performance

The PNB bamboo house only has little weight (see table 3.4) compared to for example concrete structures. This is especially favourable in case of earthquakes. Accelerations in the earth due to the earthquake, also work in the structure of a building and these accelerations in the building are directly related to the weight of the building. As for security against earthquakes, it has proven to be 4 to 6 times higher than specified in the Costa Rican codes for seismic construction. More or less the same goes for security against hurricanes. Security against rain, warmth and humidity are quite adequate, except for again the iron or tin sheet roof that does not provide for adequate security against heat.

Table 3.4: Construction elements and their weight.
Source: PNB, 1993 [8].

Construction element	*Weight (kg/m2)*
PNB walls with esterilla	90
PNB walls with caña brava	130
Concrete block wall	250
Adobe wall	500 – 700
Galvanised iron roof	20
Fibrecement roof	30
Tiled roof	90

3.3.3 Process description

Technoware

Due to the relatively high complexity of the production process of the PNB house, tools and equipment used are quite numerous, but practically all are hand tools (except for the concrete mixer).

Humanware

The house can be built completely by the people themselves (autoconstruccion), so the type of labour required for this is simply anyone who can make sense out of the manuals! Some of the tasks to be performed are quite specialised though, like laying bricks, plastering, and installations.

Orgaware
The organisation of the construction of the houses consists of the prefabrication of the panels, the selection of beneficiaries, and then the self-help building with or without the aid of professionals.

Infoware
The information available on PNB is:
- Different publications about the project as a whole
- Some technical papers about the construction of the houses
- A self-help construction manual.

[8]

3.3.4 Conclusion on construction system Costa Rica

The PNB has been initiated as a direct result from the national housing crisis. Its success stems from the way in which it is adequately designed according to national and sector setting aspects.

Product
The PNB house is not a house for the very lowest of income groups (like the VHC house in Ecuador is). On the other hand, it provides for facilities like cooking, bathing, toileting. Also the functions of living, eating, and sleeping can be performed in the PNB house. Furthermore the appearance as well as physical performance create a house up to social standards as well as (inter)national building standards.

Process
The construction process, although claimed to be suitable for self-help building, does in fact ask for quite some professional skills.

4 Bangladesh and the Chittagong Hill Tracts

This chapter describes the situation as it is at present in Bangladesh, according to the research design presented in chapter 1. First the national setting is described, consisting of the physical profile, history, culture, socio-economic profile, technology and policy. Secondly the sector setting is described of both bamboo and housing sector. Thirdly the technology needs of the housing sector in the Chittagong Hill Tracts are described.

4.1 National setting

4.1.1 Physical profile

Geography

Bangladesh is a country in the south of Asia. Its Western, Northern and Eastern borders are shared with India, and in the Southeast Bangladesh borders Myanmar. In the south, Bangladesh borders the Bay of Bengal, where some of Asia's greatest rivers enter the ocean. As a result, a large part of Bangladesh consists of rivers and delta [1]. The country's size is approximately four times The Netherlands.

Most of the country is formed by flat alluvial plain, but in the Southeast one can find a hilly area, covered with dense jungle: the Chittagong Hill Tracts (CHT). This area not only distinguishes itself in geography, but also in population. The hills are inhabited by tribal population, who have their own culture, different from the Bangladeshis that inhabit the plain land.

Figure 4.1: Map of Bangladesh with CHT area marked. Source: Mapquest.com.

The CHT includes the three hill districts of Khagrachhari (north), Rangamati (middle), and Bandarban (south) and covers an area of approximately 10% of the total size of Bangladesh. The average elevation of the valleys rarely exceeds 60 metres above sea level, but most of the CHT is extremely hilly. The CHT has a number of mountain ranges that run through the region in a north-south direction. The highest peak is Keokradang: 1,230 metres above sea level [2]. The valleys with their rivers are fertile, but in the remaining hilly land agriculture is limited due to steep slopes and forests. Soil erosion is an increasing problem due to the pressure on land by a population largely dependent on agriculture [3].

Climate and natural disasters

The climate of Bangladesh –and also the CHT- is tropical. It has a cool, dry winter (October to March); a hot, humid summer (March to June); and a humid and warm, rainy monsoon (June to October). During the monsoon period, a large part of the country is flooded. The floods are mainly caused by the rivers bringing water from the Himalayas, so the CHT are not part of this flood area. Other natural hazards occurring in Bangladesh are cyclones (CHT: only the areas that border the coastal districts are affected) and tornadoes (throughout the entire country). Finally, the country has experienced infrequent moderate tremor as well as droughts, but loss of life, property and food stock resulting from this didn't reach alarming proportions [4,5].

In the CHT, annual rainfall ranges from 2,032 to 3,810 mm, with southern parts being more wet than the northern parts. About 80 % of the total rainfall occurs during the months from May to September. Monthly maximum mean temperatures range from 25 to 34 ºC and minimum from 12 to 25 ºC. Extreme temperature ranges from 7 to 40 ºC. Average relative humidity is about 65% during winter months and 90% during the rainy season [3].

In house design one will have to take into account the tropical climate as well as the heavy annual rainfall and possibly occurring cyclones and tornadoes. Moreover one has to take into account the steep sloped hills.

4.1.2 Historical profile

Bangladesh has a turbulent history. A detailed version of the history of Bangladesh and the CHT can be found in the appendix A4.1.1 [6,7,8,9]. At present the competition between the two main political parties rules the country. If the one is in power, the other boycotts the parliament from time to time or declares a national strike (hartal) to protest against the government. In October 2001 elections were held and the former opposition party came in power again.

The Chittagong Hill Tracts people have had their own chiefs up to the early 18th century who had full authority. In 1947, when government of the CHT was handed over to Pakistan by the British, the CHT lost its special status and autonomy. The hill people were marginalised from the mainstream politics, and this marginalisation continued within the state of Bangladesh from 1971 on forwards. Some examples of this marginalisation are the construction of a huge hydro-electric dam near Kaptai leading to the inundation of a great amount of farm land in 1960 and the settling of landless Bengalis in the CHT since 1979 which lead to even more loss of farm land [2]. In 1997 the so-called 'Peace Accord' was signed between the GoB and The United People's Party of the Chittagong Hill Tracts (PCJSS, formed in 1972). However sincere the efforts have been in designing and implementing this Peace Accord, only small steps have been accomplished yet. This is partly due to the fact that the accord was not recognised by the main opposition party at that time, which is at present the ruling party. Moreover a number of political groups from the CHT challenge the PCJSS to be the sole representative of the hill people and signing the accord on their behalf.

The competition between the two main political parties of Bangladesh is not constructive for the development of the country –let alone the development of the CHT- and although it is slowly moving towards better conditions, this is not much thanks to the workings of the government. The conflict situation in the CHT has improved somewhat since 1997, but conditions are far from stabilised and many conflicts still have to be settled. A situation like this will seriously hamper overall development of a country or region, and the housing situation will inevitably bear the consequences.

4.1.3 Socio-economic profile

Bangladesh classifies as one of the world's Least Developed Countries. In the Human Development Index[7], Bangladesh ranks 147th out of 174 countries [10]. This position is reflected in Bangladeshi socio-economic situation. The indigenous people of the CHT are ranked lower on the social ladder than the plain land Bangladeshis. They are a minority: 0.6% of total Bangladeshi population. In the CHT today, only 50% of population is still indigenous, especially in urban areas their numbers are declining. As mentioned before, the people of the Chittagong Hill Tracts have a culture that differs completely from that of the plain lands of Bangladesh. On the other hand, amongst the CHT population there are over 12 different tribes that all have their own distinct cultures, varying for example in religion (see appendix) [2]. The marginal social position of the CHT people makes them vulnerable and they are becoming more and more cut off from their main income source (agriculture) and other economic activity has not been developed yet on any considerable scale. Literacy rate as well as the number of people with secondary education in the CHT show that despite quite some improvements in Bangladeshi education have been accomplished, this still doesn't reach everyone, especially not the CHT people (see appendix 4.1.2 for more).

For housing, especially in the CHT, this means that quite a traditional housing situation can be expected as the people's resources do not provide for more than that.

4.1.4 Technology profile

Technology indicators for Bangladesh (see appendix A4.1.3) show that overall the status of technology is not very high at all. This is not in favour technology development for housing.

[7] A composite measure of achievement incorporating longevity of life, education and standard of living.

4.1.5 Policy profile

Industrialisation and Technology Policies
Since the 1980's, Bangladesh headed from import substitution towards liberalisation. The policies focussed both on developing indigenous technology, and transferring imported technology with adaptation to local circumstances. But despite all good intentions reflected in planning documents, Science and Technology policies and industrial policies, implementation almost always lacked [11].

Housing Policies
Bangladesh has an acute shortage of affordable housing both in urban and rural areas. The Government acknowledges this and in 1993 a *National Housing Policy* is formulated which recognises the problem and enables the promotion of house building and gives guidelines. Also in the case of these housing policies, the successful implementation of these various plans and programmes, remains a challenge to be fulfilled though [12].

In the case of the rural areas in the CHT, there is no form of policy or regulation that has direct impact on the housing practice, and the government also doesn't provide for any financing system for these lower income groups. People make construction plans on their own, or with the help of a local construction expert[8]. As for financing, the NGO sector fills in the gap by providing micro-finance options like micro credit and savings programs. Rural loans in general vary from Tk 2,000 to 10,000 [9] (see appendix A 4.1.4 for more on these policies and NGO loans).

Bamboo related policies
There is no direct policy concerning bamboo in Bangladesh. In the Fourth Five Year Plan (1990-95), bamboo is mentioned briefly. In this document, bamboo is considered to be very important to the rural economy, both as a construction material and as a raw material for cottage industries. The shortage of bamboo in the country is mentioned, and a plan to raise 5,000 ha of bamboo plantations on government land in Chittagong, Cox's Bazar and the CHT is discussed [13]. In order to protect resources and developing of the bamboo sector, much more activities will have to be undertaken by the GoB.

4.1.6 Conclusion on national setting Bangladesh

Bangladesh is a developing country slowly moving towards recovery of damage caused over time. Politics, policy making, technology development, economy, health and education, all reflect that. Issues like inadequate policy making but also the frequent floods seem to stand in the way of significant development. For house construction this means that little resources are available, leading to a shortage in housing and leaving the population to the traditional building materials like bamboo.

4.2 Sector setting

The two major sectors concerned in this research on bamboo housing are the housing sector and the bamboo sector. In this chapter these sectors are described, in terms of technology needs and technology capabilities, followed by a conclusion on each of the sectors.

4.2.1 Bamboo sector

Technology needs
Technology needs refer to needs for products and process technologies. As for bamboo culms, which can be seen as intermediate products, the supply does not meet the demand (see table 4.1) and therefore bamboo is more expensive in Bangladesh than anywhere else in the world [13]. Still, it is the cheapest building material for housing in the country. This is why housing forms the most important use of bamboo. Over 90% of each year's harvest is used for either structural support of the house or the partitions and walls by people building their own house [14,15]. However, also in Bangladesh bamboo has a very low status as a building material for housing. Besides for construction, bamboo is used in virtually every aspect of life, especially in the CHT. Other industrial users of bamboo are construction industries (scaffolding); rural electrification board (poles in rural areas); cottage industries (baskets and handicrafts); transportation industries (boats, bullock carts, riksja); and pulp and paper industries [13,16].

[8] Personal communication with experts in different development issues in the CHT [21].
[9] US$ 36 to 178.

Table 4.1: Demand and supply of bamboo (million culms) in Bangladesh.
Source: Nuruzamman, 1999 [16].

	Demand	*Supply*	*Shortfall*
Estimate1988	761.1	679.8	81.3
Projected for 2008	*868.1	**637.8	230.3
Projected for 2013	*901.5	**576.9	324.6

* including the needs of rural and urban housing, agricultural implements, industrial and transportation requirements.
** mainly due to large scale death of Melocanna Baccifera as a result of flowering.

As for the supply of bamboo, one can generally state that bamboo resources are managed poorly and therefore supply is lacking. About 80% of the total national supply comes from village forests [16]. There are specific agencies responsible for harvesting natural forest bamboos[10]. In the CHT bamboos are mostly sold through a permit system issued by the local officers, specifying the quantity, area and the limit. Such bamboos are rafted or taken by boat by the permit holder to important selling centres. There is no significant amount of bamboo plantations in Bangladesh apart from a few projects set up in the late nineties (few thousands of hectares of bamboo).

Technology Capabilities

1. Technology stock

Product technologies

As described in the above, the applications in which bamboo is used are house construction, scaffolding, electricity poles, handicrafts and baskets, different sorts of vehicles, and pulp and paper. The technologies are traditional and have not undergone much development.

Process technologies

The same goes for the process technologies. Tools and equipment, skills and knowledge, information and documentation and organisation structure are traditional in the bamboo sector.

2. Human resources stock

Specific data on the human resources stock in this particular sector are not available. Reference is made to the human resources on national level as mentioned in the 'technology profile' in the first section of this chapter.

3. Natural resources stock

Bamboos grow throughout Bangladesh with the exception of the Sundarbans, a littoral forest in the Southwest of the country (see figure 4.2). The naturally growing bamboos are localised in the forests of Chittagong, the Chittagong Hill Tracts, Cox's Bazar, Sylhet and Northern Mymensingh. The Chittagong Hill Tracts are well furnished with natural bamboo forests. In addition to that, the traditional shifting cultivation by hill people burns the vegetation, but the unhurt underground rhizome systems rapidly regenerate into pure bamboo forests covering the wide areas and formed bamboo forests as secondary vegetation [17]. The CHT has some reserved forest located mainly in the east. According to Banik though, as a result of overexploitation and felling bamboo forests, as well as gradual conversion of bamboo forests into plantations through clear felling and burning, have been degrading year after year with an estimated average annual loss of 2.6 percent [16].

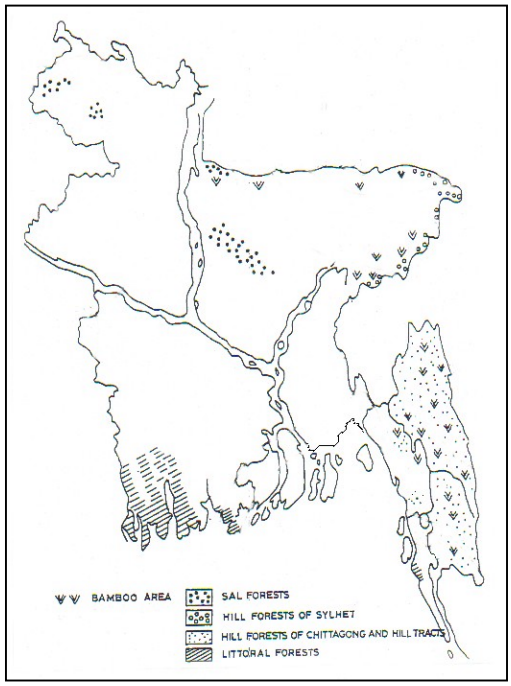


Figure 4.2: Bamboos in Bangladeshi forests.
Source: Nuruzzaman, 1999 [16].

In the whole of Bangladesh one can find more than 33 bamboo species. Only 7 of them are occurring naturally in the forests of the Chittagong Hill Tracts. Throughout the

[10] Karnaphuli Paper Mills Limited (they have licensed areas in the forests of Kassalong and Rankhiang reserves); Sylhet Pulp and Paper Mills Limited (they have allotted areas in the forests of Sylhet Forest Division); Auction purchasers through their own agencies; Permit holders for domestic uses and trade.

entire country, bamboo is being cultivated on and around village homesteads as well. Whereas the forest species are mostly medium sized and have thin-walled culms, the village bamboo species are mostly tall and have thick-walled culms. See appendix A4.2.1 for the species names of bamboos occurring in Bangladesh.

Melocanna Baccifera – Muli bamboo
The species most common in Bangladesh, and in the CHT for that matter, is Melocanna Baccifera, Muli in local language. According to Nuruzamman [16], this species constitutes 70-90% of total bamboo forest in the country. Muli is naturally distributed throughout hills of Bangladesh[11]. In contrast to most others, this species has a net-like extensive rhizome system where the clumps are diffused and open producing culms at varying intervals in all directions. It is called a 'runner', instead of a 'clumper' where the culms form clumps. According to Banik, this might very well have been selected naturally in the hilly regions for protecting the forest soil from erosion. Muli bamboo can grow 10 to 20 m. tall, with a diameter of 1.5 to 7.5 cm at base. There is one problem facing the muli bamboo resources: flowering. Bamboos flower once in a lifetime, and die very soon (within one to two years) after flowering. During this time, maximum quantities of seedlings become available, but due to weeds and predators, these often do not get the chance to grow. Currently this is an issue in the CHT as a period of sporadic flowering has occurred in the late 80s which is usually followed by gregarious flowering (period of 10-14 years – up to the present). Evidence of this gregarious flowering actually taking place has not been found though.

4. Technology infrastructure
The only institution concerned with bamboo research is the Bangladesh Forest Research Institute (BFRI). Its core business is not development work though, as it is basically a research organisation. Only little research is being done on applications of forest products, no research whatsoever has been executed on bamboo for housing, and management of resources also is not an issue of study for the BFRI. As a public research institute it is still very traditional and therefore slow and bureaucratic. Furthermore, the main person involved with bamboo research and promotion is retired now and no adequate replacement seems to be available.

4.2.2 Housing sector

Technology needs
Bangladesh faces a huge problem in housing and related services (such as potable water, sanitation and energy). According to the 1991 census the backlog in housing was 3.1 million units (2.15 million units in the rural areas and 0.95 million in urban areas). In 1996, the government estimated that by 2000 the housing shortage would be likely to exceed 5 million. Statistics on houses that are of temporary or semi-temporary nature and lack proper construction vary for rural dwellings between 85 and 90% and for urban dwellings between 60 and 84%[12]. Besides this, lack of access to land, finance, improved building materials and technology form constraints for access to decent housing. Most of housing supply is met by the private informal sector. Government sector's supply is said to be around 5% of the housing supply [18].

No data was available on the housing situation in the CHT. From the author's field experience, in the CHT there appears to be not so much a quantitative housing need (effective demand), but more a qualitative one. The latter has been examined in the fieldwork of this research project, and results are given in the following section 4.3 on housing needs. This concerns the qualitative technology needs in housing, or in other words the need for qualitative improvement of the housing situation.

Technology Capabilities
1. Technology stock
Product technologies [13]
The *functions* that take place inside the house are living and socialising, eating and cooking, and sleeping. Washing and bathing take place outside the house because there are no *facilities* available inside. The *shape* of the houses is square, some of them are elevated on poles with a veranda in front, and a few have two storeys. The roof always has a certain overhang and may have additional parts for the protection of the walls. The *materials* of the houses are either earth or timber and

[11] Its natural habitat is restricted to the high rainfall hilly areas (250-600 cm per annum) of the world. [15]
[12] According to GoB 1996 [18] it is 90% for rural and 60% for urban and according to UN 2000 [12] it is 85 for rural and 84 for urban. Probably this is not as much due to the time difference as it is due to different criteria used.
[13] No data available on general housing situation in CHT. These are results of author's 'village case studies'

bamboo. Earth houses mostly have foundation, structure and walls made of rammed earth, but sometimes structure is made of timber. The other category of houses consists of timber and bamboo, with a foundation of wooden or bamboo piles, a timber or bamboo frame for structure, and split bamboo for walls. As for roofing, frames are made of bamboo or timber, and finishing is made of tin sheet as well as sungrass (a local vegetable material). The production of a rammed earth house takes two to three months and costs approximately Tk 30,000 (US$ 534). The production of a bamboo house is a lot cheaper, about Tk 15,000 (US$ 267). Also the production time is a lot shorter, about three weeks. Both of the technologies can be labelled 'low' in terms of complexity. A more detailed description of the houses of the CHT can be found in the following section, where the qualitative housing needs are described with the present housing situation as a starting point.

Process technologies [14]
The technologies used in house construction are a tradition, and simple, so that basically everybody can work with it. If they cannot afford otherwise, the houses are built by the people themselves. Every village has its own expert in house construction, called 'maji'. If one can afford it, they will hire a maji and let him build their house.

The *tools* used for building a bamboo house are simply a multi-purpose knife, the 'dao'. All bamboo elements are handled with this tool. Besides that, when earth is involved in making the foundation, a 'shattle' (sort of spade) is used and a 'karchi' (curved knife) is used to cut the grass that serves as roof cover. For constructing a rammed earth house, some more tools are needed like: dao, shattle, spade, handsaw, bucket, hammer and nails.

The majis have learnt their *skills and knowledge* through family tradition. From the age of 12 they start to learn the profession from family. Practical training in construction is the only education they had. They will learn and work alongside with their brothers, uncles, etc. There is a heavy competition between the different majis. Their technologies are 'very confidential', and they will not share the technologies (learned by family tradition) between them. Due to the traditional nature of this construction process, *information and documentation* is not available at all. The *organisation* is structured as follows. Each maji has its own helpers. These are not fulltime employed by the maji, but per assignment, the maji will call helpers from the concerning village for the job. These helpers can have other jobs, but can also grow into being a maji themselves. House building takes place mainly during the winter season (December to March). During the rest of the year the majis and their helpers can have other jobs, or spend their time on collecting building materials, or in some places there is on-going activity by the majis. They make different items with the split bamboo, like mats (which is also a construction element), baskets, and so on.

2. Human resources stock
There are different levels of maji, divided into 3 grades based on skill (see table 4.2). Accordingly, their incomes vary. Incomes also vary per period of the year, because in winter (the dry season in which most of the houses are built) income is higher. The majis claim that their attitude towards learning and using new technologies is positive but it must be practical learning. Besides that, there is already a precedent of paying the beneficiaries of training programs[15]. The beneficiaries ask for compensational payment for attending trainings because during the training they don't work of course, and will miss part of income.

Table 4.2: Grade, age, number and income of majis.

Grade, age, number and income of majis			
Grade	Age	Number (per village)	Monthly income (Taka)
1	>40	0.25	4500-9000
2	>35	0.50	3500-6000
3	>30	1.50	2500-4500

3. Natural resources stock
All resources for the construction of these bamboo and rammed earth houses, except for the tin sheets used for roofing, are available locally.

