

MASTER

Flood risk reduction strategies

recommendations for flood risk reduction in the Limoncito Watershed in Puerto Limón, Costa Rica

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Flood Risk Reduction Strategies

Recommendations for Flood Risk Reduction in the
Limoncito Watershed in Puerto Limón, Costa Rica

Master Thesis

Technology and Development Studies, Eindhoven University of Technology
ProDUS, University of Costa Rica

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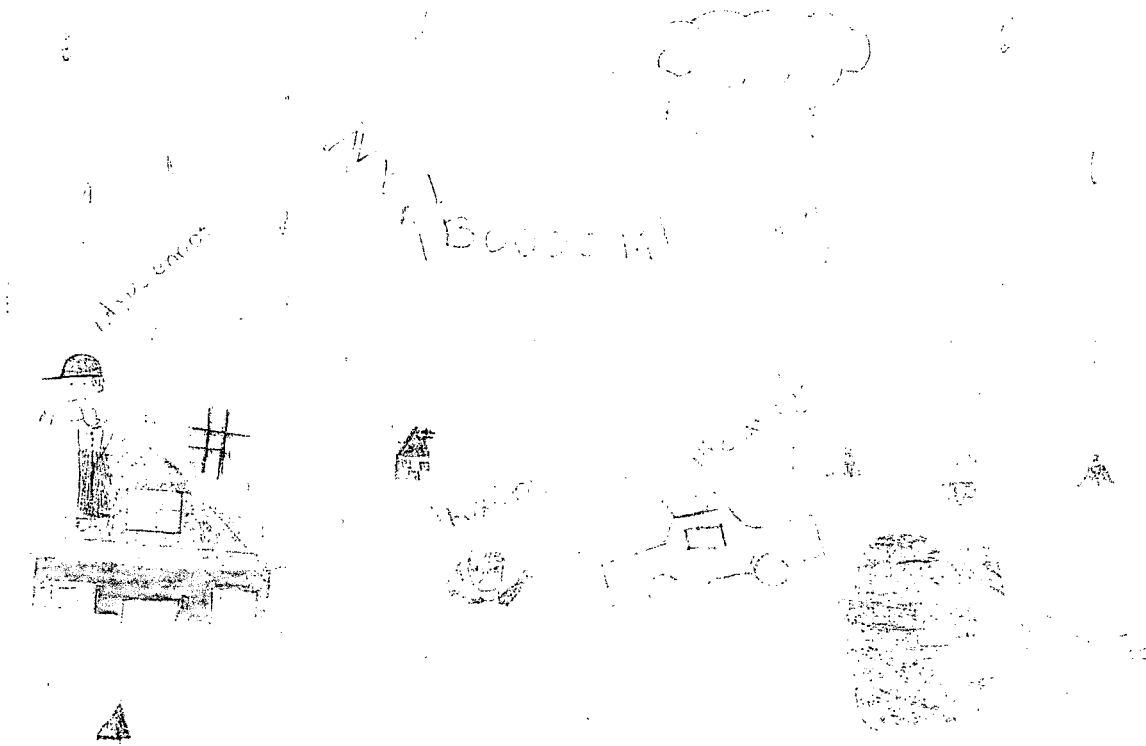
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Para el hermoso Puerto Limón

For the beautiful Port Limon



Drawing by Marcela Lizeth Mendez, winner of the drawing contest: Floods in my neighbourhood, held at the school of La Colina in April 2003.



Preface

With great enjoyment I have been working on this paper. It has shown to be a very interesting topic and a research touching many aspects of society and technology. It was only with the inspiring help of many people that I was able to write this research paper as it is now. I have been privileged to learn the limonese society and culture, through the help of many friendly people in Limon. I would like to thank especially Rodrigo Esquivel, a limonese taxi driver who showed me the neighbourhoods as they are in their true being. And who looked after my safety during the many visits to Puerto Limon. Unfortunately, the situation was too delicate to visit the neighbourhood without the company of local people, like Rodrigo. Besides Rodrigo I would like to thank Silvia Blandon and Israel Oconitrillo personally for their help. Silvia, worker in the cadastre department of the municipality of Limon, provided me with many interesting contacts. And furthermore she helped me greatly by convincing the people within the local institutes of the importance of this research. Her friendliness helped me feel at home in Puerto Limon and made the visits pleasant. In Puerto Limon I would also like to thank Israel Oconitrillo, a journalist of 'La Nacion' and head of communication in Japdeva. He helped me with many interesting stories. Moreover I hope the results of this research will find their way to many people through his hands. His contacts within Limonese society and institutes will be an extraordinary opportunity to distribute the findings and results of this research.

Furthermore I would like to thank Rosendo Pujol and Ana Lorena Bolaños. Both helped me feel at home at ProDUS and in Costa Rica. Making it a period that I will always remember. I would like to thank Rosendo for giving me this opportunity at ProDUS and for proposing this particular research topic, which proved to be an interesting one. In ProDUS especially Ana Lorena, helped me at feel home in an extraordinary way, giving me a great time in ProDUS and Costa Rica. Her kindness, and warmth were great. She also helped me with the Spanish language when it was needed.

Mostly I would like to thank Johan Cubillos, mechanical engineer from Venezuela. He was the one who listened to my stories and put experiences into perspective. His company on many visits was very helpful and pleasant. And I could not have made the measures, which of course needed more than two hands.

Finally I would like to thank the three supervisors. Henny Romijn was a great support in the bad times when her positives words helped me stay enthusiastic. Moreover I would like to thank her for reading the draft several times and helping make this paper more readable. Furthermore I need to thank Pieter Huisman, who with his great experience had useful comments. Also I would like to thank Emilia van Egmond, who helped me with the first communication with Costa Rica and providing me with a great contact such as ProDUS.

I sincerely hope this paper could add something to the knowledge accumulation on flood risk in the Limoncito watershed. And that it, perhaps, inspires others to continue to do research on flood risk reduction in the Limoncito watershed.

Mark Vlok
Eindhoven, The Netherlands
November 2003

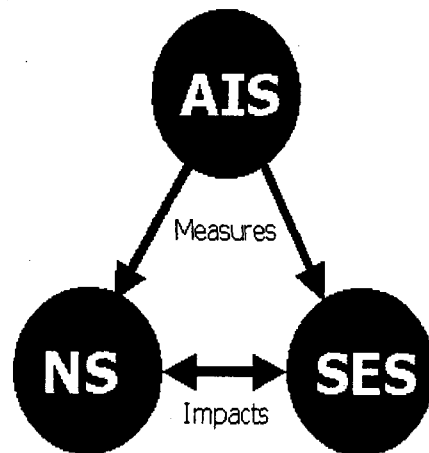


Summary

This research aims at the flood risk reduction strategies present in the Limoncito watershed. This watershed is located on Caribbean side of Costa Rica, in the canton of Limon. The watershed is for a large part situated in the urban areas of Puerto Limon and immediately this illustrates the complexity of the situation. The river and citizens put pressure on the scarcely available lands in the urban area and the harmony between a save and economical habitat and the risk of river floods is delicate.

The research was divided into two parts in order to come to an understanding of the watershed and recommendations that could reduce the flood risk in the Limoncito watershed. In the first part, the descriptive part, the watershed was described according to a predetermined research model (shown in figure below) and subsequently to this the research recommendations were argued and specified in the prescriptive part. These recommendations were based on the situation described in the descriptive part and are drawn upon the direct and indirect reduction of the flood risk. The recommendations specify measures that should be taken in the AIS (Administrative and Institutional System) or recommend certain adjustments within system itself.

The descriptive part existed of the elaboration of the three systems, namely the Natural System [NS], the Socio-Economic System [SES] and the Administrative and Institutional System [AIS]. They have been described separately and in relation to each other in order to obtain a complete understanding of the watershed, with the focus on flood risk and the flood risk reduction strategies.



Since data and information were scarce an important aspect of the research was to gather and record information on the watershed. The research paper can be seen as a stepping-stone to more research on the watershed. It has been the first research that took into account the actual situation and it was the first in which actual data was gathered in the case of floods in these areas.

The NS of the watershed is subject to frequent floods, from data it is estimated that floods occur at least once a very year. Yet inhabitants indicate even a frequency of 3 floods a year. Since the watershed is very short (only 25 kilometres) and for a large part present in urban areas these floods often are flash floods with high peak run-offs. The flood risk is increased by various factors in the NS. The most obvious are the numerous inefficiencies in the waterways, such as bridges and pipes that block the river and dam up the water in case of water level risings and debris and sedimentation that reduce the river cross-section and slow down run-off. Through the flood risk the NS has an impact on the SES in two important ways. First of all socio-economic development is hold up since the physical capital goods are deteriorated and second there will be less investments in the flood prone area. This increases the equity of between the different neighbourhoods in Puerto Limon even more.

The water quality was also found to be problem in the watershed, especially if the flood frequency is taken into an account. The water that runs into the houses during a flood is likely to be very contaminated, since the Limoncito River is one the most contaminated rivers in Costa Rica and has



high concentrations of Faecal Coliforms. These concentrations are a result of the absence of a proper public sewerage system. The health situation of flood is therefore very poor.

The socio-economic equity within the city is dramatic. There is a great difference between neighbourhoods often depending on either the land was urbanized formal or informal. Ineffective planning and inferior public infrastructure such as roads and public sewerage characterize the former illegal neighbourhoods. The problem is that these neighbourhoods nowadays are legal and therefore are areas that also have the right of government attention and expenditures.

The urban area of Limon has developed rapidly as migration started with the first connection of Limon with the rest of Costa Rica. As soil was hardened and waterway cross-sections were decreased. Consequently higher peaks in the runoff were occurring and the flood risk increased. Both factors, hazard and vulnerability, have worsened because of urbanization. Citizens have started to live more closely to rivers and became more vulnerable and the impacts of the urbanization have increased flood risk.

In the administrative and institutional setting there is no clear planned strategy towards reducing flood risk. The organisations take measures individual and generally do not perceive the goal of flood risk reduction. As a result the only actors with a real flood risk reduction strategy are the inhabitants of the floodplain. However the individual measures they take have significant negative side effects. Whereas they reduce the flood risk of individuals they do increase the flood risk of the community. Further more they are uneconomical since they are taken unorganised and on a small scale.

The recommendations focus on two levels, namely the national and local level. On national level the government should implement a legal framework in which watersheds are managed and coordinated on a watershed level by an appointed institute. Such a framework could furthermore clarify responsibilities across institutions and allocate resources more efficiently.

On a local level the municipality should take full responsibility for the flood risk reduction in the watershed. Yet resources should be made available to carry out these tasks. For example by the implementing a watershed tax, which should be used on flood risk reduction measures. Furthermore a close cooperation with Japdeva in the socio-economic development of region is highly recommendable, since the municipality represents the public and Japdeva holds part of the capabilities and resources.

The flood risk reduction measures of the municipality should focus on three aspects, namely the urban development of the city in order to reduce the impact of the SES on the NS, the water quality of the river in order to reduce the impact of possible floods on the inhabitants and the hydraulic efficiency of the waterways in order to reduce the flood hazard of Limoncito watershed.



PREFACE	4
SUMMARY	5
<i>Appendices</i>	8
<i>List of Figures</i>	8
<i>List of Tables</i>	8
A.2 AIM AND RESEARCH QUESTION	12
A.3 RESEARCH METHODOLOGY	13
A.4 CONCEPTUAL DEFINITIONS AND TERMS	13
A.5 THEORETICAL FRAMEWORK.....	16
A.6 DATA COLLECTION.....	21
A.7 READING GUIDE	21
B. EXPLORATIVE PART	23
B.1 NATURAL SYSTEM.....	23
B.1.1 <i>Climatologic Characteristics</i>	23
B.1.2 <i>The characteristics of the Limoncito watershed</i>	25
B.1.3 <i>Flood History</i>	33
B.1.4 <i>The Hydraulical system</i>	35
B.1.5 <i>The Ecological Importance of the watershed</i>	39
B.1.6 <i>The chemical and biological situation of the Limoncito</i>	40
B.1.7 <i>Flood Risk [review]</i>	43
B.2 SOCIO-ECONOMIC SYSTEM.....	45
B.2.1 <i>Introduction</i>	45
B.2.2 <i>Socio-economic situation in Puerto Limon and the researched areas</i>	45
B.2.2.1 <i>National and International Setting</i>	45
B.2.2.2 <i>The economic position of Puerto Limon</i>	47
B.2.2.3 <i>Socio-economic situation of the research area</i>	49
B.2.3 <i>Urban development of Puerto Limon</i>	51
B.2.4 <i>Cultural character of Limon</i>	57
B.2.5 <i>Review</i>	59
B.3 ADMINISTRATIVE AN INSTITUTIONAL SYSTEM.....	61
B.3.1 <i>Introduction</i>	61
B.3.2 <i>National Emergency Commission (CNE)</i>	62
B.3.2 <i>Ministry of Public Works (MOPT)</i>	64
B.3.3 <i>Ministry of Housing (MIVAH)</i>	65
B.3.4 <i>Ministry of Environment and Energy (MINAE)</i>	66
B.3.5 <i>Ministry of National Planning and Economic Policy (MIDEPLAN)</i>	66
B.3.6 <i>Japdeva</i>	67
B.3.7 <i>The Municipal Government Of Puerto Limon</i>	68
B.3.8 <i>Other Local Institutions</i>	73
B.3.9 <i>The Floodplain Inhabitants</i>	73
B.3.10 <i>Review</i>	76
C. PRESCRIPTIVE PART	78
C.1 EVALUATION	78
C.2 CONCLUSION.....	79
C.3 RECOMMENDATIONS	81
LITERATURE	83



Appendices

1a	List of thesis, Department of Technology and Development
1b	List of projects, ProDUS
2	Costa Rica Watersheds
4	Population density
5	Photos of Culverts
6	Ground water levels
7	Limoncito river mouth
8	Aerial map
9	The survey
10	Risk map CNE