[14] No data available on general construction process in CHT. These are results of author's 'maji case studies'
[15] In the project that BFRI currently has in this area

4. Technology infrastructure

The main actors in the housing sector are the majis. As stated before, competition between them is high and not much co-operation takes place. There are some other organisations working in the CHT, but none of them is concerned with house building in particular. The NGO's that work in the CHT are either very large (inter-)national ones with big budgets but delivering little work of any quality, or small local NGO's that are quite competent, but lacking capacity for larger and more complex projects[16]. Several of the NGO's provide microfinance loans (that can be used for individual housing initiatives).

4.2.3 Conclusion on sector setting Bangladesh

Bamboo sector

There is a shortage of bamboo supply in the country. This is mainly due to poor management of resources. Those resources do have the potential to be abundant and stay that way however. Melocanna Baccifera (muli) is the most common and therefore most used bamboo species in the country and especially in the CHT. Not much attention is being given to bamboo resource development or applications. The BFRI is the only institute concerned with bamboo research, but those issues are not part of their core business.

Housing sector

Nation wide there is a huge shortage in housing, quantitative as well as qualitative. In the CHT it is mainly a qualitative need. In the CHT houses are either made of bamboo and timber or of rammed earth. The roof usually forms the only exception in the use of local materials: tin sheet is often used as roof cover instead of vegetable materials. The construction process, if the house is not constructed by the owners themselves, is controlled by majis (the local construction experts). They have learnt their trade by family tradition and are quite competitive amongst themselves. There are no other significant players in the housing sector of rural CHT.

4.3 Housing Needs [17]

In describing the background for this research (in section 1.1), a distinction has been made between quantitative and qualitative housing needs. As all households taken into consideration in the fieldwork of this research presently own a house, there is no matter of quantitative housing needs here, but qualitative.

4.3.1 Characteristics of the research population

The villages

The fieldwork of this research is conducted in the proposed project area of INBAR's Livelihood and Development Project. Currently, BFRI is running a Farming Systems Research and Development Project in the same area.

This area comprises seven villages in Bandarban District of the Chittagong Hill Tracts, Bangladesh. Most of the villages are located 7 to 10 km Southwest from Bandarban town. One village is located somewhat more south, along the road to Cox's Bazar (see figure 4.3). All sites are relatively easily accessible from Chittagong. Of these villages, four cases were selected for this research. The selection is based on accessibility of the villages. The four villages selected for this research are: (1) Paithong, (2) Raicha, (3) Satkamal and (4) Amtolipara.

Paithong is located more south than the other villages, along the main road from Chittagong southwards to Cox's Bazar. This village is characterised by its bamboo trade. In the rainy season the bamboo construction experts engage themselves in producing other bamboo items than houses like mats and baskets, and sell these at the bazaar. The looks of the village are dominated by the fact that most of the houses are elevated on high timber poles.

The village of Raicha has a completely different appearance. Located only a few hundred metres from the main road to Bandarban, it has a small bazaar along that main road, a school and a small stream runs along the village. Most of the houses are only slightly elevated from the ground level (in general not on poles), there are even a few two-storeyd houses, and a few tubewells.

[16] Personal communications with Ms. Catherine McKenzie, NRI.

[17] All data in this section 4.3 are derived from the 'village case studies' executed by the author. Complementary statistical tables and plots can be found in the appendix of this section.

Satkamal is partly located on and around a small hill. One or two tubewells provide for the water supply of the village. At the main road a school and a temple are located.

Amtolipara has an entrance marked with a large gate of bamboo poles that is supposed to keep out evil spirits. At the entrance of the village there is also one tubewell. The main part of the village is located some metres higher than the road (secondary) and here most houses are elevated on poles with verandas in front. There is a sloped area at the entrance of the village where the houses stand on ground that faces the problem of erosion.

All villages, except for Amtolipara which is situated alongside of the main road, have a brick path leading from the main road into the village. This brick road continues through the village as a main connection. It does not reach all houses though and it is also not wide enough for a vehicle to run over it.

The households

Family size and type

The average size of families is 5.3 members (3.1 adults and 2.2 children). A slight majority of the families (54.6%) is nuclear, 45.4% of the households has an extended family. The extended families, normally being larger than the nuclear, indeed have a mean value of 6.0 members whereas the nuclear families have a mean value of 4.7 members. There are no significant differences between the villages.

Income and yearly expenditure on house

The income that all members of the family have together has a mean of Tk 3754 (US$ 67) per month. On a yearly basis, they will spend Tk 2008 (US$ 36) on the maintenance of their house (Tk 167.3/US$ 3 per month). As a rule of thumb for the amount of money a household can spend on housing, 20% of the income is used. For the sample of this research, Tk 750 (US$ 13) could be spent on housing using this rule of thumb. The reason that the actual amount spent on housing per month is so much lower, is that all houses are owned by the households themselves, so expenditure on housing merely consists of maintenance costs. As for the specific villages, Raicha and Satkamal have higher incomes than the other two (Paithong and Amtolipara). Initial expenditure and yearly maintenance of the house are also higher for these two villages.

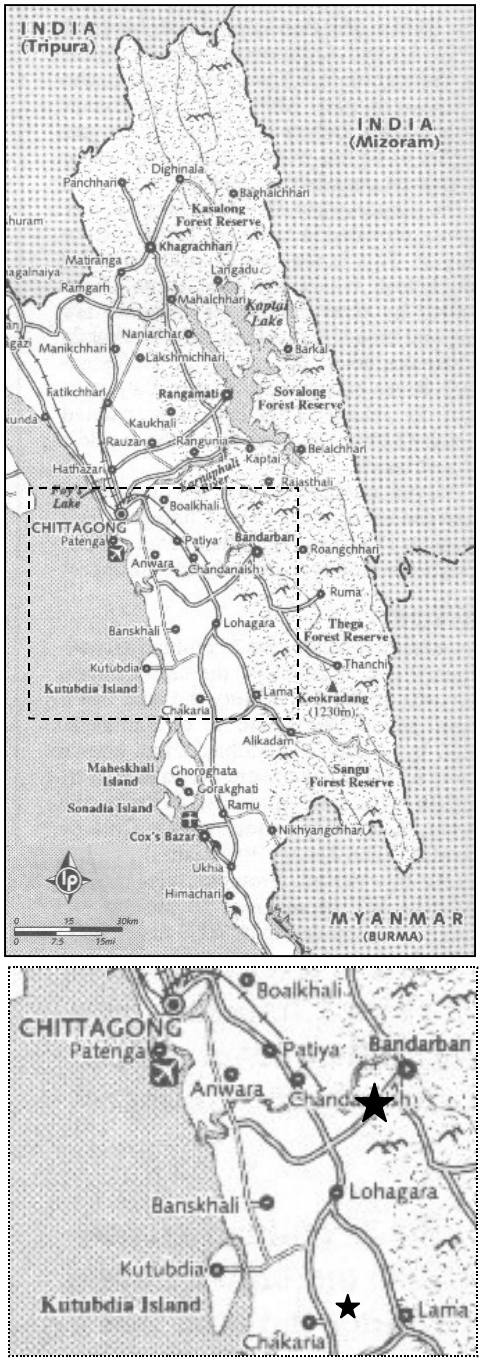


Figure 4.3: Research area located in CHT, Bangladesh (★).
Source: Lonely Planet, 2000.

Occupation

Farming is by far the most common occupation of the people of the CHT. In the sample of this research, slightly over 50% of the people have farming as their occupation. After that, daily labour and housewife are most common (resp. 16.1 and 15.8 %). Of course the occupation of house wife is done by the women, but quite an amount of women also does income generating work next to their housework. Besides these most common occupations, small amounts of people earn their money with handicraft, service, shop keeper, etc. Looking at the household incomes per village and the occupations that occur in each village, some statements can be made on the incomes earned with the different occupations. It appears that the fact that Paithong and Amtolipara both have quite an amount of daily labourers (resp. 29 and 37%) has lead to their lower amount of income. Where in Satkamal the majority (65%) earns its income through farming, the households of Satkamal are also those with the highest incomes. Raicha's households, that have the second highest incomes, earn most of their income probably through occupations such as teacher, shop keeper and other businesses.

Education
Overall, the number of people having had no education at all is quite large, 67.2%. Primary education is enjoyed by 18.3%, and secondary by 10.6%. Only 2.3 % has had higher education (7 persons from 120 households). The only people with a university degree are from the village of Raicha. There is one person with a masters degree in this village, and 4 with bachelors. This village has relatively little people with no education at all. There is an explanation for this: the village has a school, and some of the people are teachers! Satkamal, that besides Raicha is one of the villages with the highest incomes, also has quite high percentages of educated people. Education is definitely linked with income: the higher the household income, the better the education of the people.

4.3.2 Housing needs

Functionality
Number of rooms and size
Most households (45%) have two rooms in their house. One room for living, socialising, and sleeping, and one room for cooking and eating. 19% of the households has one room and 23% has three rooms, making up a mean present value for all households of 2.4 rooms, and 3.0 rooms are preferred. Out of all households 55% wants more rooms than they have at present, 34% is fine with the present number of rooms, and 11% wants less rooms than they have at present. As for the size of the rooms, the living/socialising/sleeping room has an average size of 43m² and the eating/cooking room is 8m². Preferred is a living/socialising/ sleeping room of 51m², a eating/cooking room of 13m² and a space for work/other of 12m². For this last activity, work/other, having a veranda in front of the house is preferred. For all households, the preferred increase in size is 167%.

As for differences between the villages, the households of Paithong, Raicha and Satkamal want increases in size of resp. 136%, 164% and 166%. Remarkably the households of Amtolipara want an increase of 207% in size of the house. The villages of Raicha and Satkamal both have mean values of 2.6 rooms per household with a surface of 66m² and Paithong and Amtolipara have resp. 2.2 rooms with 44m² and 2.0 rooms with 41m² per household. This reflects the income levels of the villages (the higher the income, the more rooms and the larger the size). The number of rooms is also logically related to the family size and family type. Extended, larger families have a higher amount of rooms whereas nuclear, smaller families have a lower amount of rooms.

Facilities
For *drinking water* 78% of the households use the river (stream) next to the village, but some of the villages also have common tubewells. 16% of the households uses these tubewells for drinking water and another 5% uses both river and tubewell for drinking water. The majority of households, 91%, prefers having a tubewell for drinking water, of which 3% wants a personal tubewell. Another 6% wants supply water. For *bathing*, generally the river is used (96%). Again, tubewells are preferred for bathing by the majority of households (88%). *Toilets* (sanitary ring in a small shed made of split bamboo walls) are owned by 19% of the people, and the rest uses ‘open toilets’. Overall (95%), sanitary rings are preferred. As for *electricity*, already 25% has electricity supply, the rest of the households light their home with kerosene lamps. Supply is preferred by practically everyone though (97%). As for *drainage and waste disposal*, there are practically no facilities. For drainage a brick drain is found most preferable (97%), and for waste disposal one generally wants a brick dustbin (94%). Besides that, 20% of the people wants a brick road. No significant differences between the villages have been found.

Geometry
All houses are rectangular. Some with courtyard (37%), some with veranda (only 5%), or plain (58%). Preferred by the majority of households (77%) is a rectangular house with veranda, 17% of the households prefers a rectangular house with courtyard. The houses are presently elevated 78 cm from the ground, where 98 cm is preferred (average elevation for all households). 36% of the households has its house elevated 25 cm, 20% has it elevated 50 cm, and 37% has their house elevated 100 to even 200 cm from the ground. Most of the households (92%) have one-storey houses and 73% of these households are fine with having one storey. 18% of the households that have one storey in fact wants two storeys. Only 8% of the households have and want to keep two-storey houses. The roofs can have quite some variation. Most of the roofs are simply two- and four sloped (resp. 49 and 33%). But on the preferred side, one can see that three roof slopes is reasonably popular (16%). This means two roofs, and one extension on the front side to cover a veranda. But still, four roof slopes is most

preferred (68%). The overhang of the roofs is presently 50 cm on average (8% has 75 cm, 19% has 60 cm, 50% has 40 to 50 cm), but 100 cm is preferred by most (96%).

Materialisation

Material use has been examined for five different elements of the house: foundation, structure, walls, roof structure and roof finish. The material used for the construction element 'walls' is used as an indicator for the type of house: bamboo or rammed earth. In table 4.3 the most common combinations of material use per construction element and their occurrence in the four villages are presented. The complete table can be found in the appendix.

Table 4.3: Present housing according to material use.

Total	Village*				Walls	Foundation	Structure	Roof structure	Roof finish
no.	P	R	S	A					
15	3	1	5	6	Split bamboo	Wooden piles	Timber	Timber	Tin sheet
5	1			4	Split bamboo	Wooden piles	Timber	Bamboo	Tin sheet
8	3	3	1	1	Split bamboo	Wooden piles	Timber	Bamboo	Veg.mat.
7		1	3	3	Split bamboo	Wooden piles	Bamboo	Bamboo	Tin sheet
20	6	4	4	6	Split bamboo	Wooden piles	Bamboo	Bamboo	Veg.mat.
12	6		2	4	Split bamboo	Bamboo piles	Bamboo	Bamboo	Veg. material
3		2	1		Split bamboo	Wood + bamboo	Bamboo	Bamboo	Veg.mat.
19		11	6	2	Rammed earth	Rammed earth	Bamboo	Timber	Tin sheet
4		2	1	1	Rammed earth	Rammed earth	Bamboo	Timber	Veg.mat.
* P=Paithong, R=Raicha, S=Satkamal, A=Amtolipara									

The bamboo houses are most common: 72% of all households has a house with split bamboo walls. These houses have either wood/timber or bamboo for foundation as well as structure and roof structure, and vegetable material (sungrass) or tin sheet for roof finish. 26% of all households has a rammed earth house. The differences of these rammed earth houses with the bamboo houses lies in the foundation and walls. A rammed earth house has foundation and walls made of rammed earth. The other construction elements -structure, roof structure and roof finish- have the same material uses as the bamboo house. The reasons given by the households for using these materials generally are:

- Timber : strong and locally available
- Bamboo : locally available and free of cost
- Split bamboo : locally available
- Rammed earth : secured from any source of attack and temperature control, and sometimes: secured from fire, strong, and locally available
- Sungrass : locally available and free of cost
- Tin sheet : durable

Table 4.4: 'Needed' housing according to material use.

Total	Village*				Walls	Foundation	Structure	Roof structure	Roof finish
	P	R	S	A					
11			3	8	Split bamboo	Wooden piles	Timber	Timber	Tin sheet
4	2	1		1	Timber	Wooden piles	Timber	Timber	Tin sheet
3	3				Timber	Concrete piles	Concrete	Timber	Tin sheet
6	4			2	Rammed earth	Wooden piles	Timber	Timber	Tin sheet
5	5				Rammed earth	Concrete piles	Concrete	Timber	Tin sheet
5			1	4	Masonry	Wooden piles	Timber	Timber	Tin sheet
6	3		2	1	Masonry	Concrete piles	Timber	Timber	Tin sheet
58	3	21	23	11	Masonry	Concrete piles	Concrete	Timber	Tin sheet
* P=Paithong, R=Raicha, S=Satkamal, A=Amtolipara									

On the preferred side (table 4.4), there is somewhat more difference in type of houses (again using 'walls' as an indicator): bamboo, timber, rammed earth, and masonry. The masonry house is preferred by most: 64% of all households. In general, this masonry house has foundation and structure made of concrete and it has a timber and tin sheet roof. Practically all houses preferred have a timber and tin sheet roof. The reasons given by the households for wanting these materials generally are:

- Timber : strong (sometimes also: durable, locally available)
- Split bamboo : present material good enough (also: locally available)
- Rammed earth : secured from any source of attack and temperature control
- Concrete and masonry : durable and strong
- Tin sheet : durable

Production
The construction time of the house depends mostly on the use of materials. A bamboo house can be built in a few weeks, but building a rammed earth house will take a few months. The mean value for the number of days it took to construct the present bamboo houses is 24 days and for the rammed earth houses it is 71 days. What the households are willing to spend on constructing their house is for bamboo and timber resp. 28 and 21 days. For rammed earth it is surprisingly low, only 21 days. On the much wanted masonry house the households are willing to spend 60 days for construction. The complexity of the present houses is not very high, the houses consist of simple elements.

House cost
Also house cost depends on the use of materials. Rammed earth is more expensive, not so much because of material cost, but more because of the cost of labour and the fact that it takes longer to construct. The mean value for initial expenditure on the house is for a bamboo house Tk 15.035 and for rammed earth Tk 31.578. Higher initial costs do not mean lower maintenance costs though. The costs for yearly maintenance of a bamboo house have a mean value of Tk 1.955, and for rammed earth Tk 2.144. If we look at the material used for roof finish, we can see that the houses with a tin sheet roof had an initial cost of Tk 30.176 and the houses with a roof of sungrass cost Tk 10.368 initially. Yearly expenditure costs do not relate directly to roof finish though (yearly maintenance for houses with tin sheet roofs are much higher than those for houses with sungrass roofs while it should be the other way around if related), but have more to do with the other construction elements.

Physical performance
Taking into consideration the climate and geography of the area, the physical performance of the house has to meet certain needs. A house in the CHT needs to be secured from rain, heat and humidity, and to a lesser extent secure from wind forces and earthquakes. As any other house, it also needs to be fire resistant, sound proof, and durable against chemical as well as biological factors.

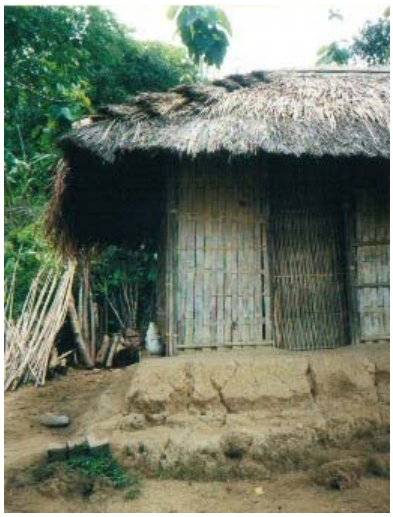
4.3.3 Conclusion on housing needs

The population of all four village case studies is quite homogenous. A remarkable difference however is that two of the four villages have higher incomes than the others. This also becomes evident in variables like education of household members, size of the house and the number of rooms. To summarise the needs that the target group expressed for qualitative improvement of their house, they need a house with three rooms for performing the combined functions of living/socialising/sleeping, eating/cooking, and work/other. As for facilities the house should have electricity, but water supply, bathing and toilets can be outside the house. The house should be elevated on poles, rectangular of shape with a veranda, and only one storey. The roof should have two or four slopes with quite some overhang, it should be made of a timber structure with tin sheet finishing. The foundation, structure, and walls of the house should be made of concrete and masonry because those materials are strong and durable. The production of the house should not be too complex, and may take 20 to 60 days. Present costs of a house are approximately US$ 355, whether they can spend more depends on the availability of loans. As for physical performance, the house should be secured from rain, heat, humidity, wind forces, fire, sound, and chemical as well as biological factors.

Picture pages Bangladesh

Above left: bamboo bazaar. Above right: tools.
Source: personal collection.

Raicha: river along and brick path through village.
Source: personal collection.



Above 2x: Bamboo and clay house, Satkamal.
Source: personal collection.

Kitchen of bamboo house, Raicha.
Source: personal collection.

Clay house, Raicha.
Source: personal collection.





Above left and right: Bamboo houses in Raicha.
Source: personal collection.


Left and above: Amtolipara and its elevated houses with verandas in front.
Source: personal collection.

5 Conclusions

In this chapter an answer is given to the main question of this research: *"What are the opportunities and constraints of applying two bamboo construction technologies for housing from Ecuador and Costa Rica in selected rural villages of the Chittagong Hill Tracts, Bangladesh, emphasising on the particular housing needs of the target group?"* The two Latin American technologies are compared with the different aspects of Bangladesh, in a way that the aspects of Bangladesh are being assessed on the extent to which they create opportunities and/or constraints for the application of the two LA technologies in Bangladesh.

Firstly the two technologies (as described in sections 2.3 and 3.3) are compared with the national setting aspects of Bangladesh (as described in section 4.1), in particular the policies. Secondly, the two technologies are compared with the sector setting aspects of Bangladesh (as described in section 4.2), in particular the housing stock. Thirdly, the two technologies are compared with the housing needs of the target group (as described in section 4.3). These comparisons are combined in section 5.4 in a general conclusion on the opportunities and constraints of application of the two bamboo construction technologies for housing - giving the answer to the main research question. At the end of section 5.4, all conclusions are summarised in an additional table.

5.1 Opportunities and constraints created by national setting

In assessing the Bangladesh national setting on the extent to which it creates opportunities or constraints for the application of the two bamboo construction technologies, not all aspects discussed in the foregoing chapters are directly relevant. Physical, historical, socio-economical and technology profiles relate to that question in a way that they provide a general picture of the country's ability for technology development. The policy profile directly creates opportunities and constraints for the two technologies, reflected in specific rules, regulations and incentives.

Socio-economic and technology indicators (resulting from historical as well as physical profiles) show that Bangladesh is a country where the population is still very much concerned with earning a day's pay. Development initiatives undertaken are more focussed on basic needs like health, education, food security and income generation than on technology development directed towards housing. A solid base for initiatives towards technology development does not yet seem to exist.

Specific rules and regulations for housing are not available (have not been found) for Bangladesh, general standards[18] though may in fact provide some constraints for the application of VHC as it barely fits those standards. PNB on the contrary seems to fit these requirements very well. As for financial incentives, the GoB gives no subsidies for low-cost housing and banks do not give out loans (at least none that are available for the lower income part of the population). The NGO sector of Bangladesh tries to fill this gap by providing micro credit and organising saving programs. For rural areas, these loans are not very high though. This forms a constraint on the application of both technologies, but especially for PNB as its costs are really high.

What may form a constraint for the application of any new technology in the CHT, is the fact that the people of the CHT have a marginal social position. If national effort should be invested for the benefit of this area, this may very well meet quite some resistance.

5.2 Opportunities and constraints created by sector setting

5.2.1 Bamboo sector

The low status of bamboo as building material provides a constraint for application of the VHC house where bamboo is also used in a way that is generally seen as 'low status'. The PNB house however has the potential of overcoming this constraint as it is processed in a way that it has a more socially accepted appearance (plastered walls), and the bamboo is used in a way that it lasts longer.

[18] Erkelens [1]: affordable-cost standards refer to a housing unit of one or two rooms built of less durable or durable materials plus an affordable infrastructure.

Although through the lack of supply of bamboo as a raw material the costs are quite high, bamboo is still the cheapest building material available in Bangladesh. This is considered an opportunity for the application of VHC as well as PNB. The bamboo needed for VHC and PNB is available in Bangladesh either in forests or in village homesteads. A constraint is formed by the fact that natural resources are managed very poorly and plantations do not exist. In the future the lack of supply is likely to grow.

Both product technology and process technologies are very traditional for the Bangladeshi bamboo sector. As for product technologies this does not form a constraint for VHC or PNB as those technologies also use bamboo in quite a traditional way. In the case of process technologies, the fact that they are very traditional does form a constraint. The fact that BFRI is the only institute concerned with bamboo in the country, presents a serious constraint to any development of the bamboo sector.

5.2.2 Housing sector

As for the target group housing needs are not quantitative, everybody of the target group owns his own house. The fact that VHC and PNB are designed for serial production (prefabrication of panels), forms a constraint because there is no need for the huge quantities that especially VHC can deliver. Housing needs are qualitative, and VHC does not very much provide for extra quality - constraint. PNB on the contrary provides for a qualitatively better house – opportunity. Qualitative housing needs and the extent to which they form opportunities or constraints for the application of both VHC and PNB are further discussed in section 5.3.

The PNB provides for more extended functionality than the present housing stock of the target group, which may in fact form a constraint considering the extra costs of it. The VHC provides for less functionality which is a serious constraint. Present stock geometry does not provide for much of a constraint. Only in the case of ‘elevation’, present stock has quite some elevation that PNB does not provide for. From functionality point of view this elevation is needed for storage. If compensational storage is provided for, this doesn’t form a constraint either. The present use of building materials forms an opportunity for VHC as this technology uses basically the same materials as the majority of the present stock. PNB on the other hand uses some materials unknown to the target group (or at least: not in the present stock) which may indeed form a constraint. The production complexity of the present housing stock is very low. Both VHC and PNB use prefabricated panels (somewhat more complex production), this may form somewhat of a constraint. More of a constraint though is formed for PNB as its overall production complexity is quite high. As for production time, there should be no constraints. The costs of the VHC house fall within the margins of present house costs for the target group. The PNB is way more expensive though (8x more than average cost of earth house, the more expensive). As for physical performance, the VHC basically provides the same as the present housing stock. The PNB provides for more though.

Present process technology is very traditional and rigid. Overall there is willingness to learn new technologies, but there is a precedent in the research area of paying beneficiaries for training, as a compensation for lost income. This forms an overall constraint for the application of new technologies in the research area. The present tools, skills and knowledge may be sufficient for the application of VHC, for the application of PNB it may very well form a constraint. As for information and documentation, at present there is none available, so the manuals for both VHC as PNB may form constraints, especially for PNB with the more complex production. The present organisation (one expert and its helpers do the construction) may very well form a constraint for the application of both VHC and PNB as these process technologies have a more complex organisation structure.

The human resources in the housing sector are traditionally educated, they are very familiar with bamboo as this is a traditional building material. They are to some extent open for new technologies and training. This forms opportunities for the VHC house (not much learning needed), but it may form constraints for the PNB house as new skills may have to be learnt. Resources for the VHC house are basically all locally available - opportunity. For the PNB house this is not the case though - constraint. Potential technology infrastructure for applying new bamboo construction technologies is available, but there is no experience in this field yet – possible opportunity.

5.3 Opportunities and constraints created by the housing needs

In this section the qualitative housing needs of the target group[19] are assessed on the extent to which they create opportunities and constraints to the application of the two bamboo construction technologies VHC and PNB.

Functionality

Preferences of the target group go out to a house with 3 rooms providing for the functions of living/socialising/sleeping, eating/cooking, and working. The facilities needed inside the house by the target group are restricted to electricity supply. Taking these preferences of the target group in consideration, this clearly forms some constraints for the application of the VHC house as it doesn't provide for them. The PNB on the contrary does provide for these preferences, and more. On the one hand this forms an opportunity, but on the other hand a constraint as the PNB house provides for a lot that the target group does not 'need', but that also bring along a lot of costs!

Geometry

The overall, more sophisticated, appearance of the PNB house obviously forms an opportunity for its application in the research area, and for the same reason a constraint is formed for the VHC house. The preference of the target group for an 'elevated' house forms a constraint for PNB though where it forms an opportunity for VHC. Again, this elevation is not so much a physical necessity as it is a functional requirement. The space underneath the house is wanted for storage. This could be considered a constraint for PNB unless other storage options are offered. Other geometrical aspects give no constraints to either of the houses.

Material use

The house preferred by most (48%) has concrete foundation and structure, brick walls, and a timber and tin sheet roof. A house like this apparently indicates 'status' for the target group and the target group's preference will go out to a house that looks like this as much as possible. The material use for the roof and its structure are basically the same for VHC and PNB, they match perfectly with the target group's preference. PNB, with its concrete foundation and plastered bamboo walls cater clearly a lot better to the preferences of the target group than the VHC house does with its timber foundation and bare bamboo walls. Moreover, the reasons the target group gives for wanting these materials for their house is that they are both strong and durable. Altogether this is an opportunity for the application of the PNB house (it definitely provides for a 'strong and durable' house), but a constraint for the VHC house (as it is foremost seen as a temporary solution).

Production

The time the target group is willing to spend on the production/construction of a new house is approximately 1 month. This should pose no constraints for the PNB house as it takes a little over a month to construct. The VHC house only takes a day to construct (incl. prefabrication of the components). This seems to be an opportunity for VHC (less time spent on house construction, more time to earn income).

Costs

The costs of a VHC house (US$ 380) is affordable for the target group, only slightly higher than the mean value of present house cost (which is US$ 355), and the average family from the target group can repay a loan for this house (incl. interest) in approximately four years[20]. According to present standards for loans provided by NGO's this would be quite a large loan and repayment time also would be longer than usual. The costs of the PNB house (about 10 times higher than the costs of VHC) seem absolutely unaffordable for the target group. The highest income family of the target group would take approximately 13 years to repay the loan. Many of the expensive elements in the PNB house are not 'needed' by the target group though (like a paved sidewalk around the house, inside paved floors and inside doors), or can be executed in a cheaper way (like kitchen supplies, sanitation, and the plastered walls[21]).

Physical performance

The physical performance needed does not form any serious constraint for the application of the VHC as well as the PNB house. Especially the PNB house offers quite a good physical performance. Only the VHC house's security against cyclones (which is to a small extent needed) is not too good.

[19] Preferences of the target group w.r.t. the product technological characteristics of the house.
[20] Assuming that 15% of income can be spent on housing, and interest is 15%.
[21] Alternative: give roof plenty of overhang (1m). Plaster only bottom part (1m) of wall. Use earth for plastering top part of wall.

5.4 Conclusion on the application of the two technologies

First some conclusions are drawn regarding technology development in Bangladesh and the CHT in general. Then a summarising conclusion per technology is drawn on the opportunities and constraints of applying them in the research area. In the following chapter the translation into practice is made and practical as well as scientific recommendations are given.

5.4.1 Technology development in general

There are some major constraints towards technology development resulting from the national setting of Bangladesh. Basically, the country lacks a solid base for initiatives towards technology development. This constraint will have to be overcome by time. Besides that, any national effort for investment in the CHT may form a problem as these people take a marginal position in the country. For development of bamboo construction technologies in general a huge constraint is formed by the fact that bamboo has such low status as a construction material for housing. The precedent in the research area of paying beneficiaries for training forms an overall constraint for the application of new technologies in the research area.

5.4.2 Application of Viviendas Hogar de Cristo, Ecuador

Product technology

The *functionality* of the VHC house is inadequate in all aspects. Compared to the present stock of houses it delivers little functionality, and compared to what the target group 'needs' it delivers even less. The *geometry* of the VHC house offers a constraint concerning appearance. Even though it matches quite well with a large part of the present stock, it is considered of lower status and therefore it is not very well accepted at all. The same goes for the *material use* of VHC, which matches quite well with the present stock, but is not compatible with the actual needs of the target group. The *production* of the VHC house doesn't form any serious constraints, neither does the *physical performance*. The *costs* of the VHC house, although it matches with present house cost, may form a constraint when the target group has to depend on external financing (loans needed are higher than what is normal nowadays in CHT).

Process technology

The *tools, skills and knowledge* needed for the VHC house do not form any serious constraint. The *information/documentation* and *organisation structure* of VHC are somewhat more complex and this may form a constraint.

Conclusion

Overall can be said that the VHC house (product as well as process) pretty well matches with the present product technology stock of the research area, but as for meeting the needs that the target group expressed for qualitative improvement the VHC house is quite inadequate. The fact that it lacks functionality and durability/status of materials is most important.

5.4.3 Application of Proyecto Nacional de Bambú, Costa Rica

Product technology

As for *functionality* the PNB house offers much more than the 'general standards', the present functionality, and the 'needs' of the target group. The *geometry* of the PNB house does not form any serious constraints. The *material use* offers opportunities as it caters to the 'needs' of the target group, even though some of the materials are quite costly. The same goes for *physical performance*. *Production complexity* is quite high which forms a constraint. The *costs* of the PNB house are a huge constraint.

Process technology

In all aspects, the PNB's process technology is more complex than present process technologies. This may form a constraint as extensive training will be necessary.

Conclusion

The PNB house is far too expensive for the target group. It is obviously designed for a somewhat higher-income group. Some of the elements that add much to those costs are not 'needed' though by the target group of this research nor are they required in terms of 'general standards'. On the other hand the PNB house has some elements that do meet the qualitative needs that the target group expressed.

5.4.4 Overview of conclusions

The conclusions made in this chapter are summarised in the following table 5.1. In the first column all aspects from the Bangladeshi national and sector setting are listed. These were compared with the two LA technologies in sections 5.1 to 5.3. For this comparison the table should be read in a horizontal way (showing the opportunities (+) and constraints (-) created by the Bangladeshi national and sector setting. In the following section 5.4 a final conclusion is drawn per technology. The table is used for this final conclusion by reading the last two columns in a vertical way.

Table 5.1: Conclusions.

Bangladeshi setting				**VHC**	**PNB**
National	History/physical/socio-ec/techn			-	-
	Policy			+ -	-
	Culture			-	+
BAMBOO sector	Techn. Needs	Prod		+	+
	Techn. Stock	Prod		+	+
		Proc		-	-
	Human Resources Stock			+ -	+ -
	Natural Resources Stock			+	+
	Technology Infrastructure			-	-
HOUSING SECTOR	Techn. Needs	General conclusion		+ -	+
		Prod	Functionality	- -	+ -
			Geometry	- +	+
			Material	-	+
			Production	+	+ -
			Costs	+	- -
			Physical perf.	+	+ +
	Techn. Stock	Prod	Functionality	-	+
			Geometry	+	+ -
			Material	+	-
			Production	+ -	+ -
			Costs	+	- -
			Physical perf.	+ -	+
		Proc	Techno	+ -	-
			Human	+	-
			Info	-	- -
			Orga	-	-
	Human Resources Stock			+	+ -
	Natural Resources Stock			+	-
	Technology Infrastructure			+ -	+ -

6 Recommendations

6.1 Practical recommendations

In the foregoing chapter conclusions are drawn on the opportunities and constraints of applying two LA bamboo construction technologies for housing in Bangladesh. In this section 6.1 recommendations are given on this issue, to make use of the opportunities, and overcome the constraints. In order to do this, certain actions have to be undertaken by the relevant actors for low-cost housing in the CHT, within a given timeframe (short term or long term). In the following table 6.1, these actions are listed together with the actors that could/should undertake these actions.

Table 6.1: Recommendations.

Actions	***Time frame****		***Actors *****			
	ST	LT	Inbar	local NGO	local actor	GoB
Application of VHC:						
▪ Do not apply this technology as such in the research area.	x		x			
▪ Consider (ST*) applying VHC in urban or disaster affected areas of Bangladesh where there may very well be a need for this kind of housing. If it is proven to be successful, then apply (LT*).	x	x	x	x	x	
▪ Consider (ST*) setting up a production plant in the research area so that, especially in the rainy season, more income can be generated for the local construction workers by processing the local bamboo into a value added product and 'exporting' this to above mentioned urban areas where the VHC house may very well be needed. If it is proven to be successful, then apply (LT*).	x	x	x	x	x	
Application of PNB:						
▪ Do not apply this technology as such in the research area.	x		x			
▪ Take some elements of the PNB house (as mentioned in the previous chapter) and incorporate them into a new design that will suit the needs of the target group (ST*). If it is proven to be successful, then apply (LT*).	x	x	x	x	x	
▪ Consider (ST*) applying PNB for a higher (urban) income group to promote the use of bamboo for housing in general. If it is proven to be successful, then apply (LT*).	x	x	x	x	x	
Bamboo for low-cost housing in general in Bangladesh:						
▪ Promote this issue to local actors.	x		x			x
▪ Invest in R&D on this issue.	x					x
▪ Provide for subsidies adequate for the low-income group	x					x
▪ Develop technologies adapted to local environment making use of foreign knowledge and present model houses.	x		x	x	x	
▪ Introduce bamboo for housing in higher (urban) income areas in order to increase social status and acceptation of this material for housing.	x		x	x	x	

* ST: short term, within 5 years; LT: long term, above 5 years.
** INBAR: international networking organisation; Local NGO's: work in Bangladesh on various development projects; Other local actors: those that are active in the field of low-cost housing in Bangladesh, the CHT in particular. GoB: Government of Bangladesh.

Developing a technology fitting the target group's needs (which is one of the actions mentioned in the above recommendations) does not fall within the direct aim of this research, which has been to determine the opportunities and constraints of applying two specific technologies in the research area.

Indirectly this should lead to the aim of providing better housing opportunities for the target group. Still some attention is given here to this indirect aim by giving some guidelines as to what the target group actually needs for improvement of their housing situation. These guidelines are logically derived from the 'housing needs' of the target group as described in chapter 4.

Some guidelines for specific projects for improvement of the housing situation of the target group of this research by using bamboo are:

- Use as many local materials as possible in order to keep costs to a minimum
- Use preservative treatment for the bamboo
  - Do not put the bamboo in direct contact with soil
  - Protect the bamboo from rain, by plastering and extra roof overhang
- Provide for a technology where the overall appearance of the house is more sophisticated
  - Plaster the walls (with cement and/or earth) for example
- Use an adequate roofing material that ensures both security against rain and indoor comfort
  - When using tin sheet: apply a material like sungrass underneath for temperature control
  - As tin sheet is not a local material: try to find another material for roofing
- Take advantage of the fact that people in the 'richer' villages (like Raicha and Satkamal), are more likely to take the risk to invest in new technologies. They can fulfil an exemplary function.
- Be cautious of the fact that the local construction experts (majis) at present have a leading role in the construction process.

6.2 Scientific recommendations

Finally some scientific recommendations are made, concerning the methodologies used in this research and further research to be carried out. There are quite some issues that came up in these studies that require further research:

- The CHT are in general quite neglected in development studies regarding Bangladesh.
- Bamboo housing for all income groups is not considered worthy a second thought in Bangladesh, so research into its present state as well as development is lacking.
- The specific attitude towards bamboo in Bangladesh and ways to change this attitude.
- The technology infrastructure of Bangladesh: which actors are engaged in housing in Bangladesh and exactly in what way do they operate.
- Possibilities of applying VHC in urban marginal areas of Bangladesh, and placing the production plant in the bamboo growing areas, like the CHT.
- Possibilities of applying PNB in higher income (urban) areas of Bangladesh

An evaluation of the methodology used in this research leads to the following recommendations:

- The theory used in this research is quite extensive as it is based on the thought that there are many aspects related to the success of a technology.
  - The advantages in this are that it provides for the possibility of executing an explorative – initial- research where all possibly relevant aspects are examined and problems can be identified for further (more detailed) research.
  - The disadvantages are that it is very extensive and within a limited time frame it is not possible to deal with all aspects in detail.
- The aspect of costs of the technology in relation to income of the target group have proven to be of great significance for the possibilities and constraints of applying a new technology for that target group.
- The research area, the CHT, however suitable for this research being a bamboo growing area, is in a politically unstable position and this makes research quite difficult at the moment. As bamboo is available throughout the whole country on homesteads or imported from the forests, there are plenty of other areas suitable for bamboo development projects (under the precondition that supply of bamboo is sustainable).

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M.Sc. research co-ordinator
Mrs Dr.Ir. E.L.C. Van Egmond
DG 1.02
PO Box 513
5600 MB Eindhoven
The Netherlands

Appendices

Appendix Chapter 1

A1.1 Operationalisation

A1.1.1 National setting

Aspects	Features	Indicators
Physical profile	Geography	Location
		Toral area
		Land type
	Climate	
	Natural disasters	
History and politics	General background	
	Situation today	
Socio-economic profile	Economy	HDI rank
		GDP per cap.: PPP
		Population below poverty line
		Unemployment rate
	Demography	Population
		Pop. Growth
		Areal distribution
		Ethnic groups
	Health	Infant mortality rate
		Life expectancy at birth
		Family size
	Education	Literacy (age 15 and over can read and write)
		Male literacy
		Female literacy
		Highest education followed
Technology profile	Export/import balance	
	Human resources	R&D personnel
		Number of graduates
	Physical infrastructure	Paved roads
		Railways
		Waterways
		Ports and harbours
		Airports
		Electricity production
		Electricity consumption
		Domestic telephone system
		Main telephone lines
		Mobile cellular telephones
	Natural resources	Presence
	Technical institutions	Presence
		Network/samenhang
Policy profile	Industrialisation and Technology policies	Goals
		Measures
		Rules and regulations
	Housing policies	Goals
		Measures
		Rules and regulations
	Bamboo related policies	idem

A1.1.2 Sector setting

Aspects	Features	Indicators	Sub-indicators
Technology needs	Demand	Effective demand	
		Qualitative demand	
		Affordability	
	Supply	Public sector supply	
		Private sector supply	
Technology capabilities	Technology stock	Product technologies	Functionality
			Geometry
			Materials used
			Production
			Costs
			Physical performance
		Process technologies	Technoware (tools/equipm)
			Humanware (skills/knowledge)
			Infoware (information/ documentation)
			Orgaware (organisational structure)
	Human resources stock	People employed in sector	
		Education level	
	Natural resources stock	Availability of natural resource	
	Technology infrastructure	Network of actors	

A1.1.3 Technology (VHC + PNB)

Aspects	Features	Indicators
Product technologies	Functionality	Size / total surface
		Activities/functions
		Facilities
	Geometry	Shape
		Elevation
		Height
		Roofing type
		Overall appearance
	Materials used	Foundation
		Structure
		Walls
		Roofing structure
		Roofing finishes
	Production	Complexity
		Time
	Costs	
	Physical performance	Security against windforces
		Security against earthquakes
		Durabil. against heat&humidity
		Durability against water
		Fire resistance
		Sound proofness
		Durabil. against chemical fact.
		Durabil. against biological fact.
Process technologies	Technoware	Tools and equipment
	Humanware	Skills and knowledge
	Infoware	Information and documentation
	Orgaware	Organisational structure

A1.1.4 Housing needs

Aspects	Features	Indicators	Sub-indicators
Pesonal characteristics	Ownership		
	Household size	Number of adults	
		Number of children	
		Household type	
	Household structure	age	
		sex	
	Household income	occupation	
		hours per day spent working	
		highest education followed	
		average monthly income	
		other sources of income	
	Household expenditure	House cost	
		Yearly expenditure house	
Qualitative/product techn. Needs	Function	Shelter	Number of persons – p&n*
			Number of rooms – p&n
		Activities	Surface per activity – p&n
		Facilities:	Availability, type – p&n
	Geometry	Total surface	P&n
		Shape	Type – p&n
		Elevation	Ground level-first floor – p&n
		Height	Number of floors – p&n
		Roofing	Overhang –p&n
	Materialisation	Foundation	Material used –p&n
		Structure	Material used –p&n
		Walls	Material used –p&n
		Roofing structure	Material used –p&n
		Roofing finishes	Material used –p&n
	Production	Complexity	Construction units – p&n
		Time	Days needed to constr. – p&n
	Costs (see hous ehold exp.)		
	Physical performance	Security against windforces	
		Security against earthquakes	
		Durabil. against heat&humidity	
		Durability against water	
		Fire resistance	
		Sound proofness	
		Durabil. against chemical fact.	
		Durabil. against biological fact.	

* Present and needed

A1.2 Household and housing questionnaire

Village name: _____
Respondent Number: _____

Personal data

1. Do you, or one of the household members, own this house?
?? yes
?? no

2. How many persons are living in this house?
?? …... adults (working)
?? …... children (not working)

3. Of which type is your household?
?? extended
?? nuclear
?? single person

4. Please specify sex and age for all adult household members:

	Head	Other 1	Other 2	Other 3
?? Sex (m / f)				
?? Age (in years)				

5. Please specify for the head of the household, and for other income earners in the household:

	Head	Other 1	Other 2	Other 3
?? Occupation				
?? Hours per day spent working				
?? Highest education followed				
?? Average monthly income (in Taka)				

6. Are there any other sources of income for the household, apart from the ones mentioned in the above question?
?? no
?? yes, namely: .....

7. How much money did you spend on building this house?
?? ..... Taka
?? Nothing, I inherited the house

8. How much money do you spend on maintenance of the house per month?
?? …..…..... Taka

Housing characteristics

Introduction:

The following questions concern the 'housing characteristics'. Several aspects of the house have been eleborated. Two questions will be asked for each aspect of the house:

1. What is the present status concerning that aspect?
2. What would you want to improve on that aspect, provided that you have the necessary means?

Now the questionnaire continues

1. Number of rooms

a. How many rooms does your house have?

b. How many rooms should your house have?