List of Figures

Table 1: Potential effects of natural hazards (Solway, 1999).....	20
Table 2: Number of inhabitants, households and houses (Census 2000).....	26
Table 3: Areas in the Limoncito watershed with flood problems. Determined from onsite visits and interviews.....	26
Table 4: Surface of watersheds in Limón region (source: CNE and calculated with GIS by the author).....	28
Table 5: Waterways in the Limoncito watershed (see Figure 8 for location and appendix 5 for photos).....	35
Table 6: Land-use of the watershed and its sub-watersheds (based on GIS analysis of Figure 10).....	36
Table 7: Average water quality in 1996 in Limón region (source: Q.TEC, 1997).....	41
Table 8: Sanitation options and their containment efficiency on different levels (source: WHO, 2001).....	43
Table 9: Employment distribution in Puerto Limon and comparable cities Costa Rica (source: IFAM).....	47
Table 10: Employment distribution (based on table 2).....	48
Table 11: Percentage of poor people in Puerto Limon (source: IFAM ^a , MIDEPLAN ^b).....	48
Table 12: Population distribution in Puerto Limon (source: census 2000).....	50
Table 13: Demographic figures Puerto Limon and Costa Rica, 1975 - 2005 (source: INEC).....	52
Table 14: New urban areas in and around Puerto Limon.....	56
Table 15: Ethnic distribution of canton Limon Central.....	57
Table 16: History of infrastructure connecting Limon and San Jose.....	58
Table 17: Budget of CNE from 1997 to 2000 (source: Saborió 2001).....	63
Table 18: Budget of MOPT from 1997 to 2001 (source: Saborió 2001, ^a Asamblea Legislativa 2003).....	64
Table 19: Budget of MIVAH from 1997 to 2000 (source: Saborió 2001).....	65
Table 20: Specific strategies for the regional development of Limon province proposed by MIDEPLAN (2002).....	67
Table 21: Budget of Japdeva in millions of Colones (source: Saborio 2001) and socio-economic development budget.....	68
Table 22: Municipality Figures (source: IFAM 2000).....	69
Table 23: Municipality income, in Colones (Controlaría General 2003).....	71
Table 24: Municipality own collected income, in Colones (Controlaría General 2003).....	71
Table 25: People employed within municipality (Controlaría General 2003).....	71
Table 26: Estimated yearly flood frequency, censales and total.....	74
Table 27: Percentage of people with damage on their house due to floods, censal and total.....	74
Table 28: Percentage of people with damage to personal belongings due to floods, censal and total.....	75
Table 29: Measures taken on the house to mitigate flood risk.....	75
Table 30: Review of flood risk reduction measures.....	77

List of Tables

Figure 2: Analytical research model for descriptive part of report (based on model of Van Beek; 2002).....	16
Figure 4: Evaluation and recommendations.....	19
Figure 5: Damage and Probability of disasters (Montoya, 2002).....	19
Figure 6: Range of implementation strategies (based on Masser and Montoya 2000).....	20
Figure 7: Shaded relief of Costa Rica.....	23
Figure 8: Yearly average rainfall (mm) in Costa Rica (Mark Vlok, may 2003; Data source: IMN).....	25
Figure 9: General map of Puerto Limon.....	27
Figure 10: Land use map of areas around Puerto Limon.....	30
Figure 11: Elevation map of the Limoncito watershed.....	31
Figure 13: Flood frequency in the research area between 1990 - 2002 (sources: CNE, La Nacion, La República).....	33
Figure 14: Flood distribution in the research area between 1970 - 2002 (sources: CNE, la Nacion, la Republica).....	34
Figure 15: Slopes of the "Chocolate" and "Bamboo" creeks (distance and elavation in meters).....	37



Figure 16: Bridges crossing the Quebrada chocolate.....	38
Figure 17: Pipes crossing the quebrada chocolate. These pipes and this bridges let the water rise up excessive.	38
Figure 18: Sanitation systems in the urban areas of the Limoncito watershed (datasource: census 2000)	42
Figure 19: Cross-section of bridge over the Quebrada Bamboo (a in Figure 9)	44
Figure 20: Export value handled in Puerto Limon in 2002 as a percentage of the Costa Rican GNP.....	46
Figure 21: Percentage of households with income level 1 (source: census 2000)	51
Figure 22: Photo of Puerto Limon, undated (source: National Archive of Costa Rica).....	52
Figure 23: Analysis of Urban growth Puerto Limon	55
Figure 24: Number of illegal houses in the researched area (source: Census 2000).....	57
Figure 26: Share of fluvial works in MOPT budget in 2001 (source: Asamblea Legislativa 2003)	64
Figure 27: Typical MIVAH prefab housing design	66
Figure 29: Illegal buildings the end of the Limoncito river	72
Figure 30: By flood plain inhabitants estimated yearly flood frequency (3 censales, total of 45 respondents)	74
Figure 31: Contruction of a wall with valves.....	76
Figure 32: Evaluation of the flood damage in the Limoncito watershed	78
Figure 33: Flood risk situation.....	79



0. Introduction

This thesis is written as my final graduation project in the study programme of Development and Technology Studies at the Eindhoven University of Technology. The subject of this paper started as a proposal by Rosendo Pujol in October 2002. Rosendo Pujol, director of ProDUS (Programa de Investigación en Desarrollo Urbano Sostenible), a prominent Costa Rican urban planning research institute of the University of Costa Rica, proposed a research on the frequently occurring floods in the urban areas of Puerto Limon. A subject that showed to be a very interesting one and certainly appropriate since it was the first research on this area of its kind. The project mainly consisted of 6 months of field research in Costa Rica, from February 2003 till July 2003. In the subsequent period till November this paper was finalized.

0.1 ProDUS

This Costa Rican research institute is a prominent actor in the urban planning research in Costa Rica. Besides research the institute also carries out projects that involve urban plans, such as the 'Plan Regulador', directly implemented in municipal governments. In appendix 1b a list of projects executed by ProDUS is given. The institute is directed by Rosendo Pujol, professor of the University of Costa Rica with great international and national experience in Urban Planning. Besides this he teaches several subjects at the faculty of Civil Engineering of which most involve urban planning.

The institute works with an ingenious mix of students, just graduated students and experts. This mix enhances the institute's capacity to carry out projects swiftly and with high quality. This research paper was somewhat new within the institute. Although Rosendo Pujol has reasonable working experience in Puerto Limon, the institute only carried out one or two research activities in the city itself, among which a research on solid waste collection.

0.2 Eindhoven University of Technology

The TU/e is a University in the south of the Netherlands in the city of Eindhoven. One of the faculties is the Faculty of Technology Management, which offers a course programme named Technology and Innovation Policy. In the final year of this programme one has to undertake a research project. In the Department of Technology and Development Studies, for which this thesis is written, research needs to be carried out in a developing country. The thesis is a project in which studied subjects such as development economics, sociology and the different technical subjects are combined in an integrated research approach. In appendix 1a a list of other master theses executed by students of the department of Technology and Development is given.

Besides Henny Romijn from the TU/e, whom supervised the non-technical part, Pieter Huisman from Delft University of Technology supervised the thesis. He supervised the technical part as an expert in flood and water related problems, also in developing countries.



Still today floods are a common event in the Limoncito watershed, the researched area. Besides the direct effect that floods have on life in this area, which is regarded as the **societal relevance** of this research, the region of Limon and especially the neighbourhoods (*in Spanish barrios*) in the Limoncito watershed have difficulty with the [sustainable] socio-economic development. As a result the inhabitants are more vulnerable to flood risk than more well-to-do communities. Finally, and perhaps most important, the people of Limon feel forgotten in Costa Rica. Walter Robinson Davis, delegate in the national assembly for the PLN, puts this into words as follows: "Historically, our province [Limon] has been banished to oblivion." It is a feeling present in the region of Limon and a feeling even stronger present in the researched poor and densely populated neighbourhoods. The inhabitants of these neighbourhoods feel forgotten by the local government of their own canton and probably even more by their national government. Consequently many citizens have given up hope of receiving any attention by [government] organisations. Hopefully this project is a stepping stone towards more research and more attention to these neighbourhoods and this watershed, which daily are confronting developmental problems.

Besides the societal relevance there is a considerable **scientific relevance** in the research. The research has been carried out based on the model proposed by Van Beek (2000). This model is formulated for the analysis of integrated water resource management. However in this case, with the description and analysis of flood and strategies it is found to be extremely useful. The model proved to be very appropriate due to its simplicity and explanatory character. Moreover in this research data has been used from the Costa Rican census of 2000, which was processed into analysis used for the evaluation of the situation. These data analysis have a benefit for a wider range of topics since they bear on topics such as urbanization and economic development.

Finally this is the first research done on the floods in Puerto Limon and taking into account the actual situation. Many narrative information and diffused or unprocessed data is brought together to give the reader a structured and complete elaboration on the Limoncito watershed from a multidisciplinary perspective. Since the research is the first work done in this area, the research should also be seen as a stepping-stone and an opportunity for further research on the Limoncito watershed and her inhabitants.

A.2 Aim and Research Question

The **aim of this research** is as follows:

"To describe the existing sustainable flood risk situation and measures, and to formulate appropriate recommendations for the development of a more efficient and appropriate flood risk reduction strategy for the urban areas within the Limoncito watershed"

The aim can be subdivided into four sub-aims. They are part of the central aim and support it in order to achieve it. The following sub-aims can be distinguished.

Sub-aims concerning the descriptive nature of the research are the following:

- To describe the natural system of the Limoncito watershed.
- To describe the socio-economic system of the urban areas of Puerto Limon within the Limoncito watershed.
- To describe the administrative and institutional system related to the Limoncito watershed or more specific to the urban areas of Puerto Limon within the watershed.

The succeeding sub-aim is of a comprehensive nature and intends the following:



- To perceive the problems, constraints and opportunities arising from the functioning of the three preceding systems
- and to evaluate these for possible recommendations for a better flood risk management strategy.

To reach the research aim the following **research questions** have been put forward. As the aim and sub-aims, the research question consist of a general research question and various sub-questions.

What are the problems, constraints and opportunities of the present flood risk reduction strategies for the urban areas of Puerto Limon within the Limoncito watershed?

- *What is the actual state of the natural system and what is its impact on the flood risk situation in the Limoncito watershed?*
- *What is the actual state of the socio-economic system and what is its impact on the flood risk of the Limoncito watershed?*
- *What is actual state of the administrative and institutional system and what are the taken measures to reduce flood risk in the Limoncito watershed?*

A.3 Research Methodology

The research primarily has been of an **explorative** (or analytical descriptive) nature. One must remember that information on the local hydrologic and socio-economic situation is practically absent.¹ Collection of primary data and the recording of unwritten data was therefore essential to enable an integrated analysis on the flood risk situation and the present flood risk management strategies in the Limoncito watershed.

In order to come to scientifically based recommendations the research consists of two steps. The first step of the research is a **descriptive elaboration** (or explorative elaboration) carried out on the basis of the predefined theoretical framework (§ A.5) and predefined research instruments (§ A.6). The second step will consist of a **prescriptive analysis** of the gathered data emphasized on in the descriptive part. It will contain evaluation, conclusions and recommendations based on the actual situation described in the first step. In this prescriptive analysis the flood risk reduction strategy recommendations are formulated. At the end of § A.5 the method of formulating the recommendations is further emphasized.

A.4 Conceptual Definitions and Terms

Already in the foregoing part of the text some terms are used that could be interpreted in different ways. To prevent ambiguity the **definitions of terms and concepts** are put forward in this section. The definitions are generally based on the definitions used in the field of flood management research. Yet on some definitions a slight deviation can be noted, which arises from the authors background or from the character of the researched area. First of all this research is more multidisciplinary than just a technical flood assessment, it emphasizes on the social, economic and institutional environment in

¹ Even when data or information was present it is found to be very superficial or incorrectly describing the actual present situation



which flood management is executed. Furthermore, the study was carried out in a region in which a large part of the strategies is hidden in the informal activities of citizens. These measures are carried out in an informal environment, where [groups or] individuals are acting upon a flood problem individually. Bearing this in mind the following the conceptualisation of terms have been put forward.

Flood risk is the product of the probability of events and the magnitude of specific consequences (e.g. Parker, 1994). Chicken and Ponser (1998) identify the product of hazard and exposure as the fundamental proposition of risk. What is noted in the relevant literature is a wide range of terms. In this report flood risk is defined as the product of hazard and vulnerability, referred to by Gilard and Givone (1997) determine the flood risk.

Flood hazard is the probability of occurrence of a flood, it depends on only the flow regime of the river (Gilard and Givone, 1997). The flood hazard is considered as merely a hydraulic and hydrological engineering practise. Furthermore it depends on the contamination of the water, contaminated water would be a higher hazard for flood plain inhabitants than unpolluted water.

Flood vulnerability represents the sensitivity of land use to the flood phenomenon. It depends on the type of land use (Gilard and Givone, 1997). If only the economic value and the primary effect of a flood are considered this mere definition would be correct. However it also argued that vulnerability is also established by the equity concept. The relative underdeveloped position, in relation to other parts of the city, makes the citizens of the neighbourhoods in the Limoncito floodplain even more vulnerable. The vulnerability is particularly seen in the lack of resiliency of more vulnerable areas.

Flood risk management (Hao-Ming Zhou, 1995) is the overall systematic approach to analysing and implementing risk control (Parker, 1994). Risk management decisions are made by considering risk assessments within the political, social and economic realities. Such decisions are frequently controversial due to the difficulty in determining risks that are acceptable to the public (Chin and Chittaluru, 1994). Yet deviating from the literature, management is defined much broader in this report. It can also be the managing of flood risk by [groups of] individuals in the informal sector. They also assess risk by the probability of occurrence, the risk acceptance level and the economic realities.

Strategy is defined by Van Beek (1995) as a logical combination of individual measures [actions] in which these measures should provide a solution [or betterment] to the flood risk problem. It is based on the long-run goal and objectives, and the adaption of courses of actions and the allocation of resources necessary for carrying out those goals (Chandler, 1962). Strategy executors are present in the administrative and institutional system.

Policy: a (explicitly or implicitly) chosen line of conduct considering actions (Gaillard, 2001). A policy by itself does not contain specific actions, it merely sets targets and constraints for action (levels, time, budget). (Beek, 1995) This is the exact difference with strategy which is a set of actions were a policy is the line of conduct for a series of actions.

Measures: are individual managing actions, together composing the strategy. The following categorization of measures are identified by Van Beek (1995):

Technical (structural) measures: modifications of the water infrastructure: such as canals and river bed modification

Ecological (non-structural) measures: measure to improve the function of the ecosystem for example by reforestation

Economic incentives: to induce catchment users to use catchment in a socially desired manner by changing price through charges, taxes, subsidies

Regulations measures: to restrict uncontrolled use of land by the economic actors (through land zoning, permits, and other forms of restrictive legislation)



Institutional arrangements: specifying which governmental agencies are responsible for which function of the water system.