	Present	Needed
Number of rooms		

2. Activities: availability, separation, available surface

a. Show for each of the following activities whether they are available in your house, whether it has a separate room, and how many square metres per activity you have in your house:

	Available (yes/no)	Separate (yes/no)	If not separate: combined with...?	Square metres
Living/socialising				
Eating				
Cooking				
Washing				
Bathing				
Toileting				
Sleeping				
Storage				
Work-related				
Other, nl.				

b. Show for each of the following activities whether you want them available in your house, whether it needs to have a separate room, and how many square metres per activity you need:

	Available (yes/no)	Separate (yes/no)	If not separate: Combined with?	Square metres
Living/socialising				
Eating				
Cooking				
Washing				
Bathing				
Toileting				
Sleeping				
Storage				
Work-related				
Other, nl.				

3. Facilities

a. Show for each of the following facilities whether they are available **in your house**, and in which form (type) you have them:

	Available (yes/no)	Type (describe the type of facility)
Drinking water		
Bathing		
Toilet facilities		
Electricity		
Drainage		
Waste disposal		
Other, nl.		

b. Show for each of the following facilities whether you want them available **in your house**, and in which form (type) you want them:

	Available (yes/no)	Type (describe the type of facility)
Drinking water		
Bathing		
Toilet facilities		
Electricity		
Drainage		
Waste disposal		
Other, nl.		

4. Shape of the house

a. Which shape does your house have at present?
b. Which shape of house would you prefer, if you could choose?

	Present	Needed
?? Rectangular		
?? Rectangular + courtyard		
?? Rectangular + veranda		
?? Circular		
Other, nl.		

5. Elevation of the house

a. How high is your present house elevated from the ground level?
b. How high would you prefer your house to be elevated from the ground level?

	Present	Needed
Elevation (m)		

6. Number of storeys

a. How many storeys does your present house have?
b. How many storeys would you prefer to have in your house?

	Present	Needed
Number of floors		

7. Type of roofing

a. Which type of roofing does your present house have?
b. Which type of roofing would you prefer for your house?

	Present	Needed
?? One roof slope		
?? Two roof slopes		
?? Three roof slopes		
?? Other, nl.		

8. Overhang of the roof

a. How much overhang does the roof of your present house have?
b. How much overhang would you prefer to have for your house?

	Present	Needed
Overhang (cm)		

9. Construction time

a. How many days did it take to construct your house?
b. How many days are you willing to spend on constructing your house?

	Present	Needed
Number of days		

10. Materialisation

a. Which material do you have for the following elements of the house, and why?
b. Which material would you prefer to have for the following elements of the house, and why?

Foundation		**Present**	**Reason**	***Needed***	**Reason**
	?? Wooden piles				
	?? Concrete piles				
	?? Reinforced concrete piles				
	?? Bamboo piles				
	?? Strip foundation				
	?? Other, nl.				

Structure		**Present**	**Reason**	**Needed**	**Reason**
	?? Timber frame				
	?? Bamboo frame				
	?? Masonry (bricks)				
	?? Concrete				
	?? Adobe bricks				
	?? Rammed earth				
	?? Other, nl.				

Walls		**Present**	**Reason**	**Needed**	**Reason**
	?? Timber walls				
	?? Split bamboo walls				
	?? Clay				
	?? Masonry (bricks)				
	?? Concrete				
	?? Other, nl.				
	.....				

Roof structure		**Present**	**Reason**	**Needed**	**Reason**
	?? Timber				
	?? Bamboo				
	?? Other, nl.				
	.....				

Roof cover		**Present**	**Reason**	**Needed**	**Reason**
	?? Iron sheet				
	?? Bamboo				
	?? Veg. Material (palm leaves, grass, etc)				
	?? Clay tiles				
	?? Fibre reinforced cement				
	?? Other, …				

This is the end of the questionnaire.
Thank you for your time and co-operation!

A1.3 Inverview 'Maji'

Question 1: Which tools do you use for building a bamboo house?
Question 2: Please describe the process of building a bamboo house
- construction of different elements (foundation, structure, walls, roofing)
- time and costs involved
- Assistance of other labour

Question 3: What is your attitude towards using new technologies?
Question 4: Where did you learn your profession?
Question 5: Which education did you enjoy?
Question 6: What is your monthly income?

A1.4 Codes used in 'household and housing questionnaire'

VARIABLE	SUB-VARIABLE	TYPE	CODE	REMARKS		
Ownership		string	1=yes			
			2=no			
Household size	*Number of adults*	numeric				
	Number of children	numeric				
	Household type	string	1=extended			
			2=nuclear			
			3=single			
Household structure	*Sex*		1=male	**0=niet meer adults**		
			2=female			
	Age	numeric				
Household income	*Occupation*	string	1=no work			
			2=farming			
			3=daily labour/labourer			
			4=housewife			
			5=student			
			6=handicraft			
			7=service			
			8=farming+other			
			9=other			
	Hours per day spent working	numeric				
	Highest education followed	string	1=no education			
			2=primary			
			3=S.S.C. secundary school certificate, up to grade 10			
			4=H.S.C. higher secundary certificate, grade 11 and 12			
			5=BA			
			6=MA / MD			
	Average monthly income	numeric				
	Other sources of income	string	1=no			
			2=yes			
Household expenditure	*Expenditure on house*	numeric		**1=nothing, heritage**		
	Maintenance per year (taka)	numeric				
Shelter	*Number of rooms*	numeric				
Activ.(m2)	*Living/socialising (m2)*	numeric		**0=not available/needed in house**		
	Eating/cooking	numeric				
	Washing/bathing	numeric				
	Toileting	numeric				
	Sleeping	numeric				
	Storage	numeric				
	Work-related	numeric				
	Other	numeric				

Facilities	*Drinking water*	string	1=supply water			
			2=tube well			
			3=river/stream			
			4=personal tubewell			
			5=tubewell + river/stream (2+3)			
			6=supply water + tubewell (1+2)			
	Bathing	string	1=supply water			
			2=tube well			
			3=river/stream			
			5=tubewell + river/stream (2+3)			
			6=supply water + tubewell (1+2)			
	Toilet facilities	string	1=open			
			2=ring sanitation/sanitary ring			
			3=sanitary system			
	Electricity	string	1=supply			
			2=kerosine lamp			
	Drainage	string	1=pucca bricks drain			
			2=plain			
	Waste disposal	string	1=throw out			
			2=pucca dustbin			
			3=dustbin			
	Other	string	1=brick road			
Shape	*Type - present*	string	1=rectangular			
			2=rectangular + courtyard			
			3=rectangular + veranda			
			4= circular			
			5=rectangular+courtyard+veranda (2+3)			
Elevation	*Ground level-first floor (cm)*	numeric				
Height	*Number of floors*	numeric				
Roofing	*Type*	string	1=one roof slope			
			2=two roof slopes			
			3=three roof slopes			
			4=four roof slopes			
			5=more roof slopes			
	Overhang (cm)	numeric				
Time	*Days needed to construct*	numeric				

Foundation	*Material used*	string	1=wooden piles	**0=niets ingevuld,**		
			2=concrete piles	**kan zijn: geen verandering nodig**		
			4=bamboo piles			
			5=strip foundation			
			7= rammed earth			
Structure	*Material used*	string	1=timber frame			
			2=bamboo frame			
			3=masonry			
			4=concrete			
			5=adobe bricks			
			6=rammed earth			
Walls	*Material used*	string	1=timber walls			
			2=split bamboo walls			
			3=clay			
			4=masonry			
			5=concrete			
Roofing structure	*Material used*	string	1=timber			
			2=bamboo			
			3=concrete			
Roofing finishes	*Material used*	string	1=Tin sheet			
			2=bamboo			
			3=veg. Material			
			4=clay tiles			
			5= fibre reinforced cement			
			6=concrete			
				Combi-codes waar reden in voorkomt		
Reasons		string	1=durable	11, 12, 13, 25, 26, 28		
			2=strong	11, 14, 15, 16, 17, 23, 25		
			3=locally available	12, 14, 18, 19, 20, 24, 25, 27		
			4=free of cost	14, 26		
			5=secure from any source of attack	21, 22, 23, 24		
			6=temperature control/comfortable	13, 16, 21, 22, 23, 24, 27		
			7=suitable for fitting	17, 18, 28		
			8=secured from fire	22		
			9=good	20		
			10=better	19		
			11=1+2	16=2+6	21=5+6	26=1+4
			12=1+3	17=2+7	22=5+6+8	27=3+6
			13=1+6	18=3+7	23=5+6+2	28=1+7
			14=2+3	19=3+10	24=5+6+3	
			15=2+4	20=3+9	25=1+2+3	

Appendix chapter 2

A2.1 National setting

A2.1.1 Historical profile

Ecuador has been part of the Inca imperium. When in 1532 the Spaniards spread their conquest over what is now Ecuador, in 1534 they named it Real Audiencia de Quito (Royal 'rechtsgebied' of Quito). When in the beginning of the 19th century the Spanish colonialists start to rebel against the Spanish rule, the 'Real Audiencia de Quito' becomes part of 'Great Colombia' (Colombia, Venezuela, Panama) which in 1830 falls apart and the state of 'Ecuador' is declared. Besides internal conflicts between Roman Catholic conservatives and liberals, there were also conflicts with neighbouring states. Between 1904 and 1942 Ecuador lost about half of its territories to Colombia and Peru.

After a period which was quite chaotic (a.o. dictatorships, military rule), in 1979 Ecuador had a democratic government again. This government was faced with problems as well due to the debt crisis in the early 1980s. By now the Ecuadorian economy (see the section on economy) was fully dependent on the international oil prices which caused even more problems due to the international fall of those prices. When in 1992 the new government starts a policy of decentralisation, privatisation and modernisation some of the problems were solved. The debts were restructured, inflation was controlled and foreign investments increased. In 1995 Ecuador had another border conflict with Peru which was solved in 1999. But this conflict has cost Ecuador that much that the economic situation (debt, inflation, etc,) never got the chance to recover and nowadays Ecuador is experiencing a major crisis (more about this in the section on economy).

A2.1.2 Socio-economic and technology indicators

	Ecuador [1]
GDP per capita (US$)	2,900
Country size (km2)	283,560
Population (million)	13.1
Density (no of people per km2)	46.1
Population growth rate (%)	2.00
Infant mortality rate (no of deaths per 1,000 live births)	34.00
Total fertility rate (no of children born per woman)	3.12
Life expectancy at birth (years)	71,33
For women	74,28
For men	68,52
Literacy rate[1]	90%
Gov. budget spent on education	2.7%
Ages 6-11 attending school	87%
Ages 12-19 attending school	60%
Ages 19-24 attending school	24%
Ages 24 and older primary education	44%
Ages 24 and older secundary education	23%
Ages 24 and older higher education	13%
Telephones (main lines in use)	899,000
Telephones (mobile cellular)	160,061
Electricity consumption (billion kWh)	9.386
Railways (total in km)	965
Highways (paved, in km)	8,165

[1] Age 15 and over can read and write.

Waterways (seasonally navigable, in km)	1,500
Natural resources	oil, fish,timber bamboo, hydropower
Exports	$5.6 billion (f.o.b., 2000 est.)
Imports	$3.4 billion (f.o.b., 2000 est.)
Trade balance ($ billion)	+ 2.2
Export commodities	petroleum, bananas, shrimp, coffee, cocoa, cut flowers, fish
Import commodities	machinery and equipment, raw materials, fuels; consumer goods
Researchers per million inhabitants*	133
Expenditure for R&D (% of GNP)*	0.02
Graduates tertiary education	11,722
Graduates tertiary education, per 1000 inhabitants	0.9

A2.2 Sectoral setting

A2.2.1 Guadua culture region

In the coastal area of Ecuador bamboo forms a special part of the culture. The bamboo species that is most common in that part is 'Guadua Angustifolia' (guadua in this report). It is considered one of the best bamboo species and its influence in urban as well as rural regions of coastal Ecuador is huge. For the last five millennia Guadua has integrated that much into the material culture of the people that the term "Guadua Culture Region" is used to describe the culture. The region can be divided into a northern and southern part. The northern part consists of Colombia's middle Cauca Valley and the southern part comprises the Ecuadorian coastal lowlands [4,13].

A2.2.2 Bamboo bahareque construction

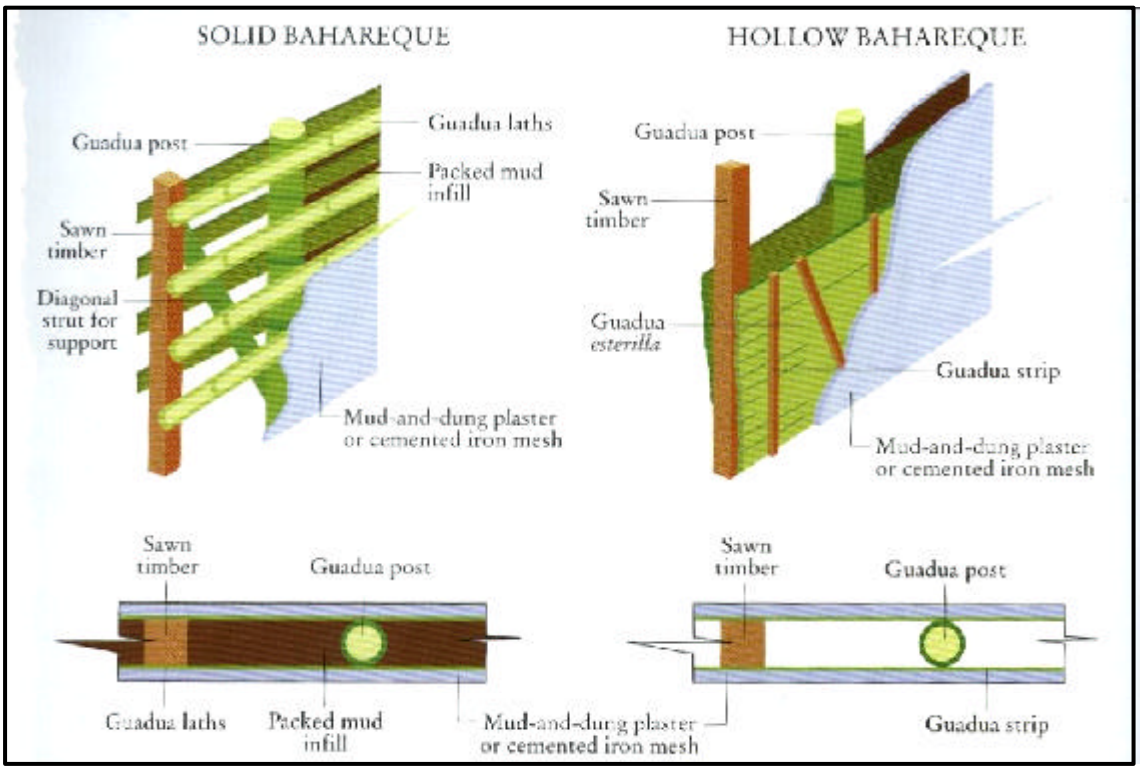


Figure A2.1: Solid and hollow bahareque. Source: Gutierrez, 2000, p. 38 [13].

There are two types of bahareque building: hollow and solid. Solid bahareque uses a double layer of spaced horizontal canes or bamboo laths whose purpose is to hold the mud placed in between the bamboo. Hollow bahareque uses a double layer of horizontal split bamboo as a supporting surface for the mortar, which is plastered on both outer faces.

A2.2.3 Bamboo housing in Ecuador

Traditional rural housing
In the coastal lowlands of the Guadua culture region of Ecuador most houses are made of vegetable material. Bamboo poles are used for structure, uncovered esterilla for walls and palm leaves or grass for roofing. In case of elevation of the house, timber poles are used. One can also see houses built on top of logs floating on the river. Moving more towards urban areas, one will find similar housing, with the exception of the roofs that are now made of corrugated iron. This is cheaper, longer lasting and easier to replace. One disadvantage to this (non-vegetable!) material is the high temperatures it produces inside the house.

Urban traditional housing
The houses in the city of Guayaquil, Ecuador, are similar to those of urban Colombia. Bamboo bahareque with cement mortar was introduced here for cultural and technological reasons, climatic reasons play no part here. The technique allows for elegant and varied constructions acceptable to the upper and middle class. An outstanding example is the building of the University of Guayaquil. This old building is made of bamboo and currently being restored using the same original construction techniques.

Urban marginal housing
In the outskirts of Guayaquil one can find the worst conditions in the entire Guadua culture region. Hundreds of thousands of squatters live there in unstable landfills or flooded areas under extremely deprived conditions. Most of the housing is made of bamboo or wood poles for structure, esterilla for walls and corrugated iron for roofing [13].

A2.2.4 Forests of Ecuador

The deforestation in the whole country is one of the severe environmental problems of the country. In the highlands, almost all of the natural forest cover has disappeared. And along the coast the once-plentiful mangrove forests have all but vanished, too. These forests can harbour a great diversity of marine and shore life, but they have been cut down to make artificial ponds in which shrimp are reared for export. About 95% of the forests of the western slopes and lowlands have disappeared to become agricultural land, with banana plantations accounting for much of this. Finally the Ecuadorian Amazon in the Oriente remains standing, but it is seriously threatened by fragmentation. Since the discovery of oil, roads have been built into the area. But also the search for oil, which uses thousands of loads of explosives, as well as the transport of oil through pipelines, which often leaks or breaks, pollutes the environment tremendously [3].

A2.3 Viviendas Hogar de Cristo

A2.3.1 Product description

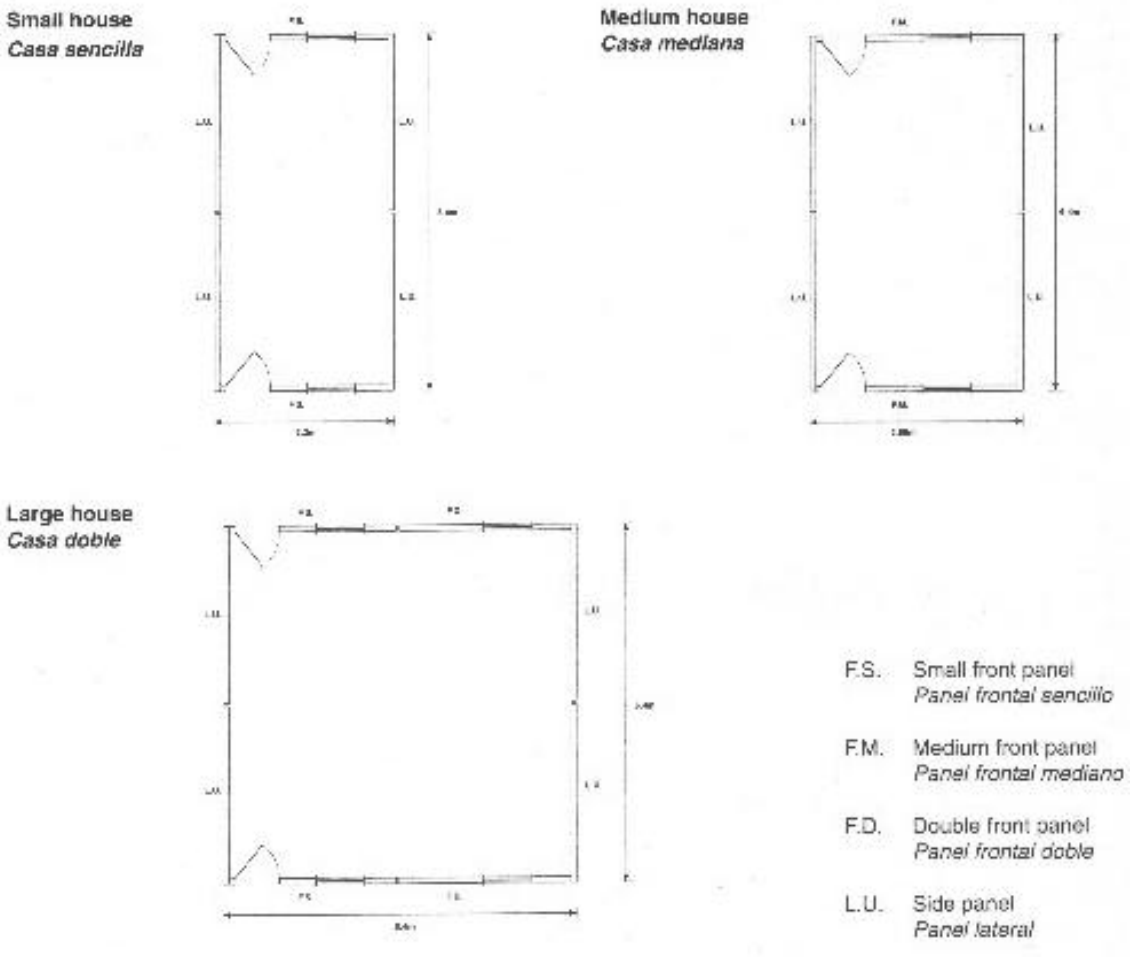
Geometry

Type	*Surface*	*Omtrek*	*#panels*	*# rooms*
Basic	20.5 m²	3.2 x 6.4 m	6	1
Medium size	25.6 m²	4 x 6.4 m	6	1
Double size	41 m²	6.4 x 6.4 m	8	1

All houses can be extended on the ground floor with an extra room. [11]

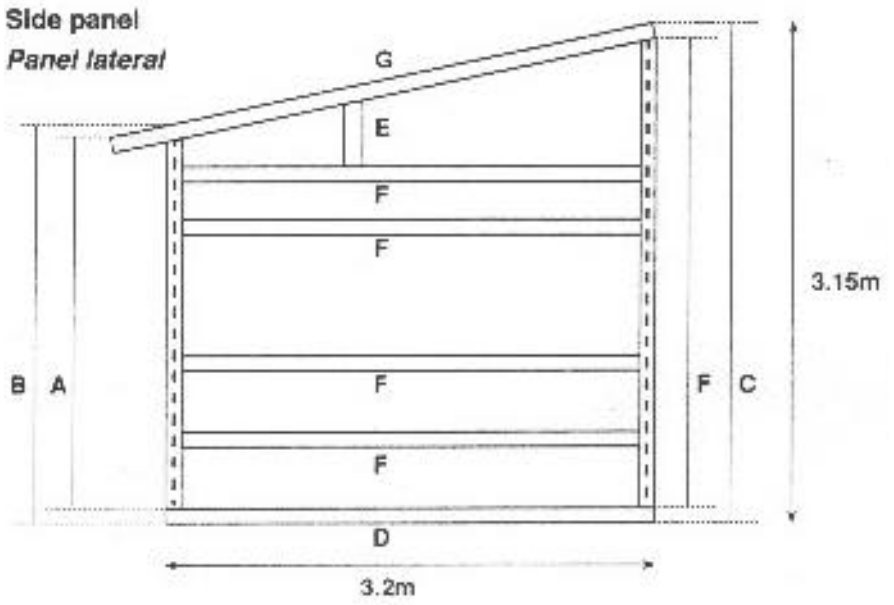
A2.3.2 Ground plans VHC houses

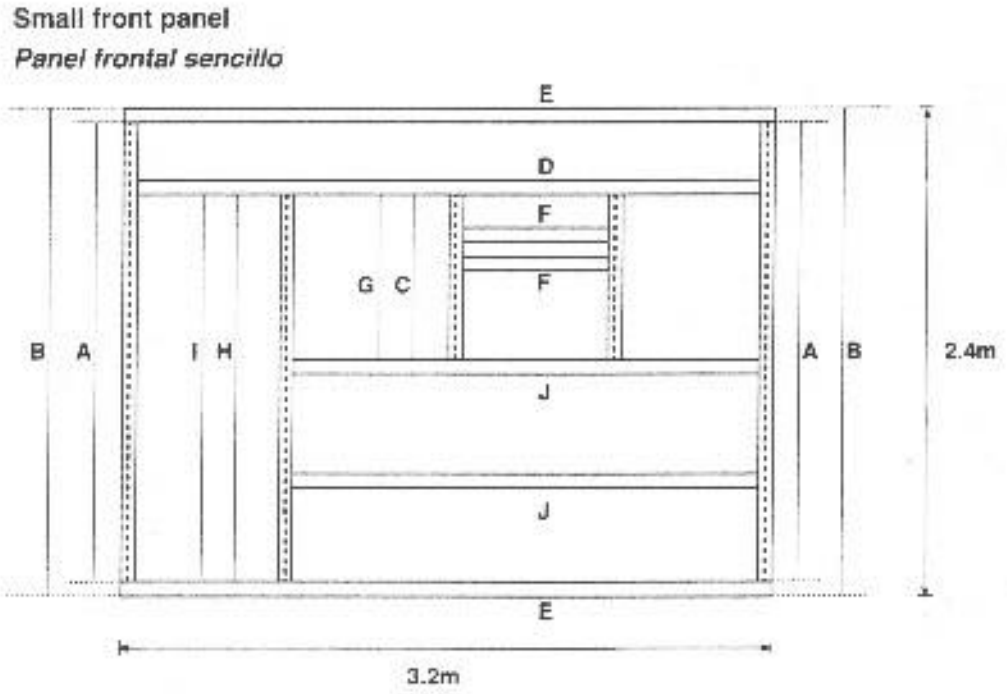
[11]



A2.3.3 Panels VHC houses

[11]





Appendix chapter 3

A3.1 National setting

A3.1.1 History

Costa Rica was colonised by the Spaniards since Columbus arrived in the country in 1502. It has been independent (again) since 1821. Compared to neighbouring countries, it has been politically stable and free of corruption. As a democratic state, Costa Rica has two major political parties dominating the political scene, and they run the country's administration alternately for four years until the next elections. Since 1948 the country has also 'cut out' the army which created a lot of money that was invested in health and education [2,3].

A3.1.2 Socio-economic and technology indicators

	Costa Rica [1]
GDP per capita (US$)	6,700
Country size (km2)	51,100
Population (million)	3.7
Density (no of people per km2)	72.5
Population growth rate (%)	1.65
Infant mortality rate (no of deaths per 1,000 live births)	11.18
Total fertility rate (no of children born per woman)	2.47
Life expectancy at birth (years)	76,02
For women	78,68
For men	73,49
Telephones (main lines in use)	450,000
Telephones (mobile cellular)	143,000
Electricity consumption (billion kWh)	5.303
Railways (total in km)	950
Highways (paved, in km)	7,827
Waterways (seasonally navigable, in km)	730
Natural resources	hydropower
Exports	$6.1 billion (f.o.b., 2000 est.)
Imports	$5.9 billion (f.o.b., 2000 est.)
Trade balance ($ billion)	+ 0.2
Export commodities	coffee, bananas, sugar; pineapples; textiles, electronic components, medical equipment
Import commodities	raw materials, consumer goods, capital equipment, petroleum
Researchers per million inhabitants*	532**
Expenditure for R&D (% of GNP)*	0.21
Graduates tertiary education	9,813
Graduates tertiary education, per 1000 inhabitants	2.7

A3.2 Proyecto Nacional de Bambú

A3.2.1 The production process of a PNB house

1. Ground preparation
- Cleaning and levelling of ground
- Marking and excavation of foundation
- Formwork for foundation
2. Foundation and substructure

- Reinforced concrete strip forms the foundation
- Armament should be also placed vertically for fixing the substructure and timber beam (see following points).
- Concrete blocks form the substructure
- Timber beam that carries the wall panels on top of concrete blocks, fixed with the armament

3. Inside floor
- The second row of concrete blocks should be covered 8 cm under the finished floor level
- 8 cm compacted load
- 7.5 cm concrete (under point 8)

4. Panels (prefabricated)
- They should be placed in a particular order to be placed at right angles without any extra tools
- Placed on top of the timber beam under point 2
- The panels are fixed to each other with 6 mm (3 at each connection)
- The panels are fixed to the timber beam (under point 2) with nails

5. Roof structure and finish
- Timber joists, placed on top of the panels
- Joist is fixed to panel
- On top of the joists: purlins
- On top of that the roofing (usually galvanised iron sheets) is fixed with nails.

6. Plaster
- The plaster is formed by 2 cm of a cement-sand mixture (3:1) inside and outside

7. Water installations
- PVC pipes (Ø 13 mm for drinking water, Ø 100 mm for waste water)
- Placed and fixed following regulations

8. Floor
- Compacted load under point 3 should be set
- 7.5 cm concrete
- finish: tiles, mosaics, etc.

9. Doors and windows
- Frames for doors and windows are fixed to panels
- Then: doors and windows are fixed.

10. Electricity
- Simple and traditional installation: 110 Volts, 4 circuits (1: lighting, 2: earth, 3: kitchen, 4: free).

11. Septic tank and drainage
- Sink, washbasin, shower and toilet
- These come together in a septic tank: two concrete tubes of 75 cm Ø, united through 10cm Ø PVC pipes buried into a layer of concrete
- From the second tank comes a conventional drainage of 14 metres length.

12. Final finishes
- Painting of exterior as well as interior
- Other smaller details.

[8]

Time of different phases of the production process of a PNB house [8]:

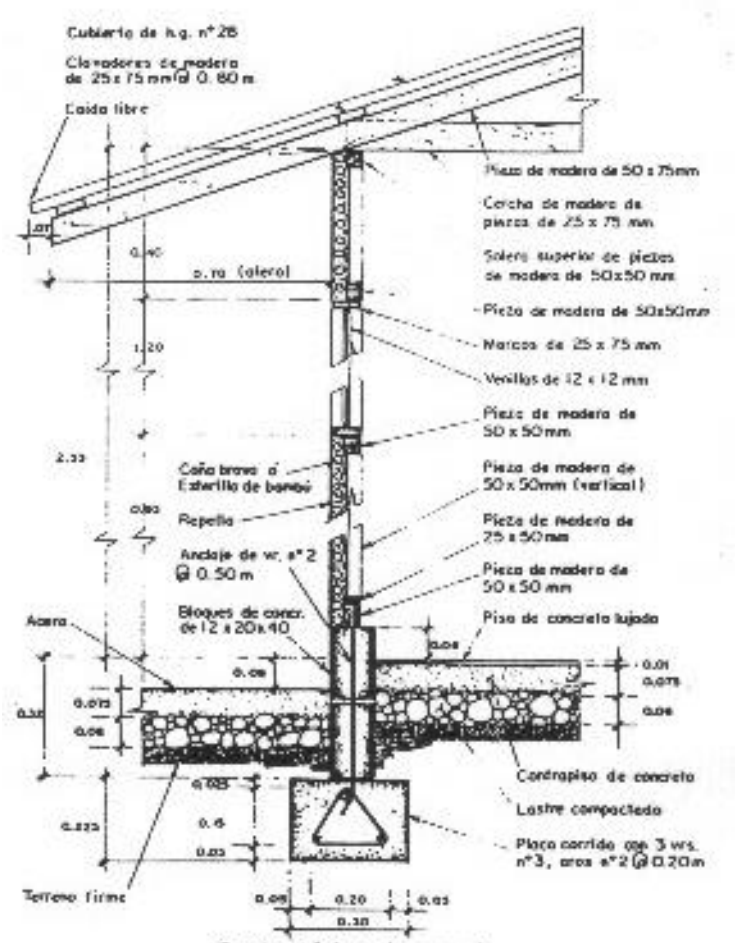
Phase	*Time (days)*
1. Ground preparation	2
2. foundation and substructure	5
3. construction of panels	4
4. Panels	1.5
5. Roof structure and finish	3
6. Plaster	8.5
7. Water installations	0.5
8. Floor	2.5 + 1.5
9. Doors and windows	5
10. Sanitary installations	1
11. Electricity	4
12. Septic tank and drainage	3
13. Final finishes	3
Total construction time	**44.5**

A3.2.2 Prefabrication of panels

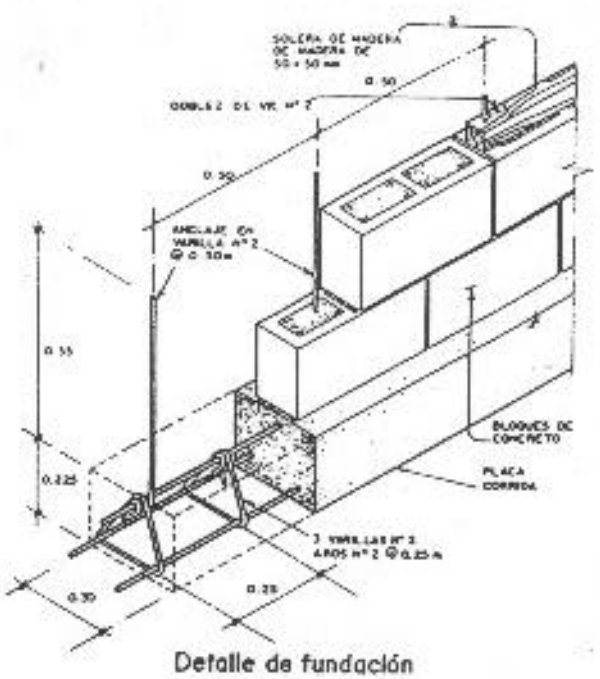
The prefabricated panels consist of a timber frame with bamboo fixed to it filling in the frame. The bamboo is in the form of 'cana brava' or 'esterilla'. Cana brava is used in its round form and has a diameter of approximately 2.5 cm. The cana brava is placed on the timber frame with one cm in between and fixed to the frame with spikes. Furthermore, the cana brava is tied together at the ends with galvanised metal cord. Esterilla is a form of split bamboo and is fixed on the panels in a similar method as the cana brava. The prefabrication of the panels ensures 'loodrecht-zijn' when they are place together to build the house. [8]

A3.2.3 Vertical cross-section

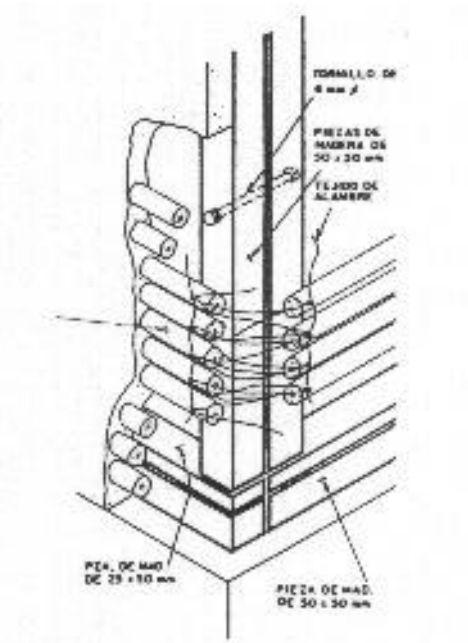
For all PNB technical drawings: [8]