Ecology is the total of environmental capital existing in the sector. It is closely related to the term sustainability. In the theoretical framework ecology is symbolized as a sphere applying to all variables and the other spheres. Gardiner (1995) identifies such symbolization as a strong sustainability (this concept is emphasized on under sustainable in this section).

Natural system The natural system consists of the system of rivers, canals, lakes, groundwater aquifers and the flora (and fauna), including its functions for the ecosystem and hydrological and hydraulic characteristics of the catchment area.

Socio-economic system is the system in which people act. This ranges from cultural expressions to exchanging goods and services.

Administrative and Institutional System is the system of actors that formulate, implement and manage flood risk strategies. These strategies can have a direct or indirect impact on flood risk or can be implicit or explicit intended and which are executed intentionally or accidentally onto flood mitigation.

Sustainable first of all indicates to inter-generational equity identified by the Pearce Report in 1989. However in this report a stronger sustainability is referred to, in which stronger indicates that environmental capital cannot be traded off with man-made capital. In other words prevention should be societies' guidance instead of cure and loss.



A.5 Theoretical Framework

In the descriptive phase the data was collected following a predetermined theoretical framework. This framework or research model is based on the lecture notes for water management used at Delft University of Technology. This contextual model of water resource planning (Van Beek; 2002, part 2 p. 8) emphasized in the Delft course, Integrated Watermanagement, is applied in this research as a model to carry out the first descriptive step of the research. The model is represented below. The model has been slightly modified for the analyses of flood risk management, since resource water management is the original purpose of the model.

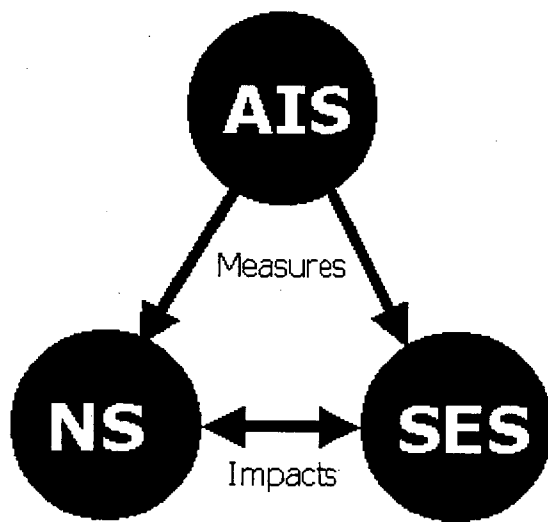


Figure 2: Analytical research model for descriptive part of report (based on model of Van Beek; 2002)

The model is composed of three systems, namely the **Natural System (NS)**, the **Socio-Economic System (SES)** and the **Administrative and Institutional System (AIS)**, and of two relations, namely **impacts** and **measures**. For this project the model was found extremely useful to investigate and describe the unknown situation. Its simplicity and flexibility have shown to be useful in a situation as that of Puerto Limon. The model enables a descriptive and multidisciplinary elaboration of the Watershed.

The conceptual definitions of the different systems are identified as follows²:

- **NS:** The natural system consists of the system of rivers, canals, lakes, groundwater aquifers and the flora (and fauna), including its functions for the ecosystem and hydrological and hydraulic characteristics of the catchment area.

This thesis particularly focuses on the hydrological characteristics and the flood risk characteristics of the system. In addition the water quality in the natural system is investigated, since it was found to be an important aspect in the impact on its inhabitants.

² The terms are somewhat different from the definitions formulated by Van Beek. Since my educational background is somewhat more influenced by the social sciences. Besides this the research area of this thesis focuses more on floods whereas Van Beek deals with Integrated Watermanagement (especially water resource management).



- **SES:** The Socio-economic system is the catchment using and catchment related human activities. Activities should be seen in the broadest sense, it is the complex of actions within social life and economic activities.

The project particularly focuses on the socio-economic situation in the area and the socio-economic impact of floods on the area. Besides this social and cultural aspects are related to the present situation.

- **AIS:** In this thesis the administrative and institutional system is the complex of individuals and institutions that formulate, implement and manage flood risk strategies. This can exist of strategies, which function directly or indirectly and which are executed intentionally or accidentally onto flood risk mitigation.

For our viewpoint the key institutions in the AIS are the (semi-) government institutions. They should be the principal and responsible³ actors in the formulation, implementation and management of a strategy, and thereby pursuing the public interest in watermanagement. However in practice this is not always the case. What is encountered in the Urban areas within the Limoncito watershed is a mixture of informal and formal activities. For this reason the citizens and entrepreneurs are included in the administrative and institutional system as active informal strategy managing actors.⁴ In the case of the Limoncito watershed the government institutes are unable to formulate, implement or manage a strategy mitigating flood risks. In such a situation individual citizens start to act and become part of the AIS.⁵ The principal difference between the individuals and the institutions is the motivation of their actions. Where the institutions should function in a democratic manner and always should be led by the public interest, the individuals only act onto their individual interest.

Besides the three systems the model exists of two relations, which in the model are indicated by the three arrows. The following two relations are distinguished:

- **Impacts:** this relation indicates the interdependence between the socio-economic system and the natural system. As indicated the two systems are interrelated. In this research the natural system acts on the economic system through its flood impact. The socio-economic system is affected by the excessive water risings of the rivers and if occurring by the polluted character of the river. The other relation is that of the socio-economic system on the natural system. In this relation the impact is originating from more intensive watershed use. For example through the increase of houses in the watershed, which will change the hydrology. Or by the increase of industry, which could increase pollution in the area.
- **Measures:** As defined before the measures actions taken to reduce the flood risk. Together they compose the flood risk reduction strategy. Both systems can be influenced by government policy.

³ Of course we believe in individual responsibility, yet we believe that even this responsibility could be stimulated by government policy.

⁴ We have taken a more definition of institution then just a organisation. However we deliberately have left out institutions such as religion and economy. They will be emphasized however from a viewpoint of citizens and entrepreneurs.

⁵ Flood mitigation strategies followed by citizens and entrepreneurs are seen as strategies by institutions in the AIS. We must reveal that this is a arbitrary decision. One could also put these actions in the SES. Reason is that we find the institutional interaction between Government and Society (in our case citizens and entrepreneurs) more interesting, by putting them in the same system the conflict between them can be described better. By putting these strategies in the SES we would emphasize on the economic reasoning of these strategies.



Vulnerability, which is embodied in the SES, can be influenced by land use policy and control (UN, 1978), whereas hazard, which is embodied in the NS, can be reduced by hydraulic measures, such as river profile extension and periodic river maintenance.

The above-described model will give an insight into the situation present in the Limoncito watershed. To gain understanding of the watershed and its systems a predetermined list of factors was drawn up. Added to this predetermined list of factors is the data needed to characterise those factors. In section § A.6 both these factors and the data needed has been presented. Although the lists were predetermined, they were adjusted in the first phase of the research. Often data was absent or poor. Especially in the case of the Limoncito river the information was of a poor level. The list therefore is drawn up taking into account the researched literature in the pre-phase, the limited time of execution, limited budget and the constraining factors of the environment such as data limitation.

In the case of emergency management several steps can be distinguished. Although all these steps will be described, the emphasis of the research will be on the mitigation of flood risk. These mitigation measures are taken in advantage of the flood and are meant as structural flood risk reduction measures. Mitigation measures are often embodied in measures such as regulations and infrastructural works. In the following model the possible influence of flood risk reduction on socio-economic development is shown.

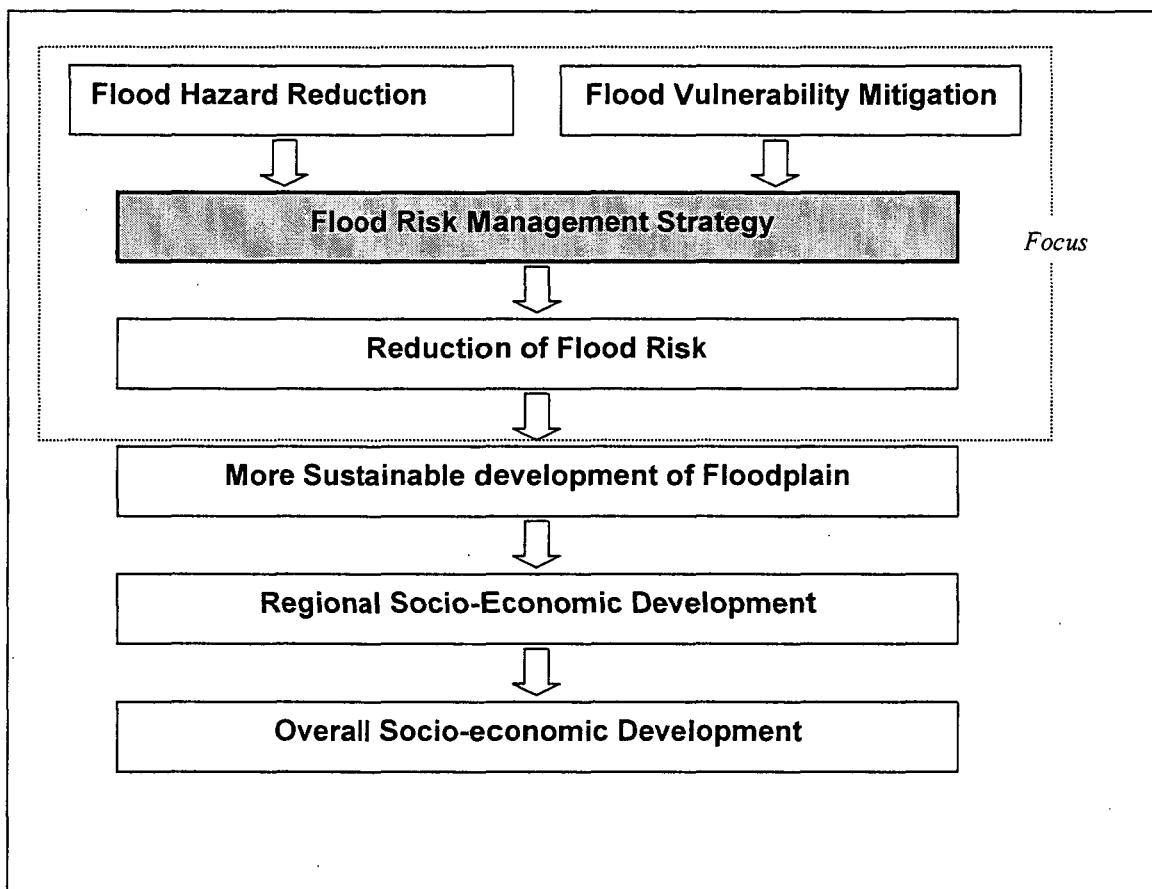


Figure 3: Influence of flood risk management on sustainable socio-economic development



The second part of the research exists of the evaluation, conclusion and recommendations. This part is analytical and prescriptive. From the three systems problems, constraints and opportunities are observed and subsequently these aspects are evaluated and interlinked, so that an integrated insight is given on the systems. In the following model the evaluation and recommendation steps of the report are visualized.

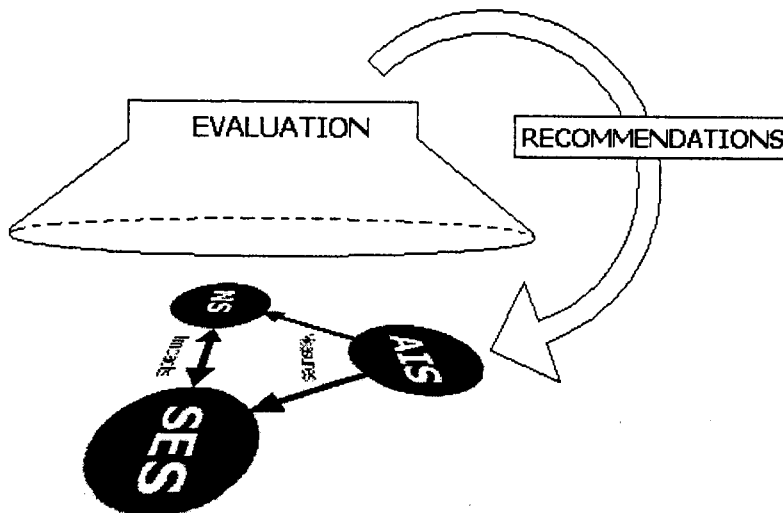


Figure 4: Evaluation and recommendations

The evaluation will be supported by evaluation methods originating from existing literature. An example is the determination of the damage character and the perception on flood probability. Especially to make the watershed comparable with other watersheds and floods in Costa Rica the following model is applied in the evaluation. An example would be an intense earthquake, in the model they would be indicated with a low probability however with a high damage level.

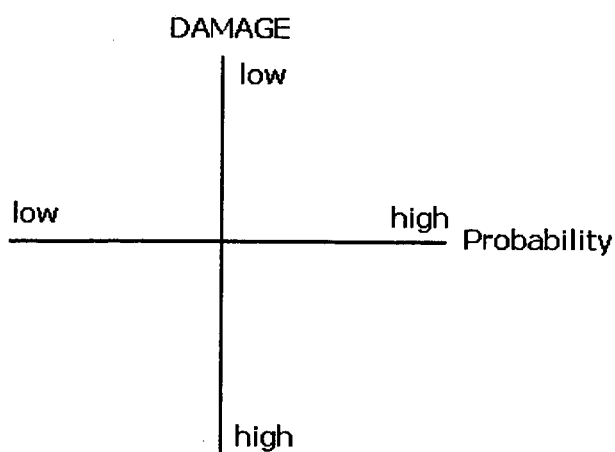


Figure 5: Damage and Probability of disasters (Montoya, 2002)



Besides the damage and probability level of the floods in the Limoncito watershed, the actual effects will be evaluated. Solway (1999) indicated and categorised sundry potential effects of natural hazards. In the following table the effects are put forward. The evaluation of the effects of the floods will give an indication of the character of the hazard and the vulnerability of the watershed.

	Social or Human Effects	Physical Effects	Economic Effects
Primary Effects	<ul style="list-style-type: none"> - Fatalities - Injuries - Loss of income or employment opportunities 	<ul style="list-style-type: none"> - Ground deformation and loss of ground quality - Collapse of and structural damage to buildings and infrastructure - Non-structural damage, loss ground quality for buildings and infrastructure 	<ul style="list-style-type: none"> - Interruption of business due to damage to buildings and infrastructure - Loss of productive workforce through fatalities, injuries and relief efforts - Capital costs of response and relief
Secondary Effects	<ul style="list-style-type: none"> - Disease or permanent disability - Psychological impact of injury, bereavement, shock - Loss of social cohesion due to disruption of community - Political unrest where government response is perceived as inadequate 	<ul style="list-style-type: none"> - Progressive deterioration of damaged buildings and infrastructure which are not repaired 	<ul style="list-style-type: none"> - Losses borne by insurance industry, weakening the insurance market and increasing premiums - Loss of markets and the trade opportunities through short-term business interruption - Loss of confidence by investors, withdrawal of investment - Capital costs of repair

Table 1: Potential effects of natural hazards (Solway, 1999)

Following the evaluation and the conclusions the recommendations will be drawn up. The recommendations will be written for the actors present in the AIS (see figure 4). The evaluated problems should be managed from the AIS through measures. The following matrix will be used to put into perspective the strategies and measures. It shows the three aspects that should be defined in the recommendations, namely how, when and who should implement measures. Therefore recommendations are originating on the following three questions: “who should implement this strategy?”, “when should the strategy be implemented?” and “how should it be implemented?”

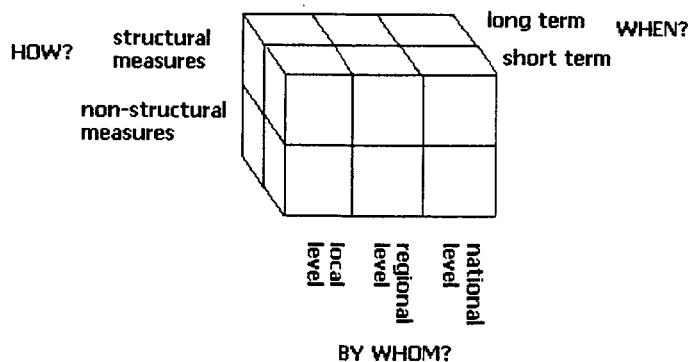


Figure 6: Range of implementation strategies (based on Masser and Montoya 2000)



A.6 Data Collection

To obtain insight in the different systems sundry factors are described. The factors put forward are depending on the local situation and the project time available. In an ideal situation additional information would have been collected for the analyses. Yet a lot of data about a number of factors were not available. Some factors or aspects that should be researched more are elaborated on in the chapter "Recommendations". For each system the research factors and aspects are put forward in the following tables.

Natural System

Aspect/Factor	Type of data	Source
Climate	Rainfall intensities, Temperature, Humidity	Meteorological institute (IMN)
Watershed dimension	Area, Slope (watershed and sub watershed)	GIS based maps
Waterways dimension	Width, Depth (river, creeks and canals)	Personal measurements
Geomorphology	Soil type, Groundwater level	Agriculture institutes (SENARA)
Flood frequency	Yearly frequency, Magnitude	Newspapers, Interviews
Pollution	Water quality, Waste management	Other researches (UN and UCR)
Ecology	Uniqueness, Quality	Ministry (MINAE)

Socio-Economic System

Aspect/Factor	Type of data	Source
Economic situation	BNP of the region, Employment, Sectors,	Institutes (e.g. MIDEPLAN, IFAM)
Econ. position of region	Export share	Institutes (e.g. JAPDEVA)
Position of urban area	Income level, Social problems, Econ. activity	Census and Interviews
Urban development	Historical development	Census and Interviews
Squatters	Number, Location	Census and Ministry (MIVAH)

Administrative and Institutional System

Aspect/Factor	Type of data	Source
Organisational character	Character, Responsibilities, Level, Size	Interviews and Legal frameworks
Resources	Technology capabilities, Financial capabilities	Interviews and Institutes
Strategy and Measures	Related to watershed	Interviews and Institutes
Perception on flood	Risk perception of inhabitants	Survey and Drawing Contest

A.7 Reading Guide

This section concludes the theoretical part of the report. The next chapters will be the descriptive part of the research followed by the prescriptive analysis (evaluation, conclusions and recommendations). The descriptive part consists of the three systems, which each will be discussed in a separate part. The three systems (NS, SES, AIS) are discussed according to an ordering in which the reader will get understanding of the Limoncito watershed.

The first part discussed will be the natural system. This system is discussed first since it elaborates on the actual problem, namely the flood risk. It is considered that the natural system is more or less a given fact at the time of research. It is seen as the dependent variable. Secondly the socio-economic system and finally the administrative and institutional system are discussed. This administrative and



institutional system is elaborated on as last in view of the fact that it seen as the independent variable. It is this system that is seen as the managing system of the two other systems. Since it is considered as the independent system the recommendations are presented for this system. It is therefore logical to elaborate on the administrative and institutional system just before handling the prescriptive part, containing the recommendations.

Finally subsequent to the descriptive part, the evaluations, conclusions and recommendations will be discussed. The evaluation and conclusion will provide an integrated analysis of the three systems. It is based for most part on the reviews given at the end of each system in the descriptive part. The following recommendations will be based on these conclusions and perceive flood risk reduction measures on the short and long term. The report will be ended with a discussion in which the author evaluates this report.



B. Explorative part

B.1 Natural System

B.1.1 Climatologic Characteristics

Costa Rica is a country with many different climates. The temperatures, seasons and precipitation levels can vary significantly across the country. From a climatological point of view the country can be divided into two sides, namely the Pacific side and the Atlantic side. They are divided by a volcanic mountain range stretching from the border of Nicaragua into Panama. Both sides have distinctive climates and therefore also have different rain regimes and different periods in which flood occur.⁶ For example the Atlantic side has a wet season when in Europe the winter and summer is passing by. While the rest of the country is characterized by a half year wet period beginning in May. In general, Central America is characterized by two seasonal periods namely a dry season and a wet season. The dry season stretches from November to April. During the dry season the trade wind⁷ constantly blows dry wind through the region. The wet season occurs from April to October, with the highest amount of rainfall in October.

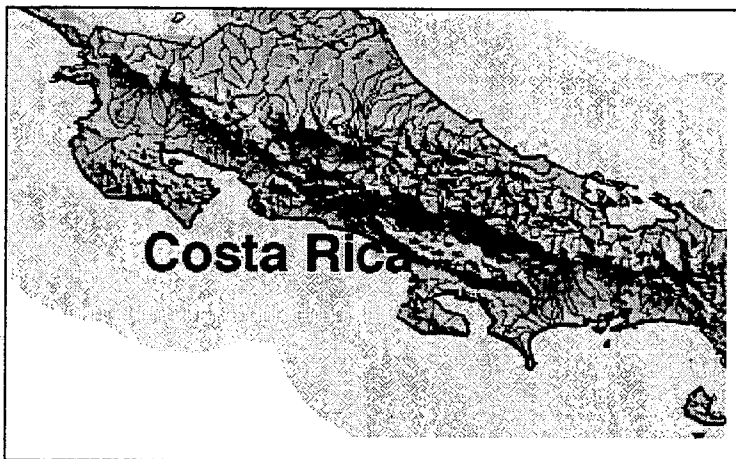


Figure 7: Shaded relief of Costa Rica

Another aspect is 'El Niño'. Costa Rica's climate is very sensitive to subtle changes in the relationships between the Pacific and Caribbean air masses, and the northern and southern air masses. Disruptions caused by El Niño have a direct impact on day to day, and season to season climate, this makes that climate forecast is easily mistaken. (Jones 1998) Although Costa Rica is influenced by this periodically returning climatological phenomenon, it is spared from another phenomenon namely hurricanes. Due to the pressure areas above the Caribbean Sea hurricanes are unknown to Costa Rica. This makes life a lot easier if it is compared to the situation to the Atlantic side of Nicaragua, a region nearby Limon.

⁶ During my visit it was remarkable that people from parts from Costa Rica then Limon did not know other than floods occurred or what seasonal periods are in this region. Although the region is only 3 hours driving from the central valley it is hardly visited and rather unknown to people living in other parts of Costa Rica.

⁷ In Dutch known as the 'Passaat'



Costa Rica has a typical tropical climate. The tropical characteristics of the climate give Costa Rica, and especially Limon being even more humid, plentiful of rainfalls. Floods of all sorts are occurring in the country. From great river floods, lasting for days in, for example, the Limon region to small flash floods in urban areas such as San Jose.⁸ The floods in our researched area are composed of both. Some floods are induced by rainfall and cause flash floods, these are actually the most common, whereas other flood can last for weeks. This year in May a flash flood occurred in the Limoncito Watershed. It only lasted for half a day. Bigger floods also occur, they happen when floods occur in the whole region, like in November last year. That flood was a national disaster causing much damage in the entire Limon region.

As briefly mentioned before, the climate in the Limon region is characterized by a somewhat different rain regime than other parts of the country. It does not have a typical dry or wet season, the Limon region is a typical humid tropical climate with rain all year round. The rain regime of Limon follows more or less the climate pattern of the northern hemisphere, with very wet periods in November and December and in July (Alfaro 1981), when the northern hemisphere is in their winter and summer. The following telling quote, once heard in Limon, illustrates the rainy climate of the region very well: "Limon has two seasons, namely one season with rain and one season with a lot of rain."

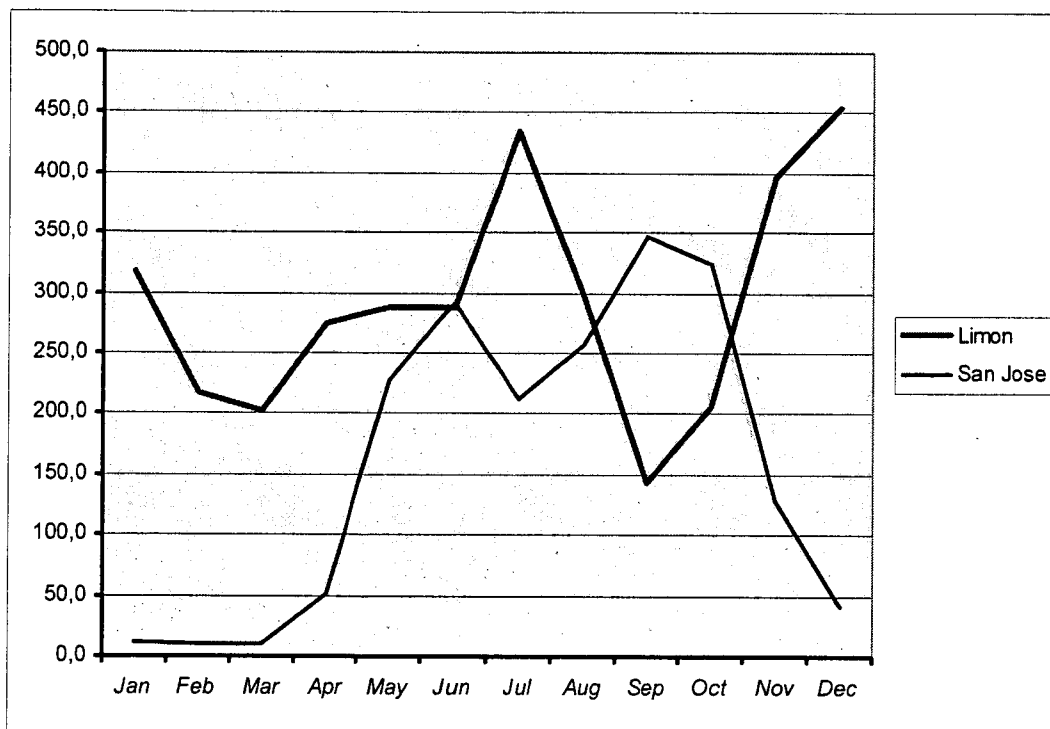


Figure 1: monthly rainfall (mm/month) in Limon and in San Jose (source: Instituto Meteorológico Nacional, data 1982 -2000)

As can be seen in graph Limon has rainfall almost throughout the entire year. Only September is a somewhat drier month. In the flood frequency graph (§ B.1.3) can be seen that the flood frequency

⁸ In front of my own house in San Pedro (Monte de Oca) for example I have seen two small urban floods within two months. (with a duration of about three hours and water levels 25 centimetres above street level) in This urban area it is an inconvenience to pedestrians, motorists (such as commuters) and shopkeepers, who attract fewer customers due to blocked roads.



more or less correlates with the amount of rainfall each month. The frequency of flooding is completely dependent on the rainfall.

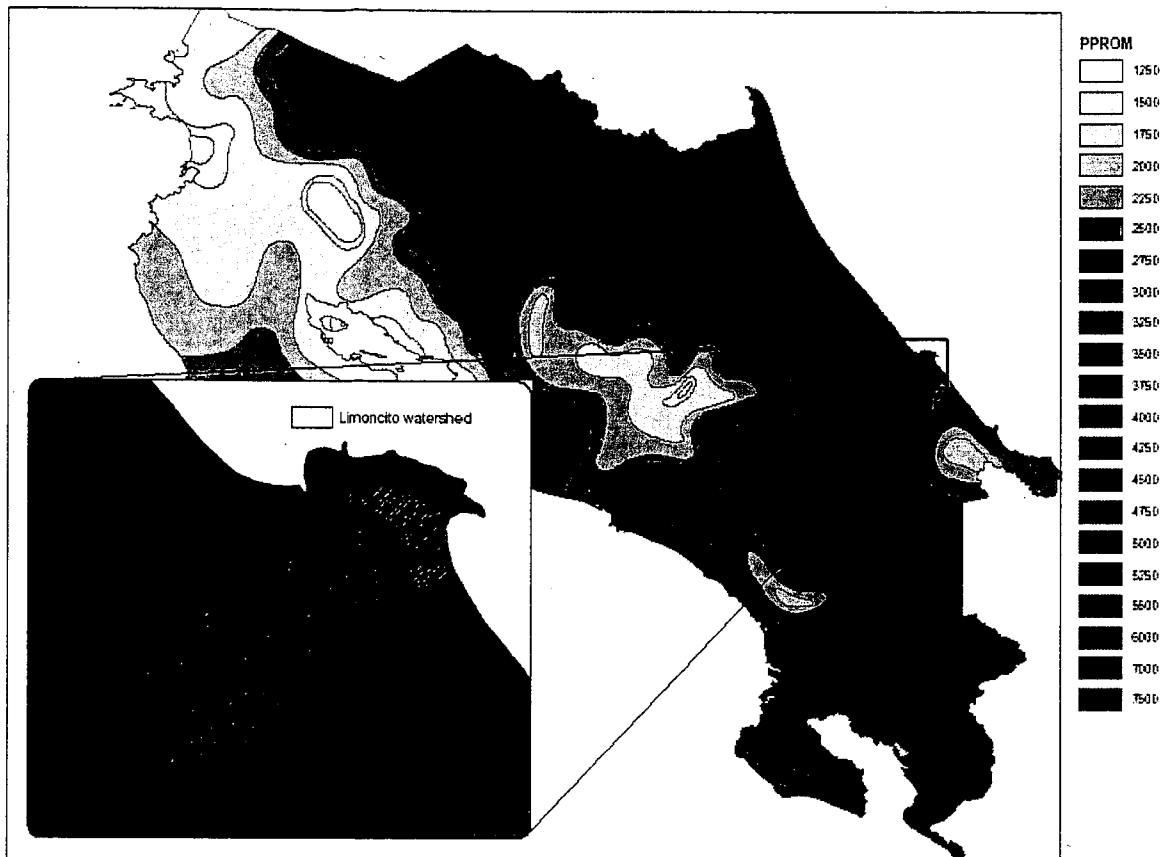


Figure 8: Yearly average rainfall (mm) in Costa Rica (Mark Vlok, may 2003; Data source: IMN)

B.1.2 The characteristics of the Limoncito watershed

The Limoncito (sub-)watershed is located in what is officially known by the government of Costa Rica as the watershed (*in Spanish: cuenca*) of Moín and other rivers (See appendix 2). The Limoncito River is one of the longest rivers situated within the Moín watershed it measures around 25 kilometres. Yet compared to rivers in other watersheds in the province of Limon it is relatively short. Although the general perception within organisations in Costa Rica on this differs, the Limoncito River should be considered as one of the more important rivers in the region.⁹ Not because of its size or length, yet because of its precarious location, namely for a great part in the highly urbanised parts of Puerto Limon. The natural system of the watershed therefore involves the lives of many people in Puerto Limon. As can be seen in the following table 64% of Puerto Limon's citizens live within the boundaries of the watershed.