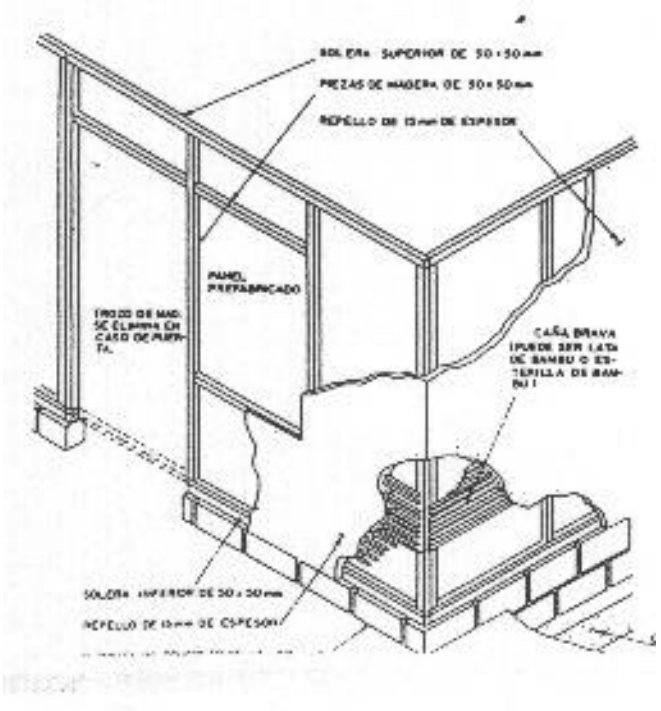
A3.2.4 Foundation and wall details



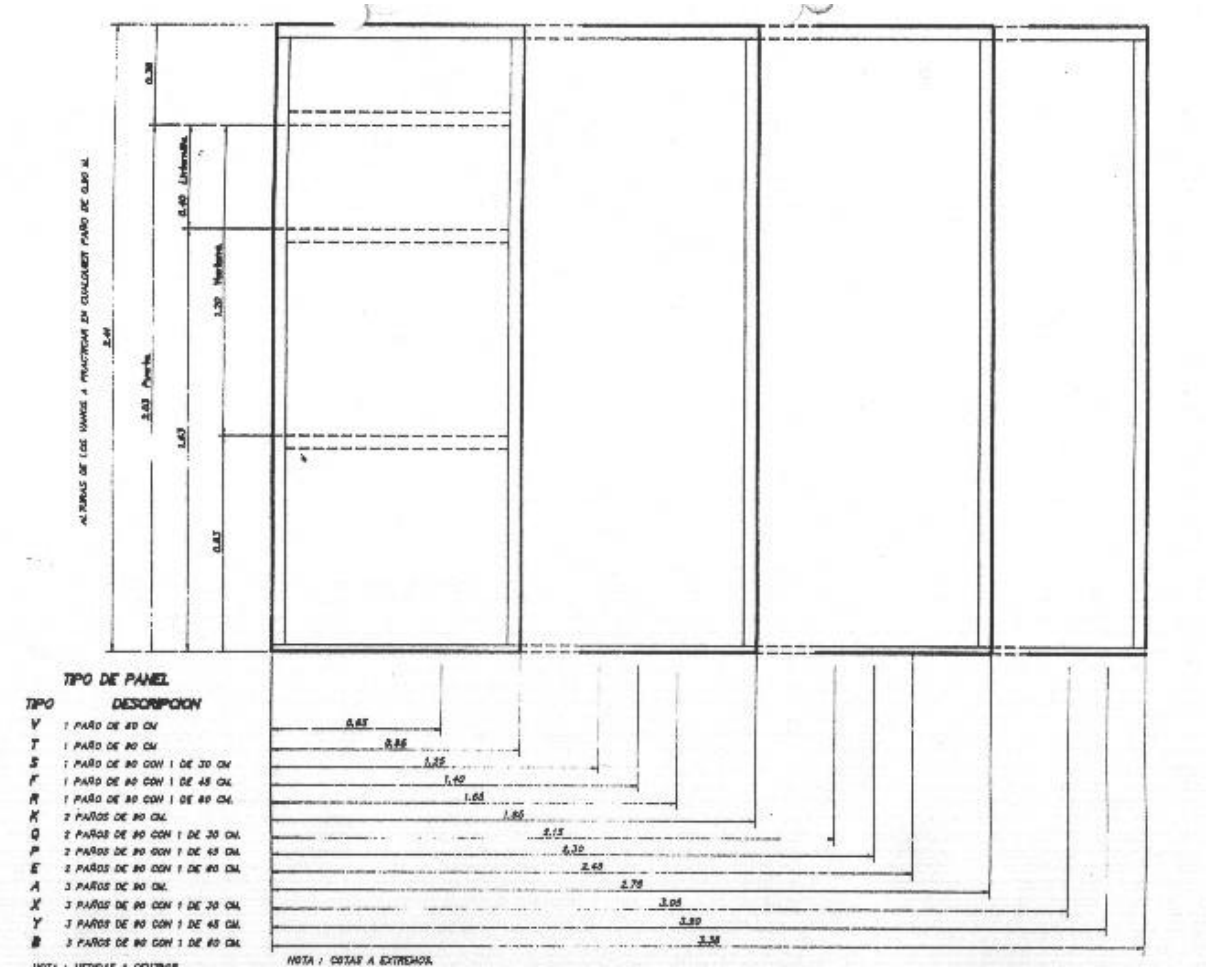
Detalle de fundación



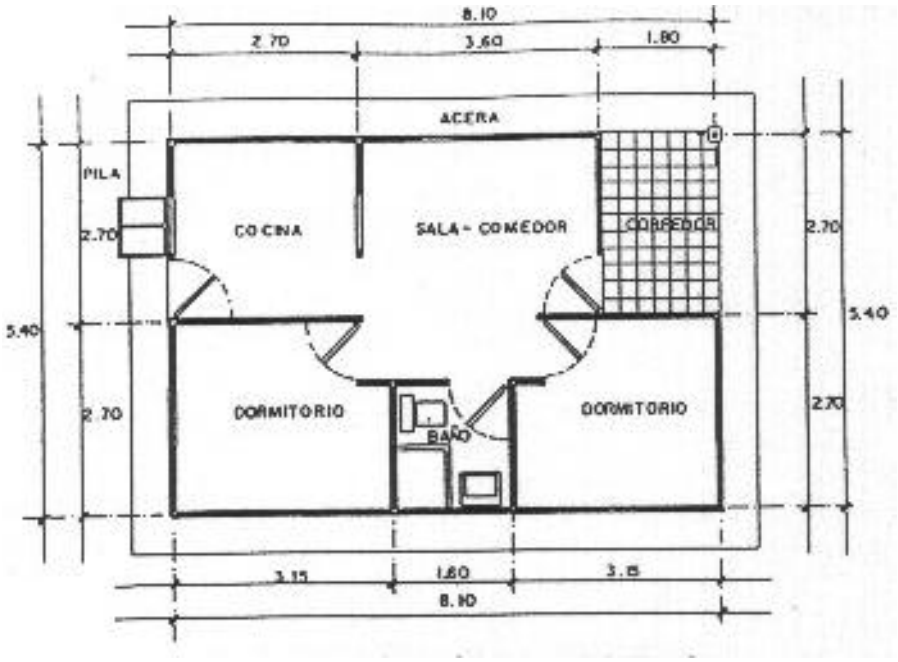
Detalle de la esquina



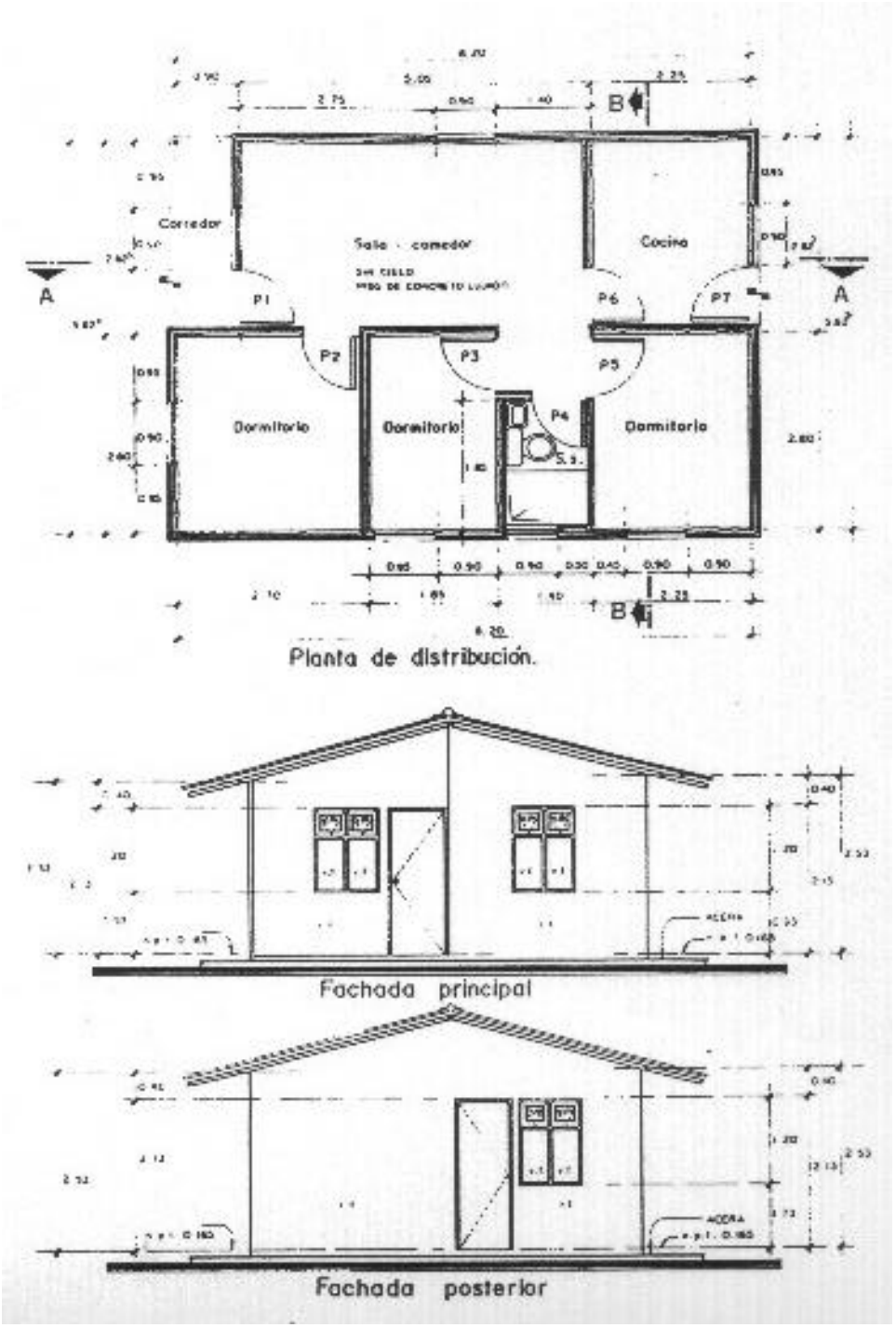
A3.2.5 Panels PNB house

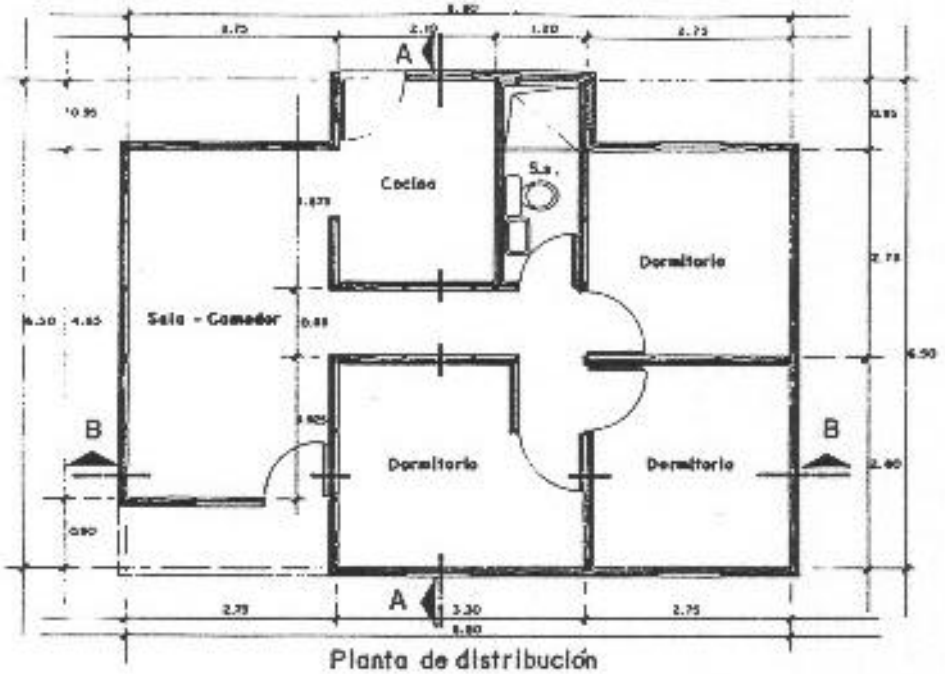


A3.2.6 Typical ground plan PNB house

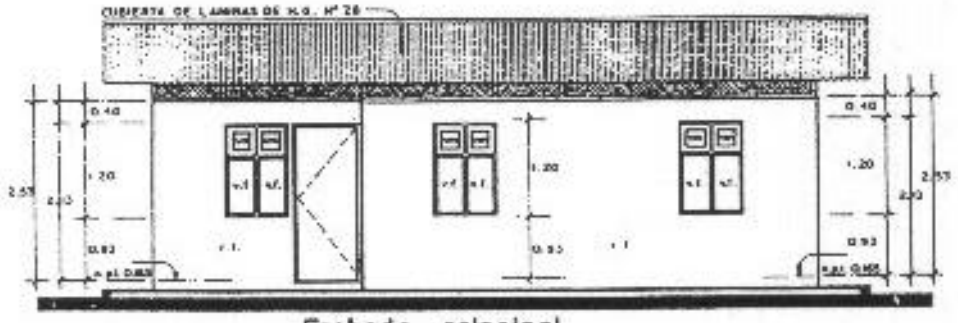


A3.2.7 Variations to PNB house: ground plan and facade

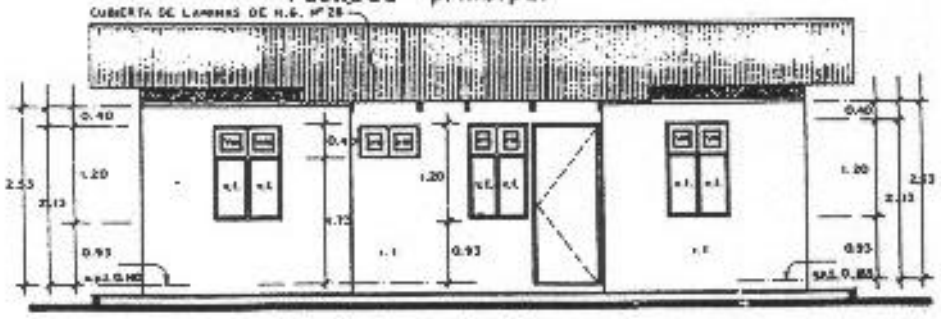




Planta de distribución

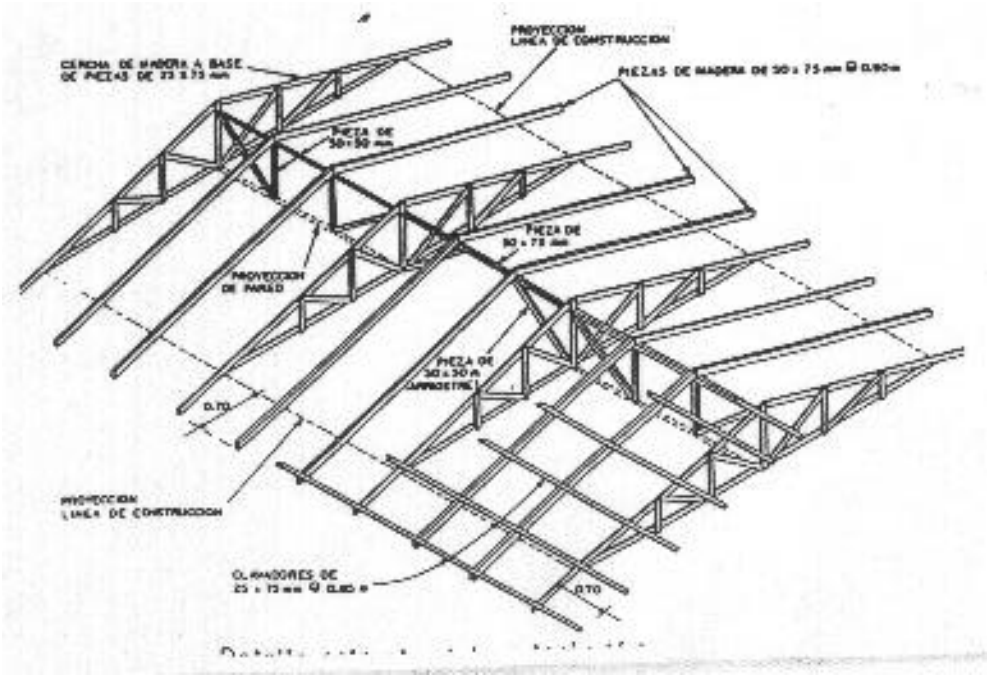


Fachada principal

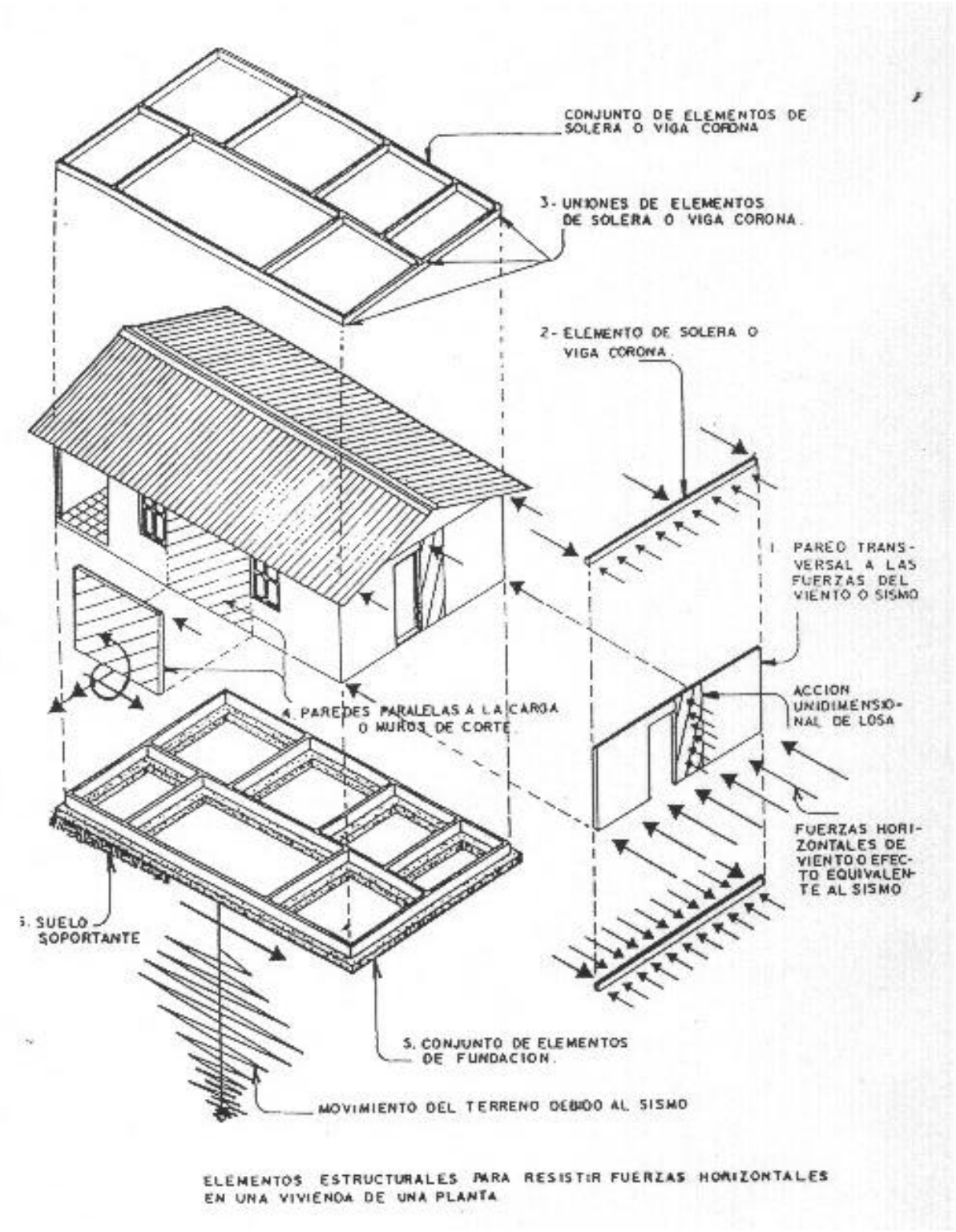


Fachada posterior

A3.2.8 Roof construction



A3.2.9 Resisting horizontal forces



ELEMENTOS ESTRUCTURALES PARA RESISTIR FUERZAS HORIZONTALES EN UNA VIVIENDA DE UNA PLANTA

Appendix chapter 4

A4.1 National setting

A4.1.1 History

Bangladesh

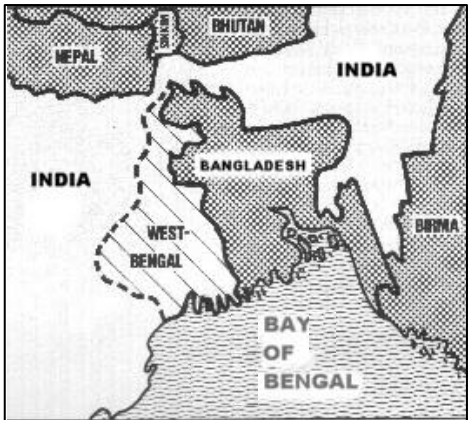


Figure A4.1: the former state of Bengal.
Source: Brandsma, 1982 [7].

Up to 1947, Bangladesh is the eastern part of the former state of Bengal (see figure A4.1). The state was divided by the river Ganges with the capital of Calcutta in the western part which is at present the Indian state of Bengal. Around 1400 BC the written history of Bangladesh starts. The state is ruled alternately by Hindu and Buddhist rulers until in the early 13th century it came under Muslim rule. First as part of the 'Sultanate of Delhi', and later as part of the 'Mogul empire' but interference from those empires was nihil. For about three centuries Bengal was a prosperous and practically independent state, with an abundance of rice and its famous 'muslin', a very fine textile.

Figure A4.2: Geographical history of Bangladesh.
Source: Brandsma, 1982 [7]

In 1960 the British East India Company arrived in Calcutta and they founded what later became known as 'British India' (figure A4.2). The British practically plundered the country. Besides that, Great Britain's industrial revolution brought mechanised textile production to British India which meant the end of the traditional textile craftsmen. Many of them moved to the rural areas. In these rural areas farmers were deprived from their land and extremely high taxes were raised.

In the 19th century an anti-British awareness slowly gained ground. Two parties emerged: the Indian National Congress (founded in 1885) consisting mainly of Hindus, and the All India Muslim League founded by the Muslims in 1906. Both aimed at independence from the British, but the All India Muslim League at the same time aimed at the partition of India in an Islamic and a Hindu part. In 1947 this resulted in the partition of British India. Indeed a separate Islamic part was formed. It was called Pakistan, and consisted of the present country of Pakistan (West-Pakistan) as well as the present country of Bangladesh (East-Pakistan).

For East-Pakistan (the present Bangladesh) this meant that they were cut off from their capital Calcutta, many Hindus fled the country, especially the educated. The government of the new Pakistan was located in the Western part which practically oppressed the Eastern part. In 1970, the Eastern Pakistani political party of Mujibur Rahman, the Awami League, became the largest of all of Pakistan, the bloody war for East Pakistan's independence from West Pakistan started. In 1971 the independent state of Bangladesh was declared.

Bangladesh started off in chaos and deprivation. A huge amount of people did not survive the war, the infrastructure had been destroyed, again many educated people had been killed or left and the governmental system collapsed. The same goes for private industries, trade, banking, insurance, shipping, etc. The first government leaded by Mujibur Rahman failed to build up the country and he was killed a few years after, in 1975. The leader that followed, Ziaur Rahman, founded the Bangladesh National Party and allowed for the existence of other parties. He managed to bring some relief, liberalising the economy and restructuring local governance. In 1982 a military coup brought an end to his rule as well as his life, and one of the generals involved, Muhammed Ershad, declared himself president in 1983. Opposition formed against him and he was forced to step down in 1990. In 1991 the first democratic

elections were held and from this time, the political scene is dominated by the two main parties, Bangladesh National Party and Awami League. In 1991 the BNP won the elections and Begum Khaleda Zia, widow of late president Ziaur Rahman, became president. In the 1996 elections the Awami League won, and Sheikh Hasina, daughter of late president Mujibur Rahman, became president. In the 2001 elections BNP wins again and for the second time, Khaleda Zia becomes president.

In conclusion, at present the competition between those two parties rules the country. If the one is in power, the other boycotts the parliament from time to time or declares a national strike (hartal) to protest against the government. This is counter constructive for the development of the country and although it is slowly moving towards better conditions, this is not much thanks to the workings of the government [6,7,8,9].

Chittagong Hill Tracts

The history of the Chittagong Hill Tracts is more or less neglected in literature. History writing mainly deals with this struggle for Bengali independence and the creation of a Muslim society. It describes an ethnic category, the Bengalis, as if it were the only ethnic group in Bangladesh, marginalising the people of the Chittagong Hill Tracts (CHT) [5,20].

Up to 1713 the chiefs or Rajas of the CHT area were still the authorities. Even under the British rule of the sub-continent, the area enjoyed some form of self-government, and migration to the area was virtually prohibited. The provisions made by the British, though seemingly favourable to the hill people at that point of time, as it protected them to a certain extent from the economic exploitations of Bengalis, in fact did more harm than good. In a way, it facilitated their alienation from the Bengali political system, into which they were later incorporated. When handed over to Pakistan, although 95 % of their population was non-Muslim, the CHT lost its special status and autonomy. The hill people were marginalised from the mainstream politics, and this marginalisation continued within the state of Bangladesh [2].

In 1960, the construction of a hydro-electric dam at Kaptai in Rangamati district was completed. A vast reservoir, Kaptai Lake, of some 550 square miles emerged, displacing about 100,000 tribal people, and inundating more that 54,000 acres or 40% of the best ploughlands of the CHT. This may very well have been the beginning of the present unrest in the CHT [10,21].

After Bangladesh declared its independence from Pakistan in 1971, a delegation of the hill peoples was formed to ensure the constitutional protection for them having a separate community. The demands they made were unacceptable to the then ruling Sheikh Mujib, who "[...] *insisted that there could be only one 'nation' in Bangladesh. He therefore asked the hill people to forget about their separate identity and become Bengalis. He further threatened to turn them into minorities by sending Bengalis into the CHT [...] In an electoral speach at Rangamati in 1973 Mujib declared: From this day onward the tribals are being promoted into Bengalis. [...] It implied that Bengalis were at a higher echelon of civilization*" [2]. The new constitution of the state of Bangladesh imposed Bengali nationality over all the citizens of Bangladesh and Bengali as the state language.

Besides political marginalisation, the CHT people were also economically marginalized. In 1979 the government decided to start settling landless Bengalis in the CHT[2]. Settling of thousands of Bengali people caused a demographic shift in the CHT, as well as it alienated the hill people from their land and forest resources, on which they mainly depend for their livelihood.

A political platform was formed in 1972, The United People's Party of CHT (PJCSS), with an armed wing, the Shanti Bahini (SB, Peace Forces), becoming the main mouthpiece for the hill people. A long struggle for recognition of CHT people's separate identity followed, but with hardly any success. The PJCSS also had the contradictory problem that though they were fighting for the CHT people's own identity, they were overlooking the fact that within the CHT, various different tribal groups existed. Talking about the hill people as one group, denied the existence of a whole range of groups, each with their own identity.

There have been several efforts to settle the conflict by Bangladeshi governments, at times resulting in limited agreements between the parties. In 1997 the so-called "Peace Accord" was signed between

[2] Percentage of Bengalis in CHT: 1947: 2.5%, 1951: 10%, 1981: 35%, 1991: almost 50%

the Bangladeshi Government and the PCJSS. The CHT peace accord recognised the CHT as a tribal inhabited region. Some points concerning this accord are:

- Regional Council (RC), combining the three hill district councils, consisting of tribal and non-tribal people, elected for a term of 5 years.
  - RC coordinates and supervises general administration, law and order and development activities of the three hill districts. It will coordinate disaster management and relief activities with NGOs and give license for heavy industries.
  - Tribal law and community adjudication shall be within the jurisdiction of the RC
  - The government will enact laws relating to CHT in consultation with the RC.
- A Ministry of CHT affairs, headed by a tribal, is set up.
- The government cannot acquire or transfer any lands, hills and forests under the jurisdiction of the Hill District Councils without prior discussion and approval of the RC. This is not applicable in the case of the Reserved Forest, Kaptai Hydroelectric project area, state-owned industrial enterprises and land recorded in the name of government.
- Rehabilitation of tribal refugees and internally displaced persons was ensured by providing a cash amount, the restoration of owned land, employment and educational facilities and opportunities. A Land Commission has been declared under a retired judge for the disposal of all disputes relating to land. Land would be returned to the owners once ownership rights can be ascertained. But in the CHT there is no conception of private property.
- Temporary military camps will be withdrawn, but permanent camps will remain.

Although sincere effort of the government seems to have been put into this Peace Accord (some existing laws had to be amended), the implementation still faces quite some difficulties. The first one is the slow pace of implementation by the government: out of the several hundred of non-permanent military camps, only 32 have been lifted; the Land Commission was officially formed in 1997, but did not meet and draw up terms of reference up to mid 1999; the return of refugees as well as internally displaces persons is made very difficult because of the lack of public records of land ownership (land is not seen as private property by the tribals). However sincere the efforts have been in designing and implementing this Peace Accord, only small steps have been accomplished yet. This is partly due to the fact that the accord was not recognised by the main opposition party at that time, which is at present the ruling party. And a number of political groups from the CHT challenge the PCJSS to be the sole representative of the hill people and signing the accord on their behalf.

A4.1.2 Socio-economic profile

Bangladesh classifies as one of the world's Least Developed Countries (LDC's). In the Human Development Index (HDI), a composite measure of achievement incorporating longevity of life, education and standard of living, Bangladesh ranks 147th out of 174 countries [10]. According to this HDI, life expectancy at birth is about 57 years; literacy (age 15 and over can read and write) is about 38%; Combined first-, second- and third-level gross enrolment ratio is 37%; and GDP per capita (in PPP$) is 1382. The total population has almost reached 130 million, and it is growing with 1.59%. Although average population density is about 900 inhabitants per square kilometre, it can range from over 2000 in metropolitan areas (mainly Dhaka and Chittagong) to an average of 250 in rural areas (Southwest, Northeast, and Southeast). The percentage of population below the poverty line is 35.6% and 35.2 % of Bangladesh's population is unemployed.

Table A4.1: Socio-economic indicators for Bangladesh [1].

	Bangladesh
GDP per capita (US$)	1,570
Country size (km2)	143,998
Population (million)	131.3
Density (no of people per km2)	897.2
Population growth rate (%)	1.59
Infant mortality rate (no of deaths per 1,000 live births)	69.85
Total fertility rate (no of children born per woman)	2.78
Life expectancy at birth (years)	60,54
For women	60,33
For men	60,74

The population of the CHT has been increasing at a rapid rate. In 1950 the population of the region was 287,000. The 1990 census showed a population of 955,000. About 55% of the population is tribal, consisting of people of Tibeto-Burmese and Chinese origin. There are at least 12 different tribes in the region, and about 90% of the population depends on agriculture. “Land being the basic factor, economic production consists of five predominant subsistence activities: (rice-) agriculture; animal husbandry; fruit tree cultivation; timber and bamboo extraction for household consumption; and horticulture. Many of the peasants and landless cultivators are engaged in day labouring and small business to add extra cash for their subsistence. The rural people especially the ethnic people have limited access to services and jobs. Direct engagement of the ethnic women in agriculture (90% according to a recent survey) is in sharp contrast with Bengali women.”