⁹ This aspect is explained in last paragraph of this page forth coming from an interview with Professor Oneamura, head of the school of Civil Engineering at UCR and hydrological specialist



	People	Households	Houses
Puerto Limon (total of canton)	60.298	18.022	16.308
Within Limoncito watershed	38.020	10.970	10.063
(Percentage of total in P. Limon)	(64%)	(61%)	(62%)
Within flood problem areas	14.896	4.308	3.962
(Percentage of total in P. Limon)	(25%)	(24%)	(24%)

Table 2: Number of inhabitants, households and houses (Census 2000)



Table 3: Areas in the Limoncito watershed with flood problems. Determined from onsite visits and interviews.

The foregoing table shows that a large part of the people living in the city of Puerto Limon is actually living in the watershed of the Limoncito. The delineation of this sub-watershed (with GIS based programs) reveals that actually a large part of Puerto Limon is situated within the Limoncito watershed. This should make the river one of the prime concerns of the city regarding flood risk management since it also has an excessive flood frequency. On the latter map can be seen that the Limoncito flows through a large part of the city, which also is very densely populated in some areas (see appendix 4). The shaded areas in the map are the urban locations with frequent flood events.

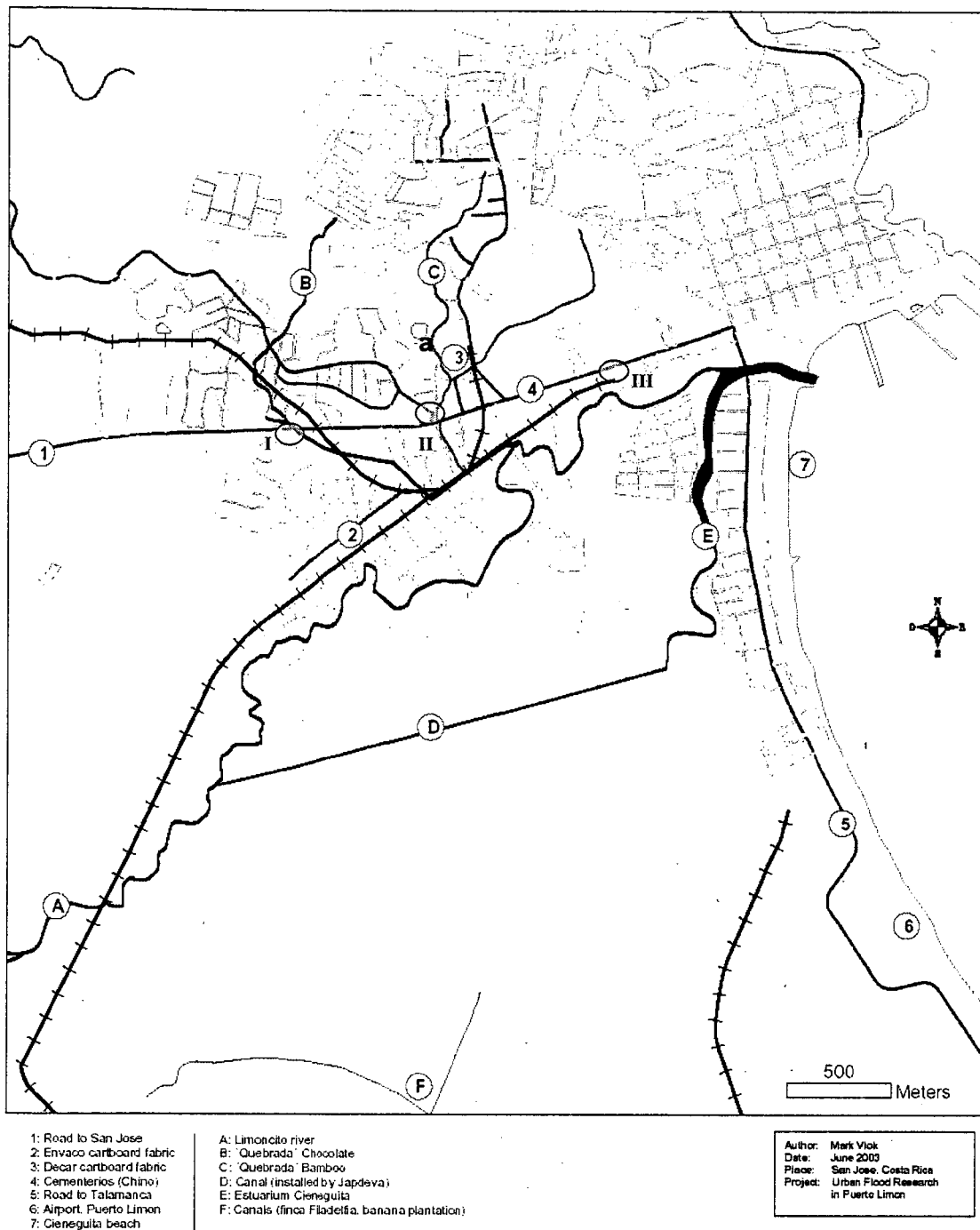


Figure 9: General map of Puerto Limon



Although there are a large number of people living in the watershed the Limoncito watershed is actually only a very small watershed compared to the other rivers on the Atlantic side of Costa Rica (see appendix 2). In the following table the catchment areas of the rivers in the Limon basin are displayed.

	Area (km ²)
Costa Rica	51.100,0
Limón province	9.218,0
Canton Limón	1.774,0
<i>Watersheds:</i>	
Río Pacuare	885,0
Río Reventazón and Parismina	2.953,0
Río Tortuguero and others	1.647,0
Río Chirripó	1.638,0
Río Estrella	1.005,0
Río Bananito	208,0
Río Banano	207,0
Río Moín and others	365,0
Río Limoncito	55,7
- Quebrada Chocolate	3,5
- Quebrada Bamboo (+Decar)	1,4

Table 4: Surface of watersheds in Limón region (source: CNE and calculated with GIS by the author)

As mentioned before most policymakers see the Limoncito as a small and therefore insignificant watershed. It is illustrating that in many interviews the respondents would express his or her doubt on the importance of conducting research on this specific river.¹⁰ Besides the apparent insignificance of the watershed due to its size there are some other reasons why research on the Limoncito is found somewhat less interesting.

Professor Oneamura¹¹, the director of the school of civil engineering of the university of Costa Rica, expressed the situation of the different watersheds in Limon as follows. It is mainly the characteristics of the other rivers that give them their importance regarding policy attention. These aspects range from international politics to economic importance of the watershed. The river Sixaolo, for example, is studied nowadays with international interest. It is because this river, which has seen floods of great magnitudes, is situated on the border of Panama and Costa Rica. Both countries tended to move the problem to the other side [country] by raising their levees (i.e. river dikes) after a flood event. Certainly this process was unsustainable in the long term and with international help a more sustainable solution is sought. Another well-investigated river nearby Limoncito is the Bananito River. It almost had all aspects making it one of the most important rivers in the region. First of all it supplies Puerto Limón with fresh water. If floods occur in this watershed they could pollute the fresh water supply. Furthermore like the other rivers (e.g. Banano and Estrella) in case of floods it is a danger to the infrastructure connecting the tourist centres of Talamanca with the central valley. The importance of keeping the road to this region open is well understood. An other aspect that not only is important in the flood risk mitigation but in many actions in Limón is the significance of the Banana plantations. The regions of Siquirres and Turrialba, for example, have seen numerous river works to decrease flood risk (Japdeva project list 2002). On the way to Limón from San Jose one can see that the plantations near the rivers are well protected with levees.

¹⁰ So far I have encounter only one report, UNEP (1999), in which the Limoncito was considered as one of the most important in the region.

¹¹ Interview, 12th of may, 2003



Now returning to the Limoncito River it can be noted that this river has none of these aspects. It is not endangering the roads to and from Limon. And neither is it threatening large-scale commercial agriculture such as banana plantations. Yet the river has one aspect which none of other the rivers have in this region, it flows through a highly urbanised area. Exposing the inhabitants to great nuisances and risk of diseases each time it overflows. In the following paragraph the water quality of the river will be discussed. Besides this the flood risk is reasonably different from the other watersheds, since most of the watersheds mentioned in this table begin in the central mountains and are rivers with a large base flow and great force. The watershed in which our sub watershed is located however is a mixture of small rivers beginning at the lower part of the mountains, resulting in low base flows and floods with a low force not destroying houses, but occurring very frequent.

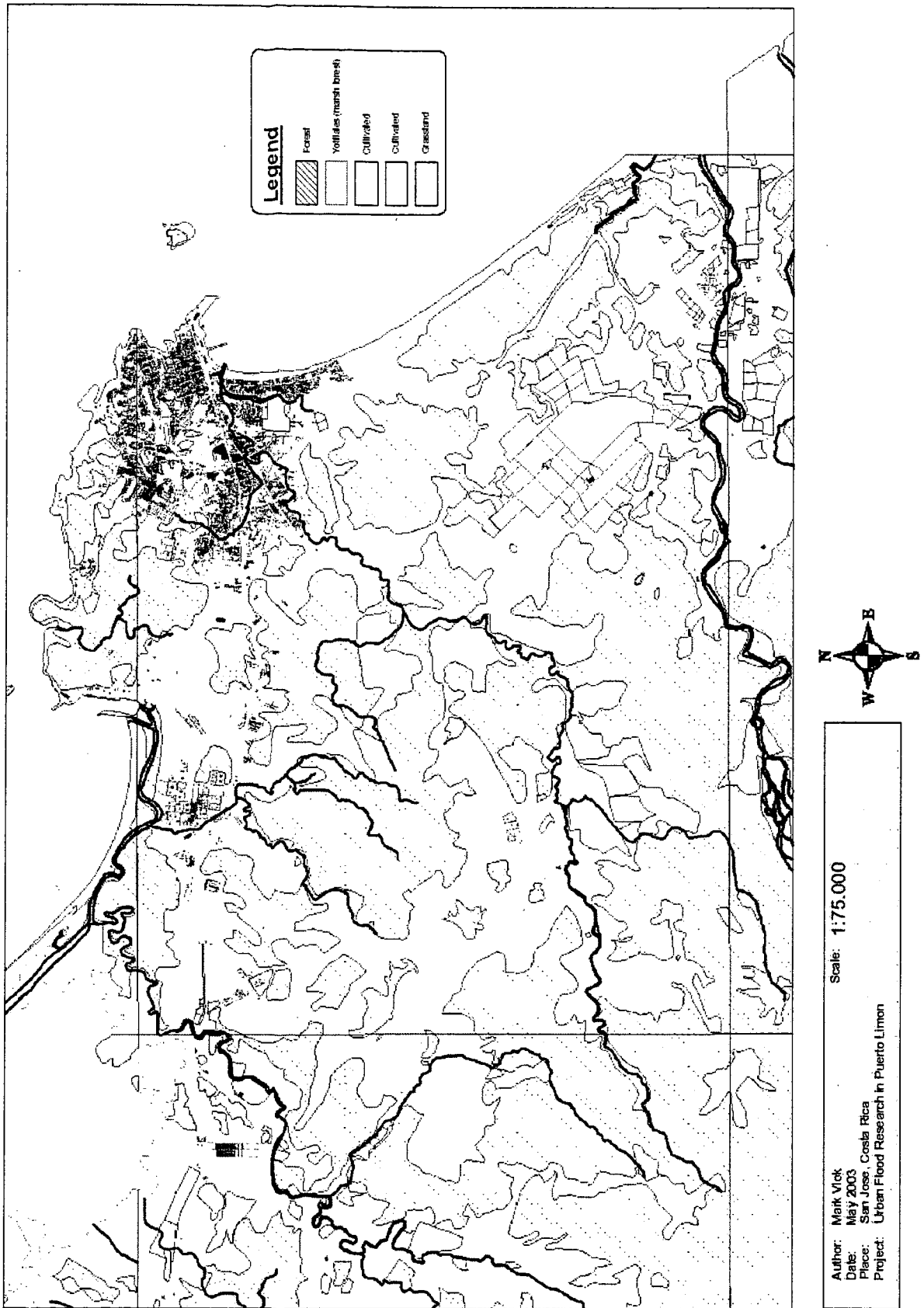


Figure 10: Land use map of areas around Puerto Limon

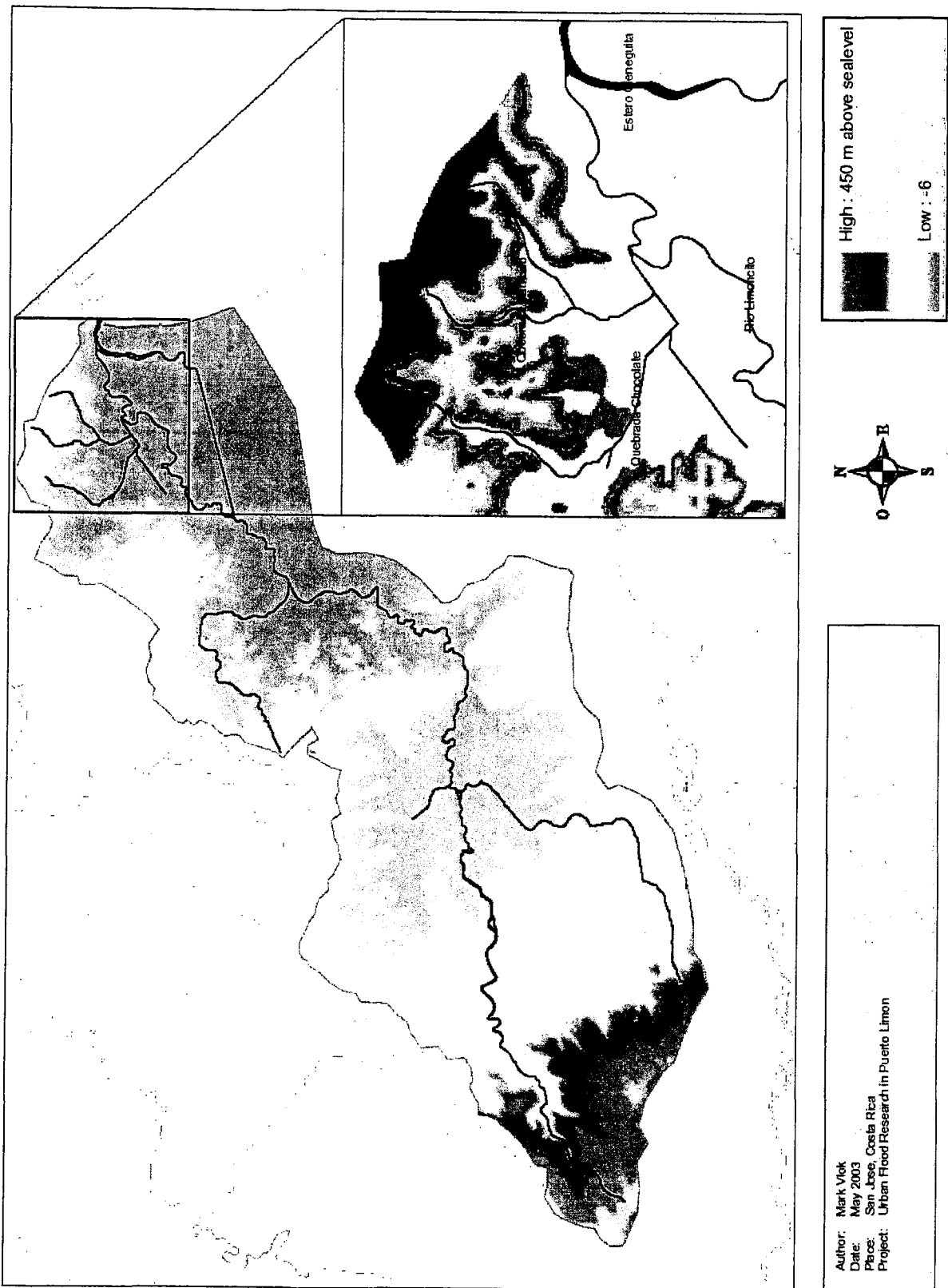


Figure 11: Elevation map of the Limoncito watershed



The latter map shows the elevation of the Limoncito watershed. The GIS based map shows that the Limoncito River for a large part flows in the flat lowlands alongside the coral mountain of Puerto Limon on the north side of the river. It starts on the foot of the mountain range in a tropical forest after which it soon enters a marshy area at the feet of the hills. The river finally ends in the harbour of Puerto Limon. Most urban water discharge enters from the left bank of the river, situated on the coral mountain, into the swampy areas on the right bank of the Limoncito River.

As can be seen in figure 8 and figure 9 a great part of the marshes around the airport are not included in our watershed. After visits it was concluded that it is not part of the Limoncito watershed. This decision was made on basis of analysis of maps and interviews of local inhabitants. The large banana plantation (Finca Filadefia) present in this swampy area is excluded in our area since it drains into the Westfalia estuary (see appendix 8), south of the watershed. Therefore it is part of the watershed of the Banano river. On aerial photos it is possible to see that the present drainage of the banana plantation is constructed in earlier days by the plantation owners. The natural drainage of this small area, before cultivation, would have been through creeks partly to Cieneguita and Limoncito river, and therefore it was part of the Limoncito watershed at that time. Result of this is that the airport of Limon is not influenced by the watershed of the Limoncito, but by the Westfalia sub-watershed.



Figure 12: Limoncito photos

a. Left: Upper part of Limoncito river, on the road to la Bomba.

b. Right: Upper part of Quebrada Chocolate, with new wall against floods.

c. Below Left: Lower part of Limoncito in Barrio Limoncito, also with some structure against floods. In both latter picture water can rise above wall level



As mentioned before especially in the low parts, where the river flows along side the coral mountain, the left bank contributes a major part of the river discharge. It is creeks (quebradas) like Quebrada Chocolate and Quebrada Bamboo contribute large quantities of water to the river in case of rainfalls. It is in districts like la Colina and Envaco (Figure 18) where the water always enters the houses first¹², because of these two creeks, which are situated in a purely urbanised area.

B.1.3 Flood History

The inhabitants of the neighbourhoods in the Limoncito watershed have great knowledge of the floods in their neighbourhood. Since they have experienced many floods the people know the character of the floods. According to narratives from the inhabitants the river Limoncito and its branches exceed their base flow about three times a year. It can be concluded that the narrative information from local citizens corresponds with information from the CNE and the national newspapers that an average of three floods per year is plausible. The information put forward in Figure 5 is certainly far from complete.¹³ Nevertheless it can be certain that the last two and half year (i.e. 2001, 2002 and 2003 until July) of the range are certainly accurate. The second deviation of the data could be that the flood is not noticed by any of the organisations, such as CNE or the newspapers. Another disadvantage of the table is that it does not inform about the magnitude of the flood. Data on this topic is not available or is very difficult to discover since it is hidden in the newspaper articles.

What is certain is the information of the floods of this year (2003) and last year November (2002). It immediately shows the variation of floods. Where the flood of November 2002 was occurring in the entire Atlantic area for several days and with great water levels, the flood of last May was very local and only lasted for a few hours.

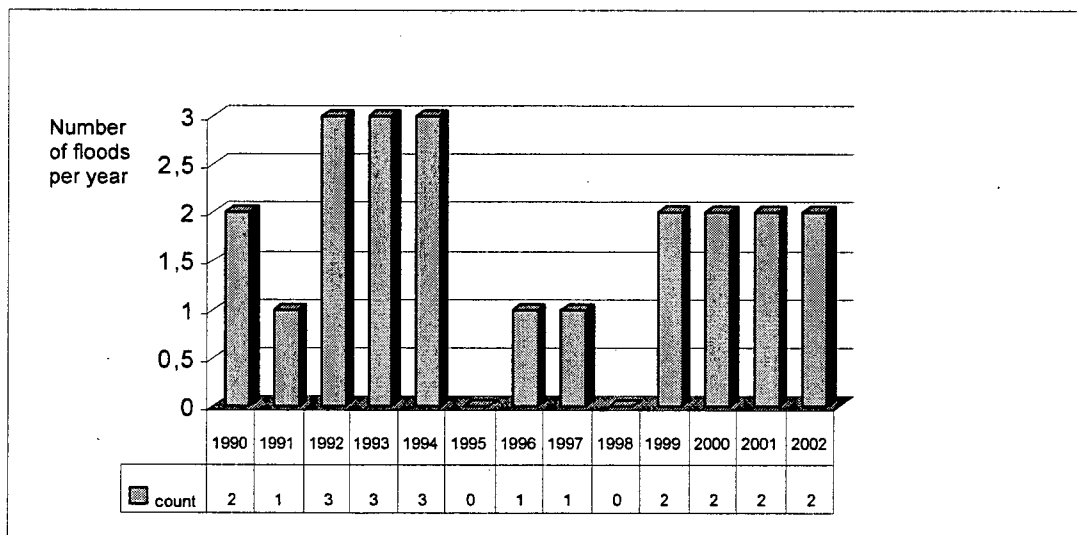


Figure 13: Flood frequency in the research area between 1990 - 2002 (sources: CNE, La Nacion, La República)

¹² Found in several informal and formal interviews with inhabitants and Israel Oconitrillo (Limon correspondent of 'la Nacion')

¹³ It is incomplete in two ways. First of all it is incomplete since we certainly did not have reviewed all newspaper articles. Due to time limits it is impossible to check all newspaper editions.



Besides the yearly flood occurrence, put in the latter graph, the monthly distribution of floods in the research area is also described. Although the total number of floods put into the graph is low, it is still following the precipitation data accurately. As can be seen floods have occurred in almost all months. However in the rainy months such as June, July and December flood frequency is greater.

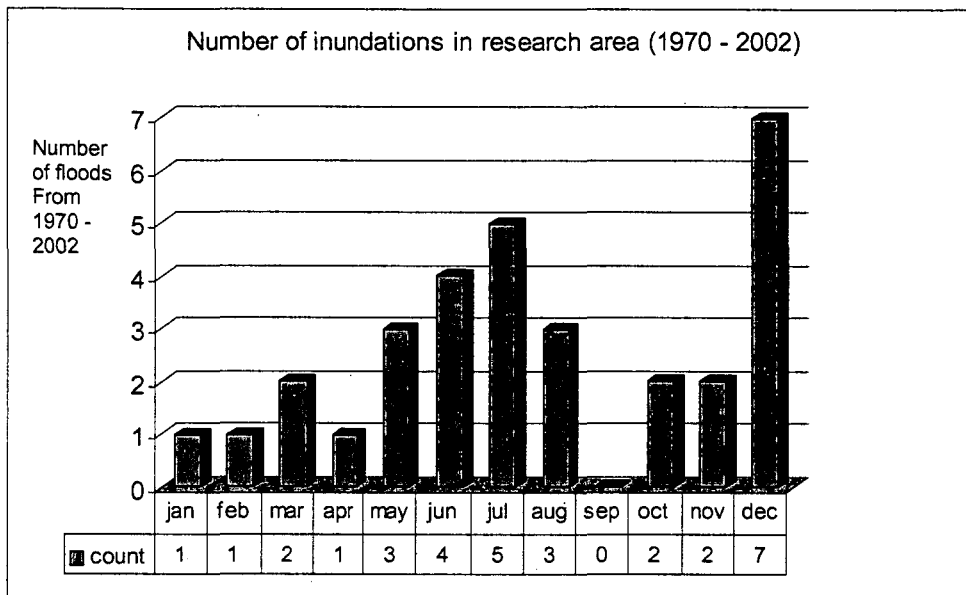


Figure 14: Flood distribution in the research area between 1970 - 2002 (sources: CNE, la Nacion, la Republica)

In the photos below daily life in Limon during the floods is shown in Limon. The floods have an impact on the socio-economic system and on the natural system itself. A good example of the deteriorating impact it has within its own system is noticed in the fertility of the soil. It has been recorded that people are unable to grow fruits in their garden due to the highly polluted soils in the neighbourhoods. The frequently returning floods leave polluted sediment which contaminates the floodplain soils.

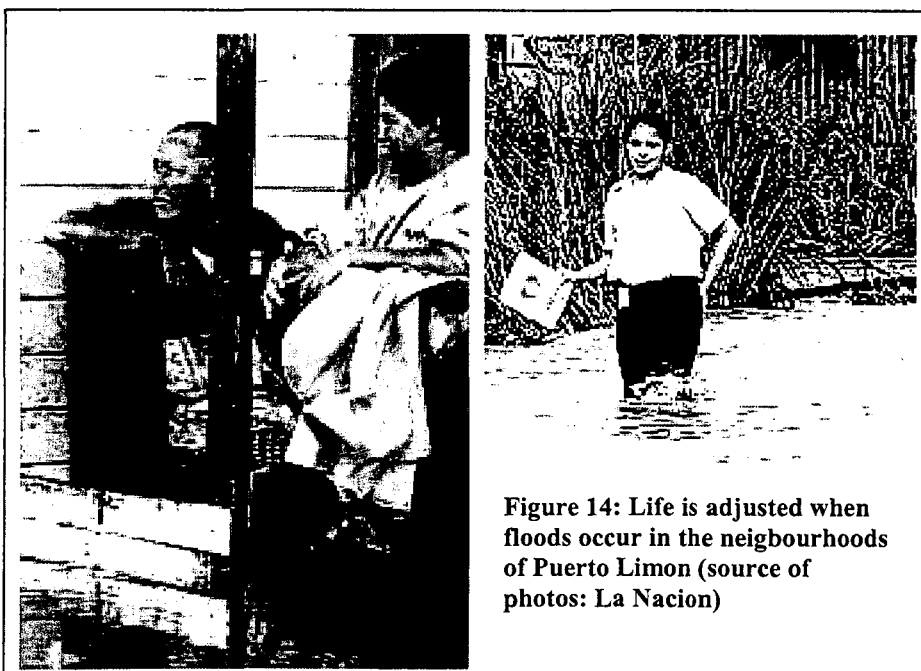


Figure 14: Life is adjusted when floods occur in the neighbourhoods of Puerto Limon (source of photos: La Nacion)



B.1.4 The Hydraulical system

In this paragraph the hydraulic situation of the watershed will be discussed. The Limoncito watershed exists of a river (*sp: rios*), an estuary (*sp: estero*), and several tributary creeks (*sp: quebradas*) and canals. In the following table these waterways will be put forward and will be described. Furthermore the different culverts are discussed. These culverts are situated under the highway to San Jose and transport the water from the coral mountain into the Limoncito River (figure 9) crossing the elevated road.