The average family size in the CHT is 5.53 with 2.88 males and 2.65 females. The number of adult family members engaged in agriculture is 1.62. The literacy rate shows that only 28% of the population is literate. The percentage of farmers having secondary education and above is only 8%. This is believed to be due to the high expense of ecucation, and the limited resources of the population [3].

The hill people still live in widely scattered settlements and there are only four population centres officially classified as urban: Rangamati, with a population of 20,000; Bandarban, with a population of 13,500 and Chandraghona and Kaptai, the main industrial centres, with populations of 9,600 and 8,300 respectively [22].

Table A4.2: The Tribes of the CHT. Source: Gain, 2000 [2].

Tribe	*Per-centage*	*Ranga-mati*	*Khagra-chari*	*Bandar-ban*	*Total*	*Religion*	*Language*
Chakma	47.77	157,385	77,869	4,163	239,417	Buddhist	Close relation with Bangla
Marma	28.40	40,868	42,178	59,288	142,334	Buddhist	Burmese dialect
Tripura	12.20	5,865	47,077	8,187	61,129	Hindu	Bodo
Murung	4.40	38	40	21,963	22,041		Bodo
Tanchangya	3.83	13,718	00	5,493	19,211	Buddhist	Close relation with Bangla
Bawm	1.39	549	00	6,429	6,978	Christian	Central Chin
Pankhua	0.64	3,128	00	99	3,227		Central Chin
Chak	0.40	319	00	1,681	2,000		Isolated language like Burmese, Chin and Bodo
Khyang	0.39	525	00	1,425	1,950	Buddhist Christian	Southern Chin
Khumi	0.25	91	00	1,150	1,241		Southern Chin
Lushai	0.13	**436**	00	226	662	Christian	Central Chin
Mro/Mru	0.03	**126**	00	00	126		Isolated language like Burmese, Chin and Bodo
Others (a.o.: Rakhain, Reang, Santal)	0.17	244	355	229	828		
Total	**100.00**	**223,292**	**167,519**	**110,333**	**501,144**		

According to Gain (2000) [2], in the percentage of tribal people in total CHT population is approximately 55%, so according to the calculation in above table, the tribal people of the CHT only make up 0.6% of total Bangladeshi population.

Table A4.3: Tribal CHT population in relation to total Bangladeshi population

	Bangladesh	*CHT*
Surface (km²)	144,000*	14,400
Percentage of total (%)	100%	10%*
Population density (number of persons per km²)	827*	96*
Population	120 million	1.4 million
Percentage of total (%)	100%	1.2%
* Gain, 2000: 1991 census figures.		

A4.1.3 Technology indicators

	Bangladesh [1,10]
Telephones (main lines in use)	500,000
Telephones (mobile cellular)	283,000
Electricity consumption (billion kWh)	11.216
Railways (total in km)	2,745
Highways (paved, in km)	19,112
Waterways (seasonally navigable, in km)	8,046
Natural resources	gas, arable land, timber, bamboo, coal
Exports	$5.9 billion (2000)
Imports	$8.1 billion (2000)
Trade balance ($ billion)	- 2.2
Export commodities	Garments, jute, jute goods, leather, frozen fish and seafood
Import commodities	Machinery, equipment, chemicals, iron and steel, textiles, raw cotton, food, crude oil and petroleum prod., cement
Researchers per million inhabitants*	52
Expenditure for R&D (% of GNP)*	0.03
Graduates tertiary education	69,278
Graduates tertiary education, per 1000 inhabitants	0.5

*Per country latest figures available: Bangladesh 1995.

A4.1.4 Policy profile

Industrialisation and Technology Policies

From independence in 1971 the government's strategy of industrialisation was based on import substitution. From the 80's on, Bangladesh headed more towards liberalisation. But despite all good intentions reflected in planning documents, Science and Technology policies and industrial policies, implementation almost always lacked. The policies focussed both on developing indigenous technology, and transferring imported technology with adaptation to local circumstances. It incorporates manpower as well as information and technology development. The main policy instrument for this has been giving boosts to the private sector and promoting export. Recently (Industrial Policy 1997), a new focus is taken. Government should play some role in the industrialisation process, 'to make up the shortcomings of the market mechanism'. The term 'technology capability' has also entered the policy language. See the appendix for a more detailed description of the policies.

Results: sectoral growth and decline

Bangladesh's economy at the beginning of independence in 1971 is based on agriculture. The agricultural sector declined, and both industry and service sector grew (see appendix, table A4.2). The industry sector only grew marginally, but the service sector grew to be the largest of the three. Within the industry sector, the manufacturing also only grew marginally, this can be accounted to the unfavourable technology infrastructure, lack of private investment and bureaucracy and corruption. The number of large scale manufacturing grew though at the expense of small scale manufacturing (see appendix, table A4.3) which may be a result of the policies of export promotion [11].

Table A4.5: Sectoral Share of GDP of Bangladesh, at constant prices (% distribution).
Source: Huq, ed. 2000, p. 4 [11].

	*1972/73**	*1975/76**	*1980/81**	*1985/86***	*1990/91***	*1995/96***	*1997/98***
Agriculture	49.76	49.33	44.23	41.53	37.60	32.24	21.66
Industries	13.78	12.87	15.57	15.71	17.16	19.56	19.45
(Manufacturing)	*(9.00)*	*(10.22)*	*(10.52)*	*(9.69)*	*(9.80)*	*(11.34)*	*(11.35)*
Services	36.47	37.80	40.20	42.95	45.24	48.20	48.86

* at 1972/73 prices
** at 1984/85 prices

Table A4.6: Relative shares of Small and Large Scale Manufacturing sectors in Bangladesh (% distribution).
Source: Huq, ed. 2000, p. 5 [11].

	1972/73	*1975/76*	*1980/81*	*1985/86*	*1990/91*	*1995/96*	*1997/98*
Large Scale*	30.50	43.23	51.54	53.67	58.05	65.36	66.48
Small Scale**	69.51	56.77	48.46	46.33	41.95	34.64	33.52

* Manufacturing establishments employing 10 or more persons.
** Manufacturing establishments employing 10 persons or less, including cottage industries.

Housing Policies

Bangladesh has an acute shortage of affordable housing both in urban and rural areas. The UN concludes that the Government acknowledges this, and to address these housing problems, the Government has undertaken the following steps. [12] In 1993 a *National Housing Policy* is formulated which recognises the problem and enables the promotion of house building and it gives guidelines. Furthermore Khas land (government owned land) is being used for solving housing problems, especially for the poorer households; private sector housing initiatives are encouraged by offering tax concessions to those using their own resources for construction; and public-private sector collaboration such as a housing project which is aimed at partially meeting the housing needs of urban middle class families. The *Fifth Five Year Plan strategy* (1997-2002) for improving the quality of life and living conditions of people includes:

- The provision of adequate physical infrastructure and other services
- Preparation of land use policy
- Master plans for urban centres and rural areas
- Developing low-cost housing options
- Initiating resettlement of slum dwellers
- Providing basic services to urban and rural inhabitants
- Combating environmental degradation and air and water pollution

The successful implementation of these various plans and programmes, remains a challenge to be fulfilled though. In the case of the rural areas in the CHT, there is no form of policy or regulation that has direct impact on the housing practice, and the government also doesn't provide for any financing system for these lower income groups. People make construction plans on their own, or with the help of a local construction expert [3]. As for financing, the NGO sector fills in the gap by providing micro-finance options like micro credit and savings programs.

NGOs offer the following types if credit[4]:

Rural credit:	Tk 2,000 – 10,000
Urban credit:	Tk 3,000 – 20,000
Micro enterprise credit:	Tk 10,000 – 50,000
Interest rates:	10 – 15 %
Instalments:	40-50 (weeks)

Green Hill, CHT's largest NGO offers[5]:

Total loan amount:	Tk 2,000 – 10,000
Interest rate:	12%
Time frame for loan refund:	1 year, by 52 instalments

[3] Personal communication with experts in different development issues in the CHT.
[4] Personal communication with expert on microfinance in Bangladesh.
[5] Personal communication with director of Green Hill.

A4.2 Sector setting

A4.2.1 Bamboos of the CHT

In the whole of Bangladesh one can find more than 33 bamboo species. Only 7 of them are occurring naturally in the forests of the Chittagong Hill Tracts:

1. Bambusa longispiculata (according to Alam, not to Banik and Nuruzzaman)
2. Bambusa teres (=tulda)
3. Bambusa tulda MITINGA
4. Dendrocalamus longispathus ORAH
5. Melocanna baccifera MULI
6. Neohouzeaua dullooa DALU
7. Oxytenanthera nigrociliata KALI
8. Melocalamus compactiflorus LATA

Throughout the whole country, bamboo is being cultivated on and around village homesteads. Some of the bamboos that are cultivated in the villages of Bangladesh are:

1. Bambusa arundinacea
2. Bambusa balcooa
3. Bambusa glaucecens
4. Bambusa mutans
5. Bambusa vulgaris
6. Dendrocalamus longispathus
7. Dendrocalamus strictus
8. Dendrocalamus giganteus (often cultivated in Buddhist temples of Chittagong)

Whereas the forest species are mostly medium sized and have thin-walled culms, in villages, bamboo species are mostly tall and have thick-walled culms.

- pole bamboos (eg. Bambusa balcooa)- thick walls, short interlodes
- split bamboos (eg. Muli)- thin walls, long interlodes

Physical and mechanical properties available of Muli bamboo (w.r.t. height and age):

- Moisture content
- Specific gravity
- Shrinkage of wall thickness and diameter
- Modulus of rupture
- Modulus of elasticity
- Compressive strength

Table A4.7: Prices of selected building materials in Dhaka (Taka).
Source: Bangladesh Bureau of Statistics (2000), pp. 326 [24].

Item	*Unit*	*1994-95*	*1998-99*
✍ Bricks, sand and cement			
- Brick 10" (1st class)	1000	2765	3316
- Sand (coarse) superior quality	100 cft.	850	601
- Cement (Imported)	Bag (Cwt.)	242	238
✍ Hardware			
- M.S. Rod (3/8 or 3 suta)	Cwt.	973	815
- C.I. sheet (26 gauge)	Bundle	3007 (1996-7)	3240
- G.I. pipe ½" dia	Ft.	21	27
✍ Timber & bamboo			
- Timber (Ctg. Teak) 8'x1"x8' plank	Cft.	1358	1780
- Timber (Garjan) 3"x3"x8' Beam	Cft.	678	748
- Bamboo (Borak) 30' long	Each	129	152
✍ Paint and varnishes			
- Paint Robbialac (syntthetic)	Gallon	578	656
- Varnish Robbialac	1 Lb. Tin	76	73
- Lime (for white wash)	Quintal	531	568

A4.3 Housing needs

A4.3.1 Characteristics of the target group

Family size and type

	Size				Type			
	Adults		Children		Extended		Nuclear	
	number	average	number	average	number	percent	number	percent
Paithong	98	3.3	72	2.4	7	23.3	23	76.7
Raicha	102	3.4	52	1.7	16	53.3	14	46.7
Satkamal	85	2.8	67	2.2	17	58.6	12	41.4
Amtolipara	81	2.7	74	2.5	14	46.7	16	53.3
Total	**366**	**3.05**	**265**	**2.2**	**54**	**45.4**	**65**	**54.6**
Family size (adults and children): 631 = 5.3 average								

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
No. adults	1	10	3,05	1,49425
No. children	0	5	2,21	1,25622
No. total	2	13	5,26	1,98945

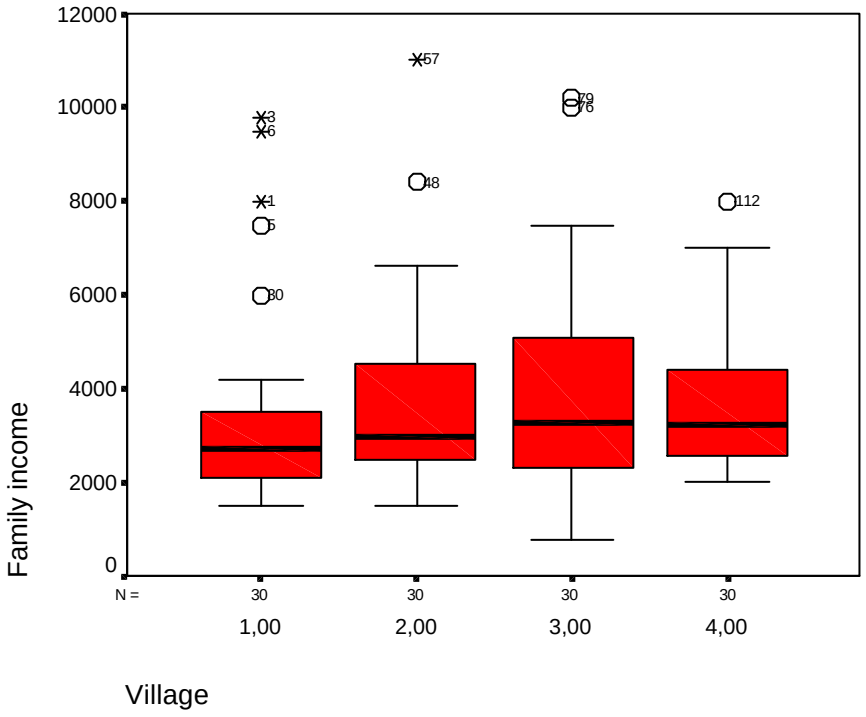
Income and expenditure on house

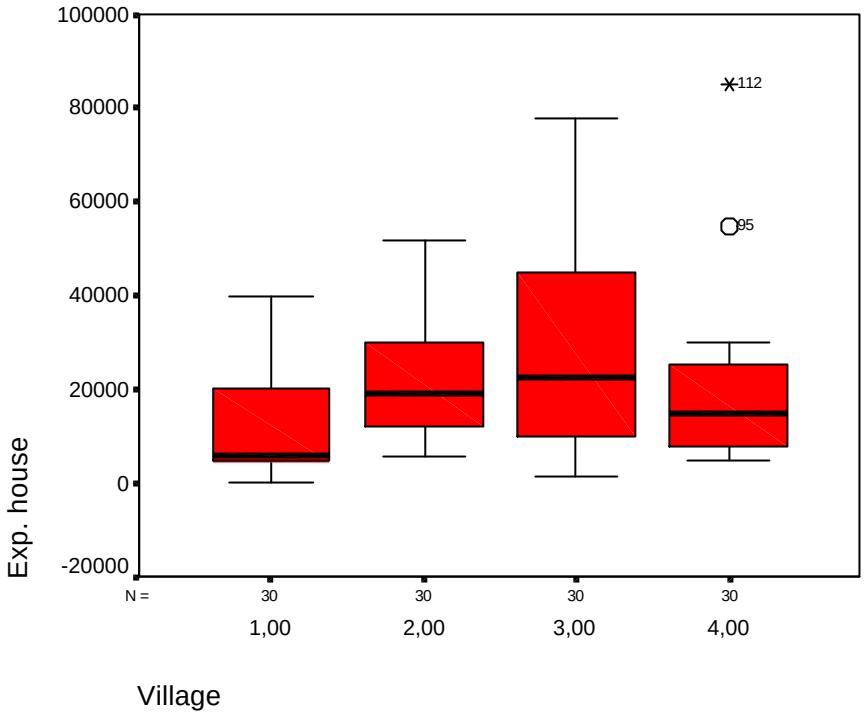
In general

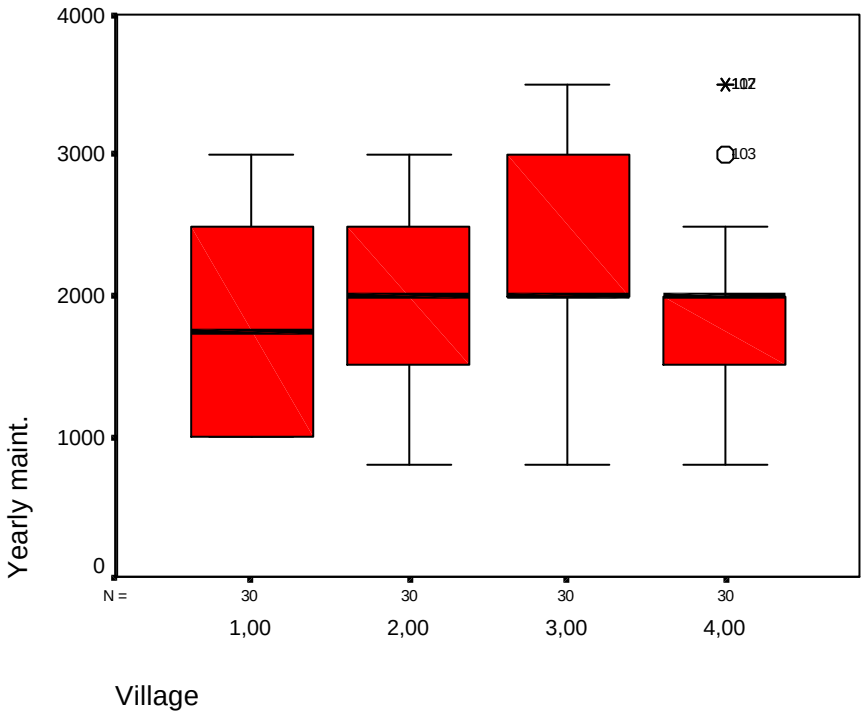
Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
Family income	800	11000	3754	2024
Exp. house	1	85000	19945	16716
Yearly maint.	800	3500	2008	723

Per village




100000
80000
60000
40000
20000
0
-20000
Exp. house
112
95
N =
30
30
30
30
1,00
2,00
3,00
4,00
Village


4000
3000
2000
1000
0
Yearly maint.
107
103
N =
30
30
30
30
1,00
2,00
3,00
4,00
Village

Occupation and education

OCCUPATION	no work	farming	day labour	Housewife	student	handicraft	service	Farming +	other	
Paithong		40	23	8	1	2		4	2	
Raicha	5	33		24	3		6	1	11	
Satkamal	1	51		8	10		5		3	
Amtolipara		36	28	10					1	
Total	***6***	***160***	***51***	***50***	***14***	***2***	***11***	***5***	***17***	***316***
Percentage	***1,9 %***	***50,6 %***	***16,1 %***	***15,8 %***	***4,4 %***	***0,6 %***	***3,5 %***	***1,6 %***	***5,4 %***	

EDUCATION	no educ	primary	secundary	higher	bachelor	master				
Paithong	60	17	4	1					82	
Raicha	38	19	16	3	4	1			81	
Satkamal	44	17	12	3					76	
Amtolipara	67	4	1						72	
Total	***209***	***57***	***33***	***7***	***4***	***1***				***311***
Percentage	***67,2 %***	***18,3 %***	***10,6 %***	***2,3 %***	***1,3 %***	***0,3 %***				
Paithong	73,2	20,7	4,9	1,2						
Raicha	46,9	23,5	19,8	3,7	4,9	1,2				
Satkamal	57,9	22,4	15,8	3,9						
Amtolipara	93,1	5,5	1,4							

A4.3.2 Housing needs

NB:

- In many of the tables codes are used, see appendix A1.4.

Functionality

Number of rooms

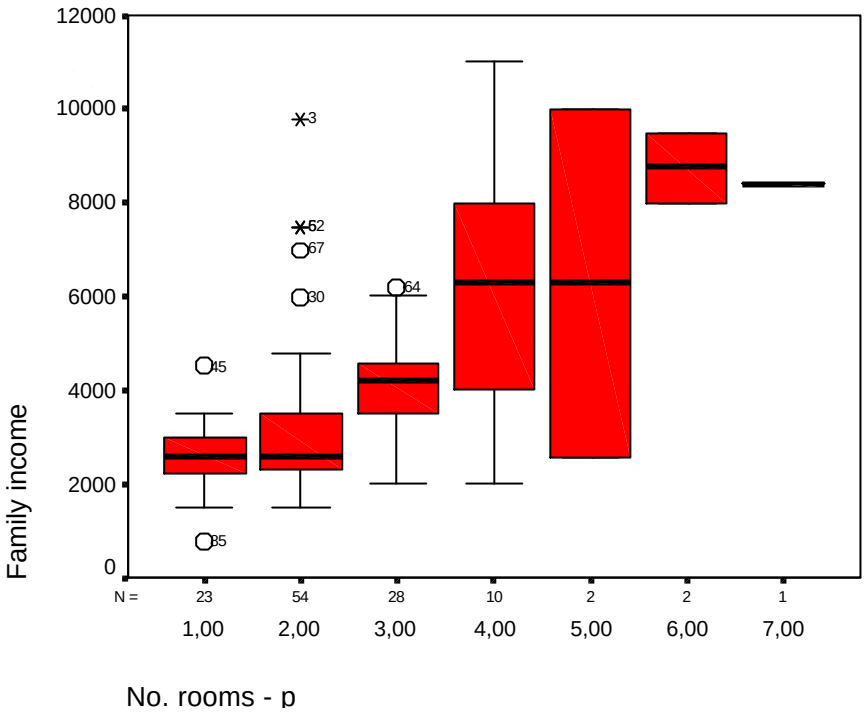
No. rooms - p * No. rooms - n Crosstabulation

		No. rooms – n									Total
		1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	
No. rooms - p	1,00	10	8	5							23
	2,00	7	19	24	4						54
	3,00	1	2	9	8	8					28
	4,00	1	1		1	2	4	1			10
	5,00					2					2
	6,00		1						1		2
	7,00									1	1
Total		19	31	38	13	12	4	1	1	1	120

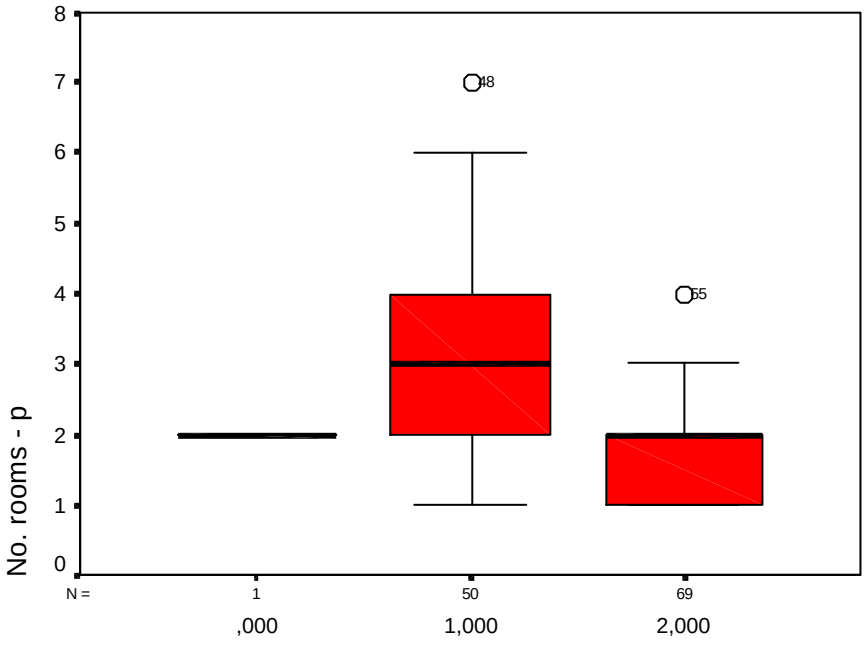
Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
No. rooms-p	1	7	2,4	1,1
No. rooms-n	1	9	3,0	1,5

Number of rooms related to total family number and family income



Number of rooms related to household type



Surface per activity

	present (m²)		needed (m²)	
	Mean	*St. dev.*	*Mean*	*St. dev.*
Living - socialising	43.2	31.5	51.3	30.8
Eating – cooking	8.2	7.4	12.8	5.6
Washing – bathing	0.2	1.0	7.1	3.0
Toileting	0.8	1.6	4.1	1.4
Sleeping	0.9	7.6	0.9	7.5
Storage	1.1	6.4	2.3	4.1
Work	0.6	2.7	10.3	9.5
Other	0.0	0.0	2.1	6.1
Total				

Extended table "Surface per activity (m2)"										
	Living / Soc.	**Eating / washing/ cooking bathing**		**toileting**	**sleeping**	**storage**	**work**	**other**	**total m2**	**Average / village**
present										
paithong	1036	106	0	0	20	105	44	0	1311	**43,7**
raicha	1615	305	18	44	0	0	0	0	1982	**66,1**
satkamal	1563	330	0	44	12	15	32	0	1996	**66,5**
amtolipara	968	237	0	4	0	10	0	0	1219	**40,63**
needed										
paithong	687	238	133	111	38	169	397	9	1782	**59,4**
raicha	1893	447	252	148	0	44	260	200	3244	**108,13**
satkamal	1936	453	228	122	0	56	490	0	3285	**109,5**
amtolipara	1593	405	242	120	0	10	100	52	2522	**84,1**

Facilities

Crosstabulation: drink water present and drink water needed

		Drink water -n						Total
Drink water -p		0	1	2	3	4	6	
	0	1		1				2
	2		7	9		3		19
	3			91	1	1		93
	5	1		4			1	6
Total		2	7	105	1	4	1	120

Crosstabulation: bathing present and needed

		Bathing -						Total
		0	1	2	3	4	6	
Bathing – p	0	1	2	10	1		1	15
	1		1					
	2		1	2		1		14
	3			94	2	3		99
	5							1
Total		2	4	106	3	4	1	120

Crosstabulation: toileting present and needed

	Toileting – n				Total
		0	2	3	
Toileting – p	0	1	12		13
	1	1	78	2	81
	2		21	2	23
	3		3		3
Total		2	114	4	120

Crosstabulation electricity present and needed

		Electricity – n		Total
		0	1	
Electricity – p	0	2	10	12
	1		30	30
	2		76	78
Total		4	116	120

Crosstabulation: drainage present and needed

		Drainage – n			Total
		0	1	2	
Drainage – p	0	3	114	1	118
	1		1		1
	2		1		1
Total		3	116	1	120

Crosstabulation: waste present and needed

		Waste – n				Total
		0	1	2	3	
Waste - p	0	1	1	20		22
	1	2	1	93	2	98
Total		3	2	113	2	120

Crosstabulation: other present and needed

		Other- n		Total
		0	1	
Other –p	0	94	25	119
	1		1	1
		94	26	120

Geometry

Type - p * Type - n Crosstabulation

		Type - n					Total
		,00	2,00	3,00	4,00	5,00	
Type - p	1,00	1	14	52	2	1	70
	2,00	2	5	36	1		44
	3,00	1	1	4			6
Total		4	20	92	3	1	120

Elevation - p * Elevation - n Crosstabulation

		Elevation - n						Total
		,00	30,00	50,00	100,00	150,00	200,00	
Elevation - p	24,00				1			1
	25,00				43			43
	30,00		1		1			2
	35,00				2			2
	40,00				2			2
	45,00				1			1
	50,00	3		1	20			24
	75,00				1			1
	100,00	2		4	8	1		15
	150,00	1			9	2		12
	200,00	1			9	1	6	17
Total		7	1	5	97	4	6	120

Elevation - p * Foundation - p Crosstabulation

		Foundation - p						Total
		1,00	2,00	4,00	7,00	26,00	28,00	
Elevation - p	24,00				1			1
	25,00	16	1	8	15	3		43
	30,00	1		1				2
	35,00	1			1			2
	40,00	1		1				2
	45,00	1						1
	50,00	14		1	8	1		24
	75,00				1			1
	100,00	11		2	1		1	15
	150,00	10		2				12
	200,00	16		1				17
Total		71	1	16	27	4	1	120

Elevation - n * Foundation - n Crosstabulation

		Foundation - n				Total
		,00	1,00	2,00	7,00	
Elevation - n	,00	1		6		7
	30,00			1		1
	50,00			5		5
	100,00	1	26	69	1	97
	150,00		1	3		4
	200,00			6		6
Total		2	27	90	1	120

Height - p * Height - n Crosstabulation

		Height - n			Total
		,00	1,00	2,00	
Height - p	,00	1			1
	1,00	1	88	21	110
	2,00			9	9
Total		2	88	30	120

Roof type - p * Roof type - n Crosstabulation

		Roof type - n								Total
		,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	
Roof type - p	1,00		1							1
	2,00			17	42					59
	3,00			2	9					11
	4,00	7	1		31					39
	5,00					3			1	4
	6,00						1			1
	7,00							2		2
	8,00								3	3
Total		7	2	19	82	3	1	2	4	120

Overhang - p * Overhang - n Crosstabulation

		Overhang - n				Total
		45,00	100,00	150,00	200,00	
Overhang-p	30,00		4			4
	35,00		6			6
	40,00		17			17
	45,00	1	33			34
	50,00		18			18
	55,00	2	2			4
	60,00		23			23
	65,00		3			3
	70,00		1			1
	75,00		8	1		9
	150,00				1	1
Total		3	115	1	1	120

Material use

Foundation

Foundation - p * Foundation - n Crosstabulation

		Foundation - n				Total
		,00	1,00	2,00	7,00	
Foundation - p	1,00	1	10	60		71
	2,00			1		1
	4,00		15	1		16
	7,00	1		25	1	27
	26,00		2	2		4
	28,00			1		1
Total		2	27	90	1	120

Reason f.p. * Foundation - p Crosstabulation

		Foundation - p						Total
		1,00	2,00	4,00	7,00	26,00	28,00	
Reason f.p.	1,00	2						2
	2,00	22				1		23
	3,00	25		6	1	3		35
	4,00	1		10				11
	14,00	19						19
	15,00	1						1
	18,00	1						1
	19,00				1			1
	21,00		1		23			24
	22,00				2			2
	23,00						1	1
Total		71	1	16	27	4	1	120

Reason f.n. * Foundation - n Crosstabulation

		Foundation - n				Total
		,00	1,00	2,00	7,00	
Reason f.n.	,00	2				2
	1,00		6	24		30
	2,00		17	36		53
	3,00		1			1
	10,00			1		1
	11,00			29		29
	14,00		3			3
	21,00				1	1
Total		2	27	90	1	120

Structure

Structure - p * Structure - n Crosstabulation

		Structure - n				Total
		,00	1,00	4,00	6,00	
Structure - p	1,00	1	5	36		42
	2,00		33	16		49
	6,00	1		26	1	28
	13,00			1		1
Total		2	38	79	1	120

Reason s.p. * Structure - p Crosstabulation

		Structure - p				Total
		1,00	2,00	6,00	13,00	
Reason s.p.	,00	2				2
	1,00	1				1
	2,00	11	1			12
	3,00	14	39	2		55
	4,00		9			9
	14,00	13				13
	15,00				1	1
	18,00	1				1
	19,00			1		1
	21,00			22		22
	22,00			2		2
	24,00			1		1
Total		42	49	28	1	120

Reason s.n. * Structure - n Crosstabulation

		Structure - n				Total
		,00	1,00	4,00	6,00	
Reason s.n.	,00	2				2
	1,00		8	17		25
	2,00		28	31		59
	3,00		2			2
	10,00			1		1
	11,00			29		29
	12,00			1		1
	21,00				1	1
Total		2	38	79	1	120

Walls

Walls - p * Walls - n Crosstabulation

		Walls - n						Total
		,00	1,00	2,00	3,00	4,00	5,00	
Walls - p	1,00				1	1		2
	2,00	1	8	14	13	47		83
	3,00	1			1	26	4	32
	9,00					1		1
	12,00					1		1
	14,00					1		1
Total		2	8	14	15	77	4	120

Reason w.p. * Walls - p Crosstabulation

		Walls - p						Total
		1,00	2,00	3,00	9,00	12,00	14,00	
Reason w.p.	,00		1					1
	2,00	1						1
	3,00	1	74	2	1			78
	4,00		2					2
	14,00		2					2
	16,00		1					1
	19,00			1				1
	20,00		3					3
	21,00			24		1	1	26
	22,00			2				2
	23,00			1				1
	24,00			2				2
Total		2	83	32	1	1	1	120

Reason w.n. * Walls - n Crosstabulation

		Walls - n						Total
		,00	1,00	2,00	3,00	4,00	5,00	
Reason w.n.	,00	2				1		3
	1,00		2		1	53	1	57
	2,00		5	1		9	2	17
	3,00			3				3
	6,00				1			1
	9,00			7				7
	10,00		1		4		1	6
	11,00					14		14
	14,00			1				1
	20,00			2				2
	21,00				8			8
	23,00				1			1
Total		2	8	14	15	77	4	120

Roof structure

Roof structure - p * Roof structure - n Crosstabulation

		Roof structure - n			Total
		,00	1,00	3,00	
Roof	1,00	7	41	1	49
structure - p	2,00	1	70		71
Total		8	111	1	120

Reason rs.p. * Roof structure - p Crosstabulation

		Roof structure - p		Total
		1,00	2,00	
Reason rs.p.	,00	1	1	2
	2,00	37		37
	3,00	6	49	55
	4,00	1	21	22
	7,00	1		1
	12,00	1		1
	14,00	2		2
Total		49	71	120

Reason rs.n. * Roof structure - n Crosstabulation

		Roof structure - n			Total
		,00	1,00	3,00	
Reason rs.n.	,00	8	1		9
	1,00		12	1	13
	2,00		87		87
	3,00		2		2
	7,00		1		1
	9,00		1		1
	10,00		4		4
	11,00		1		1
	14,00		1		1
	17,00		1		1
Total		8	111	1	120

Roof finish

Roof finish - p * Roof finish - n Crosstabulation

		Roof finish - n					Total
		,00	1,00	4,00	6,00	12,00	
Roof finish - p	1,00	2	53	3	1		59
	2,00		1				1
	3,00		53				53
	11,00	1					1
	12,00		1			1	2
	14,00		3				3
	25,00	1					1
Total		4	111	3	1	1	120

Reason rf.p. * Roof finish - p Crosstabulation

		Roof finish - p							Total
		1,00	2,00	3,00	11,00	12,00	14,00	25,00	
Reason rf.p.	1,00	58			1				59
	3,00			36			1		37
	4,00		1	17					18
	11,00	1							1
	12,00					1			1
	13,00					1		1	2
	14,00						1		1
	27,00						1		1
Total		59	1	53	1	2	3	1	120

Reason rf.n. * Roof finish - n Crosstabulation

		Roof finish - n					Total
		,00	1,00	4,00	6,00	12,00	
Reason rf.n.	,00	4					4
	1,00		111	2	1		114
	10,00			1			1
	13,00					1	1
Total		4	111	3	1	1	120

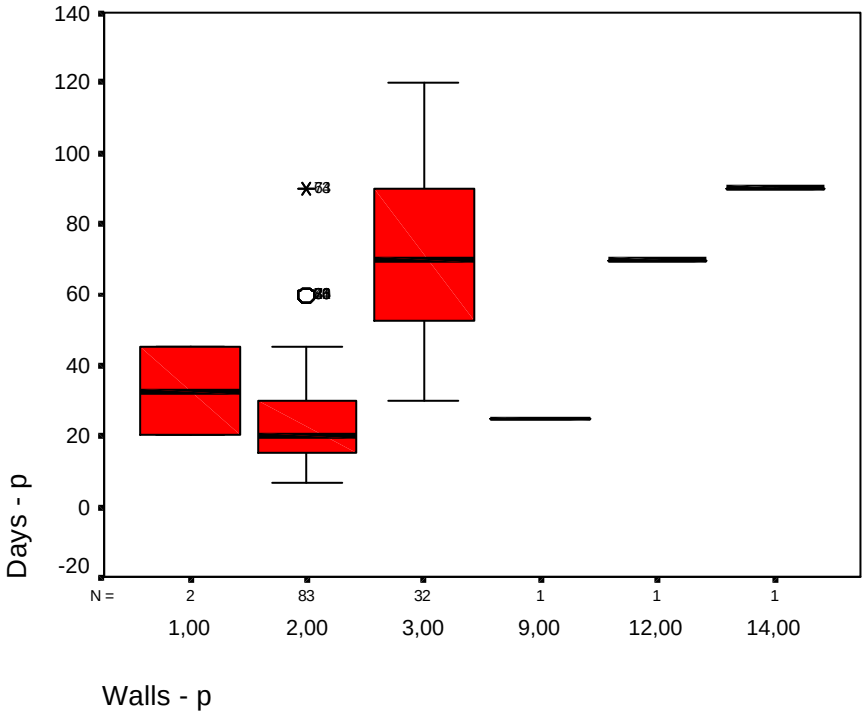
Total house material use
'Present'

Total	*Village*				Foundation	Structure	Walls	Roof structure	Roof finish
	1,00	2,00	3,00	4,00					
1			1		Wooden piles	Timber	Timber	Timber	Tin sheet
1	1								Veg.mat.
15	3	1	5	6	*Wooden piles*	*Timber*	Split bamboo	Timber	Tin sheet
2	2								Veg.mat.
1	1								Tin sheet+bamboo
1	1								Bamboo+veg.mat
1	1								Tin sheet+ bamboo + veg.mat.
5	1			4	*Wooden piles*	*Timber*	*Split bamboo*	Bamboo	Tin sheet
8	3	3	1	1	*Wooden piles*	*Timber*	*Split bamboo*	*Bamboo*	Veg.mat.
1	1						Rammed earth	Timber	Tin sheet
2		2						Bamboo	Tin sheet
1				1			not available	Bamboo	Veg.mat.
1			1			Bamboo	Split bamboo	Timber	Tin sheet
7		1	3	3				Bamboo	Tin sheet
20	6	4	4	6	*Wooden piles*	*Bamboo*	*Split bamboo*	*Bamboo*	Veg.mat.
1		1							Tin sheet+veg.mat
1	1								Bamboo+veg.mat
1		1				Rammed earth	Rammed earth	Bamboo	Tin sheet
1	1					Timber and rammed earth	Rammed earth	Timber	Tin sheet
1			1		Concrete piles	Rammed earth	Rammed earth	Timber	Tin sheet
1				1	Bamboo piles	Bamboo	Split bamboo	Timber	Tin sheet
1			1					Bamboo	Tin sheet
12	6		2	4	*Bamboo piles*	*Bamboo*	*Split bamboo*	*Bamboo*	Veg. material
1				1					Tin sheet+veg.mat
1	1								Bamboo+veg.mat
2	1		1		Rammed earth	Timber	Split bamboo	Timber	Tin sheet
19		11	6	2	*Rammed earth*	Bamboo	Rammed earth	Timber	Tin sheet
1			1					Bamboo	Bamboo
4		2	1	1					Veg.mat.
1			1				Split bamboo and rammed earth	Timber	Tin sheet
3		2	1		Wood and bamboo	Bamboo	Split bamboo	Bamboo	Veg.mat.
1		1				Rammed earth	Split bamboo	Bamboo	Veg.mat.
1		1			Wood and rammed earth	Timber	Timber and rammed earth	Bamboo	Veg.mat.

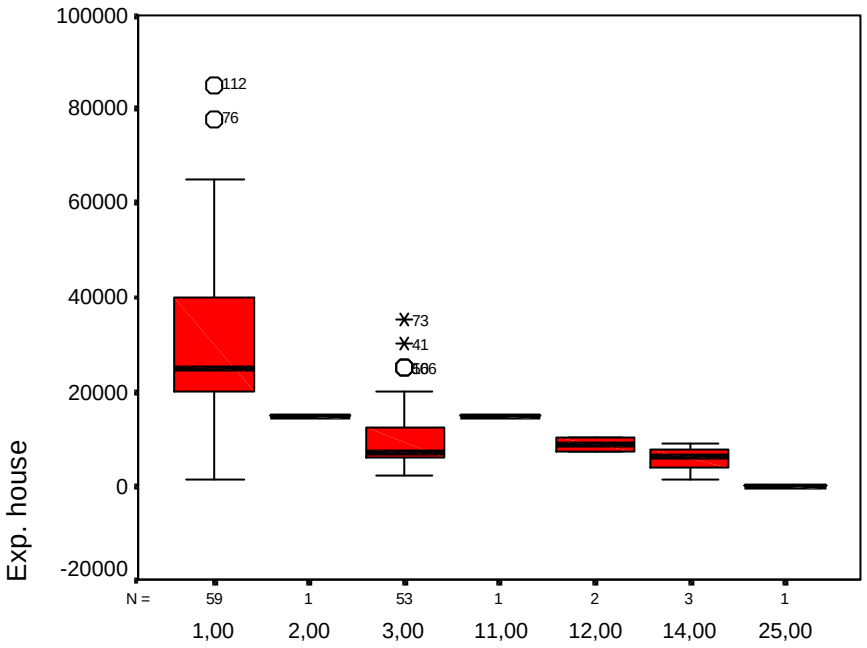
'Needed'

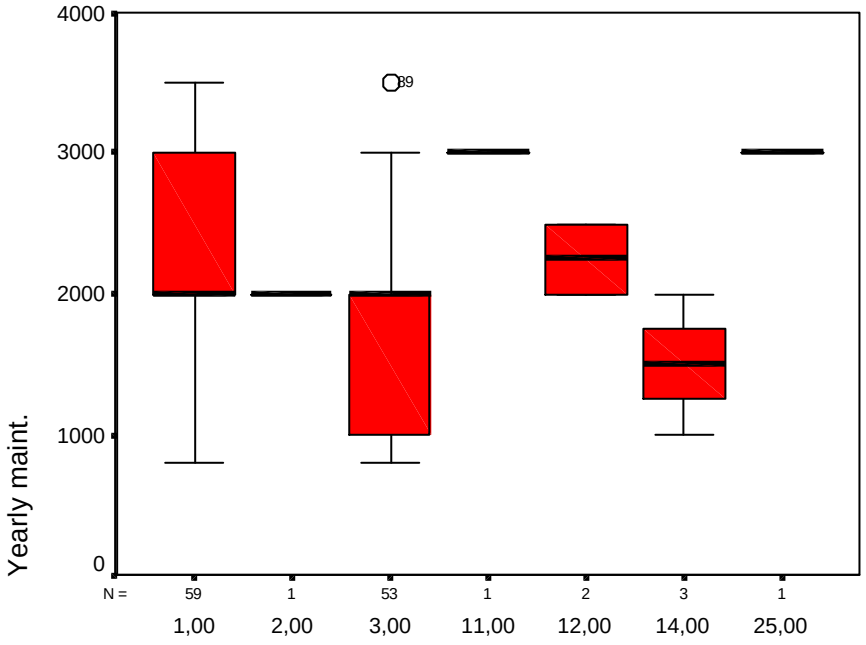
Total	Village				Foundation	Structure	Walls	Roof structure	Roof finish
	1,00	2,00	3,00	4,00					
1		1			,00	,00	,00	,00	4,00
1	1					4,00	4,00	1,00	1,00
4	2	1		1	1,00	1,00	1,00	1,00	1,00
11			3	8	*Wooden piles*	*Timber*	*Split bamboo*	*Timber*	*Tin sheet*
6	4			2	*Wooden piles*	*Timber*	*Rammed earth*	*Timber*	*Tin sheet*
5			1	4			4,00	1,00	1,00
1	1					4,00	3,00	1,00	1,00
1	1				2,00	,00	4,00	,00	,00
1	1					1,00	,00	,00	1,00
1	1						1,00	1,00	1,00
2			1	1			2,00	1,00	1,00
2	2						3,00	1,00	1,00
6	3		2	1	*Concrete piles*	*Timber*	*Masonry*	*Timber*	*Tin sheet*
3	3					4,00	1,00	1,00	1,00
1				1			2,00	1,00	1,00
5	5						3,00	1,00	1,00
1	1						4,00	,00	,00
1				1					1,00
1		1							4,00
58	3	21	23	11	*Concrete piles*	*Concrete*	*Masonry*	*Timber*	*Tin sheet*
1		1							4,00
1		1							12,00
1		1						3,00	6,00
2	2						5,00	,00	,00
2		2						1,00	1,00
1		1			7,00	6,00	3,00	1,00	1,00

Production time
Related to 'walls'



Costs
Related to 'roof finish'





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