River:	Limoncito	Approximately 25 km long main river of the sub watershed
Estuary:	Cieneguita	A water storage area for the L'cito located between the beach and the marshes
Creeks:	Chocolate Bamboo	Beginning in the densely populated districts 'Los Corales' On the coral mountain in a small gorge the creek is surrounded by illegal settlements
Canal:	L'cito – C'guita Envaco	Built by Japdeva between '92 and '96 to discharge L'cito in to C'guita Old canal along side railroad and Envaco discharging B'boo and C'late into L'cito
Culverts:	I. 2 square pipes II. 3 round pipes III. 2 round pipe	Functioning inefficient due to high amounts of debris. Some plant grow. High amounts of debris and tremendous plant grow. Obviously not cleaned ofr quite some time Almost invisible. Not functioning, completely blocked by debris and plants.

Table 5: Waterways in the Limoncito watershed (see Figure 8 for location and appendix 5 for photos)

As can be seen in Figure 11 the river starts at a level of approximately 450 meters above sea level, implicating that the river drops 450 meters in 25 kilometres at an average slope of 1/55,5. Obviously the average slope does not tell much about the present situation. In the actual situation the river slope can be divided into three stages. The steep slope of the river characterizes the first stage. In this stage the river is still present in mountains. The situation in this stage is very unstable, as mentioned in studies on the 1991 earthquake in Limon (UCR 1994). The slopes on the side of the river can easily collapse due to saturation of the hillsides or due to excessive vibrations. These instabilities in this stage can influence the river in two ways. First, it can block the river or even change the course of the river.¹⁴ And second it can cause significant sedimentation in the watershed due to collapsed hillsides. The great sedimentation in the river is typical for the rivers in the floodplains of the lion region Limon.

The second stage is the intermediate stage. The river is still having a reasonable slope causing enough water velocity, yet the river starts to meander in this stage. In this stage there are some boulders present and the riverbed is large enough to discharge water in dry and wet periods. The Limoncito flows through grasslands and forest in this stage. This stage of the river is sparsely populated, therefore the course changes occurring now and then hardly affect the inhabitants nearby.

The last stage of the Limoncito River is the lowland stage in which the swampy areas are located. These swamps prevent the floodplains to infiltrate water and the capacity to store water is absent all year round (see appendix 6). In this stage the river hardly has a slope left and therefore rapidly loses its velocity. As a consequence the river is causing sedimentation. The sedimentation is especially

¹⁴ An example of this situation was the Pacuare River that changed its course significantly in 1996 after the earthquake. Instead of having a separate course it is now discharging into the Revantazon River.



seen at the river mouth. Like in many other rivers in the region¹⁵, which have a sand bump in the river mouth. The cause of these sand accumulations is the loss of velocity of the river. The tides differences in this part of the Caribbean are very small and the river therefore only flushes in case of heavy rainfall. As a result of this the Limoncito and other small rivers in the region are without current near the river mouth. To prevent further sedimentation Japdeva¹⁶ has built two small breakwaters at the river mouth (see appendix 3). The stone dams are built to keep velocity of the water in the river mouth at a reasonable speed thereby preventing sedimentation.¹⁷ However in between the dams some large objects are present which partly block the river mouth.¹⁸ This probably makes the construction function less effective.

In the lowland stage the river is complemented by another infrastructure work constructed by Japdeva. This is the canal between Limoncito and Cieneguita. The function of this canal is to overflow excessive discharge directly from the Limoncito River into the Estuary. Advantage therefore is that water is transported away from the densely populated areas, such as the Limoncito, Envaco and La Colina districts (see appendix 4). The canal is constructed in such a way that it only discharges in a situation of high water. Due to large amounts of debris in the canal the canal is not functioning in an optimal way.¹⁹ The canal has been cleaned several times by Japdeva. However despite these maintenance measures the canal is still polluted by waste.

	Forest [hectare]	Cultivated [hectare]	Grassland [hectare]	Urban [hectare]	Total [hectare]
Limoncito (total)	2.830,7	151,1	587,8	319,7	5.570,2
(perc.)	(50,8)	(2,7)	(10,6)	(5,7)	(100,0)
Chocolate	71,6	0,0	280,3	111,2	351,9
(perc.)	(20,3)	(0,0)	(79,7)	(31,6)	(100,0)
Bamboo	6,1	0,0	130,0	76,5	136,1
(perc.)	(4,5)	(0,0)	(95,5)	(56,2)	(100,0)

Table 6: Land-use of the watershed and its sub-watersheds (based on GIS analysis of Figure 10)

The lowland stage of the Limoncito River has some significant river arms in its system, namely the Chocolate and Bamboo creeks (in Spanish: quebradas). They cause major flood problems in the watershed. They start on the small coral hill in Puerto Limon and flow completely, from start to end, through urbanized areas. Before discharging in the Limoncito River, these creeks flow through a part of the lowland. It is exactly this area near the highway to San Jose in which flood problems occur and in which flood risk is the highest. In the following graph the slope of the creeks are demonstrated. As can be seen on the graphs the road to San Jose is slightly elevated. This causes a problem for the water that accumulates at the four culverts to pass the road.

¹⁵ The river mouths to the south of Limon are a good illustration of how sedimentation causes an efficient discharge of the river into the sea. Many smaller rivers do not discharge into the sea constantly. They are blocked by a sandbank (extension of the beach). Discharge only occurs when the river water level is augmented due to rainfall.

¹⁶ Japdeva, Puerto Limon harbour authority

¹⁷ Based on several meetings with Felix Chaves, engineer at Japdeva in Puerto Limon, Harbour division.

¹⁸ Based on observation we could say that the deepness of the river mouth is inadequate. The barge present in the river mouth indicates a shallow river mouth. Unfortunately cross-sections of the river mouth were untraceable during my stay at Costa Rica.

¹⁹ Based on information of local people we found out that the canal was not functioning at all since debris was blocking the canal. They mentioned, among other things, of oil drums and tree branches.

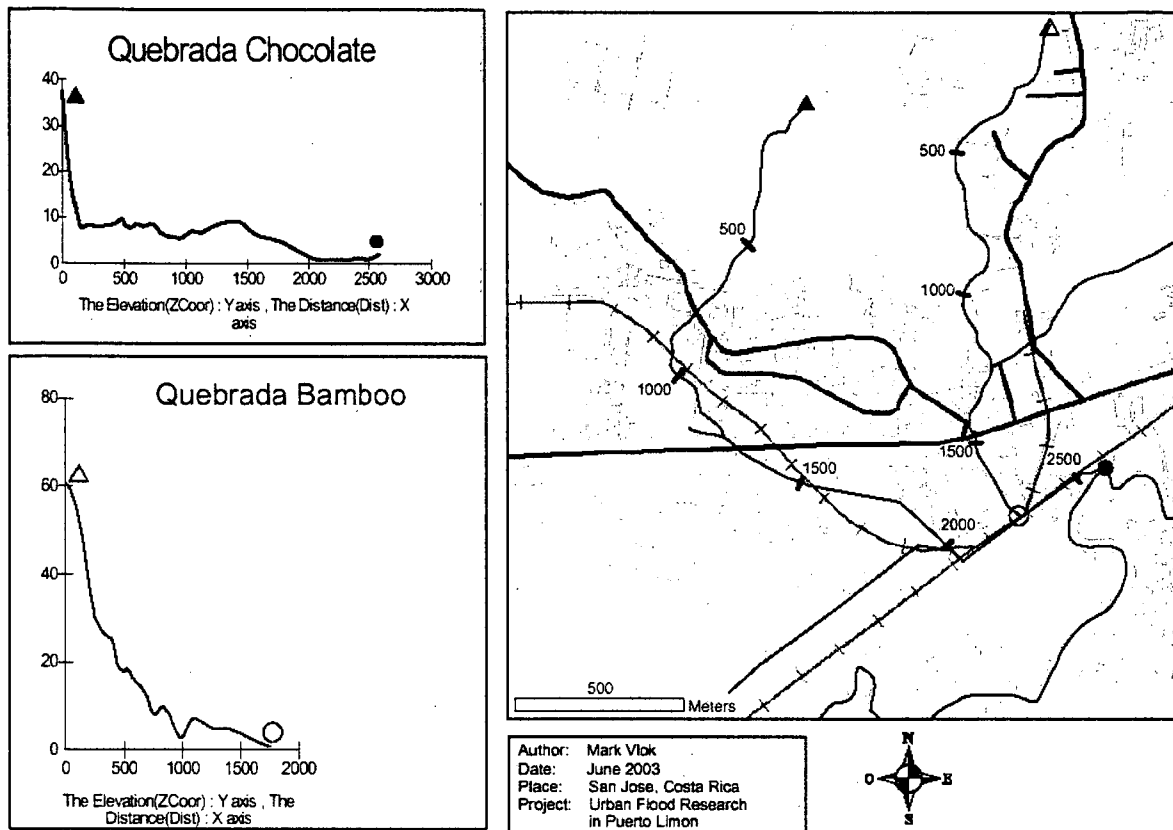


Figure 15: Slopes of the "Chocolate" and "Bamboo" creeks (distance and elevation in meters)

In the years that this region was uninhabited, the hydrological situation was completely different. If the historical development is analysed the hydraulic situation uncovers itself. The first construction made in the region was the railroad line in the 19th century (completed in 1890). It was built by professionals, whom already had great experience with building railroads in the United States. Even now the infrastructure letting the water pass is working efficient, without intensive maintenance.

However the natural system dramatically changed with the building of many houses in 1980's and the construction of the road to Limon earlier also changed the situation significantly. Due to land shortage and the free availability of land near rivers the houses were built close to the creeks on available, illegal and costless land [*illegal land settlement*]. As a result the hydrological situation and the course of the creeks and river changed significantly. Furthermore precipitation was discharged more rapidly and with greater peak values each time the area urbanized more. The common building method in Costa Rica prevents infiltration of water. In Urban areas gardens or soil around the houses are uncommon. Most houses are built to the extend of their lot, covering the complete area. If then pieces of land are unbuilt they are covered with concrete. One can imagine the impact this has on precipitation discharges and consequently intensifying peak discharges.

The road (from San Jose to Puerto Limon) construction also contributed to the worsening of the flood risk since the engineers did not take into account the local situation. At that time the only importance was an elevated and secure connection between Limon and San Jose. When the road was built the area was inhabited less densely and therefore the influence on the flood risk was less important to the road engineers. To discharge the water a number of culverts were installed in the road. However the actual number of culverts in the road is less than the number of culverts in the railroad running



parallel. Furthermore these culverts are badly maintained, which is made more difficult since culverts are hard to access (appendix 4). Of the three culverts only are two function moreover none of these three is working properly. All are blocked by debris, sedimentation and vegetation. The willingness to clean the culverts is low. It is heard that workers refuse to enter the culverts since they are a danger to their health. As a result of the inefficient culverts and the higher position of the road, it works as a levee, increasing the flood risk in the area between the coral mountain and the road.

Another problem are the bridges that obstruct the waterways. Often pipes or bridges are built little above the surface of the water. As a result floating debris such as plastic and coco material is stored between the bridge and the surface of the water. This problem should not be underestimated since little dam up of the water can cause dramatic water rising up stream. As is seen in the Quebrada bamboo where an idle pipe is blocking the water and causing problems for the houses around the creek. It is astonishing to experience that water can rise up to 1,5 meter just because of inefficient runn-off. In the following photos these situations are demonstrated.

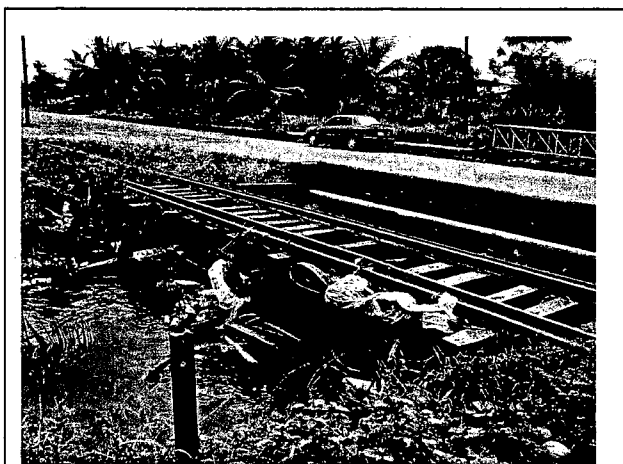


Figure 16: Bridges crossing the Quebrada chocolate. It dams the water due to its design and the debris



Figure 17: Pipes crossing the quebrada chocolate. These pipes and this bridges let the water rise up excessive.



B.1.5 The Ecological Importance of the watershed

The Limoncito watershed is a large area with a big variety of flora and fauna. A large part of the watershed exists of Yolillo, which is only found in sweat water marshes. The Yolillo (*Raphia taedigera*) is a fast growing and water resistant palm tree and is simply recognised from other palm trees. The Yolillo looks like it grows from the trunk and exists only of leaves. In analysing the watershed it is important to recognise the Yolillo, since it identifies the swampy areas. From satellite images and aerial pictures the areas can easily be identified. Also from land when passing the area the Yolillo forest is easily identified. When coming across a Yolillo forest one certainly knows that these lands are unsuitable for habitation due to its weat conditions. In the researched area the Yolillo tree is found south of Cieneguita alongside the road heading to Talamanca. The Yolillo forest continues until Westfalia.²⁰

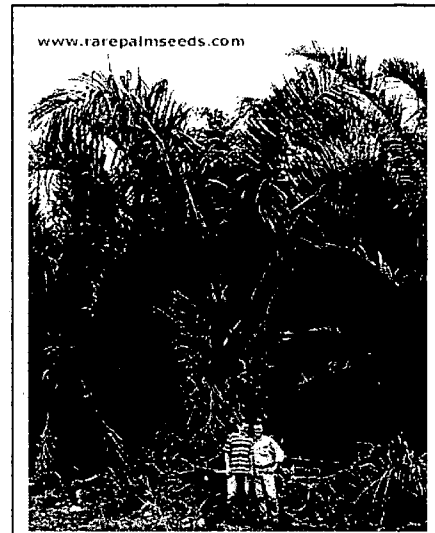


Figure 17: The Yollilo palm tree found in the swamp

Part of the Limoncito watershed is recognised as 'Humedales', about 1000 hectares of the area is considered as protected area. The 'Humedales' are natural areas, which are important in the control of floods and the protection from storms. Furthermore they generate products like fresh water, energy, wild life, fish and turism.²¹ The Limoncito 'humedale' covers an area of 1.096 hectares of which most exist of inundated forest (yolillo). Besides these marshy forests the area holds sweet water marshes. The fauna in the area exists of small mammals like the 'tepezcuitle', pizotes, iguanas and howler monkeys (see appendix). The animals use the Limoncito area as a safe refugee from the urban areas of Puerto Limon. In order to sustain its original situation the complete area is protected by the ministry of nature and energy (MINAE) as national wild life refuge.

²⁰ This area of Yolillo forest is not considered Yolillo on the map. Reason for this is that the land-use maps are made on basis of aerial photos and are analysed digitally.

²¹ Córdoba Muñoz R. et al. (1998), *Inventario de los Humedales de Costa Rica*, Ministerio del Ambiente y Energia.



B.1.6 The chemical and biological situation of the Limoncito

In a study of the UNEP (1999) an analysis of the marine environment in the Caribbean region was made. One of the investigated parts was the contamination of the rivers in the Limón region. This study contained an investigation (Q. TEC. 1997) stressing “that the main pollution problems in this area [Puerto Limón] are solid waste, domestic waste, industrial effluents, oil pollution, agrochemicals and sedimentation” (UNEP 1999). In the Limón area it was estimated that the solid waste generated by households is 22.4 ton/day of which 11.8 ton are managed, while the industry generates 605 kg/day of which only 302 kg/day are managed.(Q. TEC. 1997) One can imagine that part of these solid waste ends up in the river system and will cause tremendous problems.

In the streets of the neighbourhoods solid waste is a numerously encountered sight. Besides this, trash often ends up in the rivers and streams. Perhaps the rivers are the greatest, accidental, garbage collectors present. Whether this can be put down to the inhabitants carelessly managing their waste or whether it is the garbage collection failing remains vague. A study performed within ProDUS argued among other things that the routes of the waste collection should be updated constantly to the development of the boroughs. (Roper 2000) Since waste is collected unevenly between regions. Besides this, waste collection is a service which is paid individually, if someone is not paying for this specific service then waste is not collected. This very liberal approach is seemingly not working, since some service payers have to bear the burden of non payers.



Figure 17: Neglected solid waste near the crossing of bamboo and road to San Jose (24/05/2003)

Another great polluter in the area are the domestic sewages and septic tanks in the region. They contribute to the great amount of Faecal Coliforms in the river. It is worrying to note the frequency of floods (2 times a year) and the extent of contamination of the river. The contamination is taken by the river and dumped on the beach besides the river mouth. This beach, Cieneguita beach, is one of the most polluted beaches in Costa Rica. [swimming is certainly not advisable, as La Nacion designated Cieneguita beach as very bad swimming water just before Easter holiday]

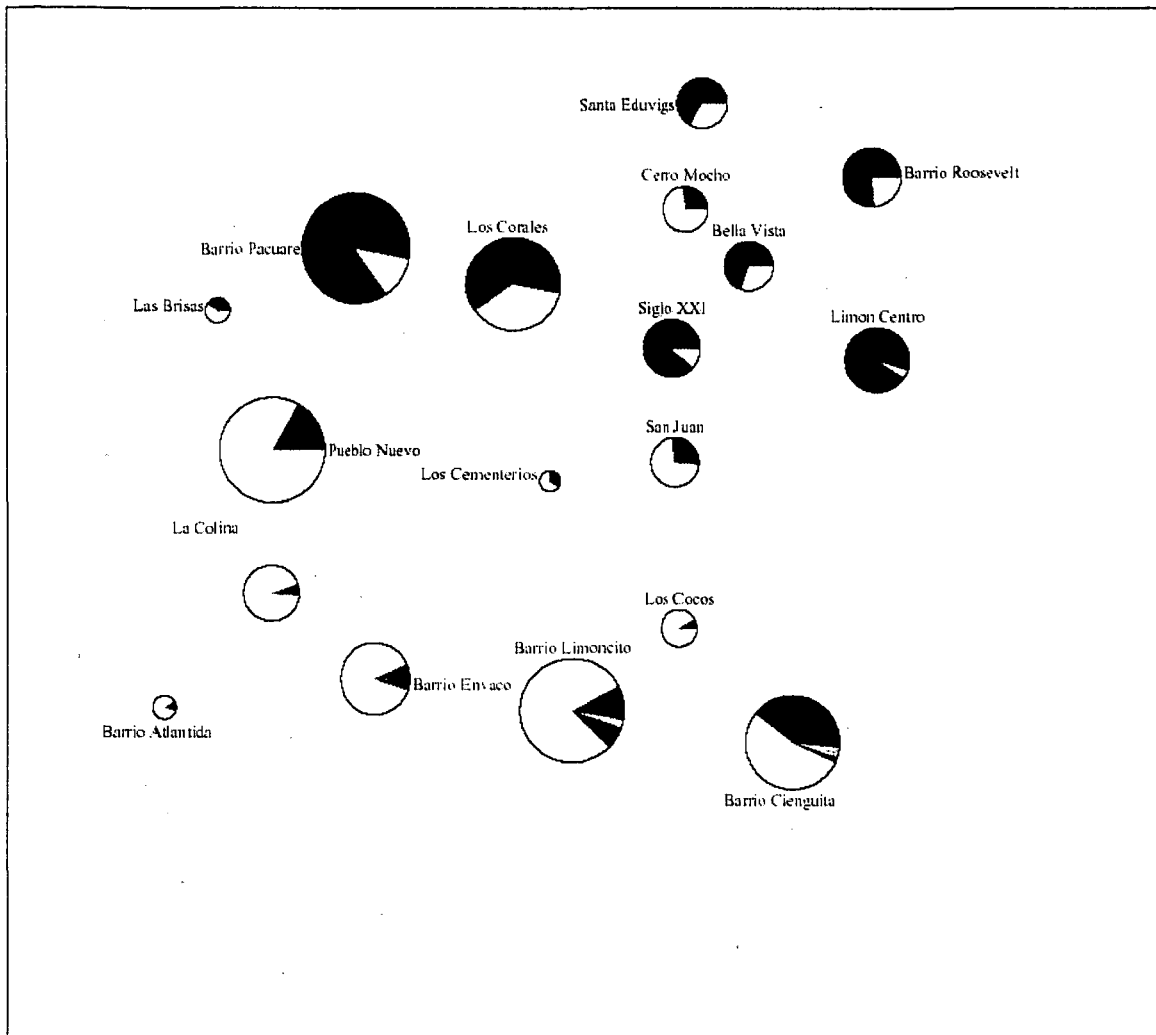


River	SS (mg/l)	BOD (mg/l)	P (mg/l)	N (mg/l)	Faecal Coliforms (bact/100ml)
Banano	177	6,4	0,08	4,70	930
Bananito	33	2,4	0,07	12,00	2.400
Limoncito	2	34,0	0,09	36,00	10.000.000
Moín	14	21,0	0,05	21,00	3.900

Table 7: Average water quality in 1996 in Limón region (source: Q.TEC, 1997)

As can be noticed from the table the contamination of the Limoncito River in 1997 was startling. If the Limoncito River would be compared with other rivers in Costa Rica it would turn out to be amongst the most contaminated (ProDUS 1997). In Costa Rica at the moment regulations regarding river water quality do not exist. There are regulations, however, for the reuse of the water in Costa Rica. If one would take these into account then the water of the Limoncito would not be suitable for the sundry types of use (e.g. recreation, agricultural, urban use). For example the reuse of water for recreation would allow only 10000 bacteria's (Faecal Coliforms) per litre (la Gaceta 1997), one thousand times less than the values found in the Limoncito river. This confirms the heavy pollution of the river by Costa Rican standards.

The amount of Faecal Coliforms found in the Limoncito is tremendous, they are seen as the main indicator for water quality. Faecal Coliforms occur in excrements of animals and humans. Therefore it is interesting to analyse the state and diversity of the sanitary infrastructure. In the next map the sanitary facilities present in the urban parts of Puerto Limon (the map is based on the 2000 census) are analysed.



District	Connected to sewerage	Septic Tank	Pozo Negro	Other System	No System	Total
Barrio Atlantida	12	112	4	1	2	131
Barrio Pacuare	1669	241	61	1	9	1981
Los Corales	857	533	45	2	14	1451
Cerro Mocho	113	293	1	4	0	411
Santa Eduvigs	330	161	1	0	0	492
Las Brisas	59	82	0	0	1	142
La Colina	31	560	3	2	8	604
Pueblo Nuevo	305	1480	17	11	8	1821
Los Cementerios	28	70	10	0	0	108
Siglo XXI	552	72	1	2	0	627
San Juan	123	343	2	3	6	477
Barrio Roosevelt	496	154	0	0	0	650
Bella Vista	335	143	1	0	0	479
Limon Centro	697	30	17	2	23	769
Barrio Envaco	61	810	31	7	18	927
Barrio Cienguita	590	794	28	51	23	1486
Los Cocos	25	262	0	0	0	287
Barrio Limoncito	138	1409	122	43	55	1767

Author: Mark Vlok
Date: June 2003
Place: San Jose, Costa Rica
Project: Urban Flood Research in Puerto Limon

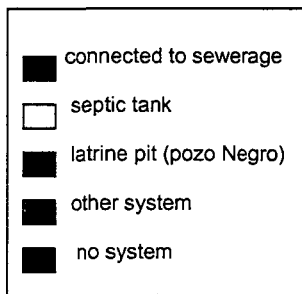


Figure 18: Sanitation systems in the urban areas of the Limoncito watershed (datasource: census 2000)



The latter map gives us an idea of the state and distribution of the sanitary facilities in the urban parts of Limon. What can be seen in the neighbourhoods, which originally were built as illegal settlements, is that only a smaller number of the houses is connected to the public sewerage system. In these neighbourhoods the most common sanitation technique is the Septic tank. The neighbourhoods located in the watershed with a high number of sanitation other than the public sewerage are: La Colina, Barrio Atlantida, Pueblo Nuevo, San Juan, Barrio ENVACO, Los Cocos, Barrio Limoncito and Barrio Cieneguita. (on Table 11 a overview of the number of inhabitants in the different neighbourhoods is given)

In a report of the WHO (2001) on water quality (Carr 2001) a description is given of the impact of the different sanitation methods. The impact is given on different levels, the level of this project would be on the community level. Since it is the entire community within the watershed bearing the negative consequences of a flood.

Sanitation system	Household	Community	Society
Pit Latrine (pozo negro)	±	-	+
Septic tanks	+	±	±
Sewerage	+	±	-

Table 8: Sanitation options and their containment efficiency on different levels (source: WHO, 2001)

Especially pit latrines and septic tanks are vulnerable in a flood situation. In such a situation the stored content of the system is exposed to the environment. Besides this pit latrines have a higher risk to contaminate groundwater through leakages. These systems particularly contaminate their environment with Faecal Coliforms.

According to the WHO the diseases related to water are underestimated by national governments. In 1992, the United Nations Conference on Environment and Development (UNCED) estimated that '80 per cent of all diseases, and over one-third of deaths in developing countries are water-associated, and on average as much as one-tenth of each person's productive time is sacrificed to water-related diseases' (UNCED 1992).

B.1.7 Flood Risk [review]

In the latter paragraph it is shown that the problems of floods also come forth from the quality of the water that enters the houses. The Limoncito River is one of the most contaminated rives in Costa Rica and therefore the flood risk consequences are even more dangerous. In this review the hydraulic and hydrological situation causing the flood risk will be elaborated on again.

The river can be divided into three stages more or less. Most important in the research are the high stage and the lowland stage. At the high stage of the 25 kilometres long Limoncito River the hills are very instable due to volcanic activity and earthquakes. As a result riverbeds shift occasionally and sedimentation is high. Like in the other rivers on the Atlantic side of Costa Rica the sediment causes problems since they lift the riverbed. The sedimentation is worsened because the velocity of base flow of the Limoncito River is very slow in the lowland stage. In the marshy lowlands another difficulty is encountered, namely the infiltration capacity of the watershed, which is very low. First of all because the marshy lowlands have very high groundwater levels and second because the watershed has a large amount of hardened urbanised surface. This hardened surface stops water infiltrating into the groundwater and accelerates the run-off of the precipitation in the neighbourhoods located on the hills. This hardening due to the urban development increases the risk



of higher peak flows. At this moment it is believed from written data resources that the Limoncito inundates the flood plain at least once a year, however many of the inhabitants even speak of 3 times a year.

The other important aspect determining the flood risk is the hydraulic situation of the waterways. Two situations will be described. First the hydraulic situation of a base-flow and second the hydraulic situation when a flood is occurring. For both the flood-risk is depending of various factors, such as cross-section dimensions, riverbed roughness, slope, run-off, river length and the bends the river makes.

In a normal base flow situation the Limoncito does not cause any inundations. In fact some river arms even dry up occasionally. However the large degree of sedimentation and the large amounts of debris hinder an efficient run-off. Besides this the river and the different arms need to cover a great distance before discharges into the sea. The difference between a straight line to the sea and the actual length of the riverbed is enormous. The length of the Limoncito River, for example is taken through the entire urban area of Limon before running of in the sea (see Figure 10). To shorten the length of he river Japdeva already installed a canal, which shortened the river length. However this canal is not working effectively since it is filled with debris. The canal however is a good start and even greater cut-offs should be considered. In the following figure a cross-sections have been measured. In figure 9 its location is shown.

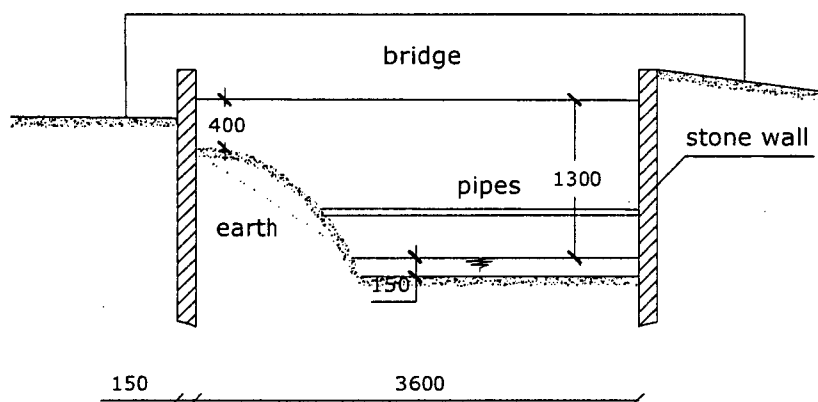


Figure 19: Cross-section of bridge over the Quebrada Bamboo (a in Figure 9)

The above cross-section is a significant example of how easy water level risings could cause floods. When the run-off increases the water level meets the pipes, immediately this causes blocking of the run-off and the water in front of the pipe rises even more. This process is amplified by the present [organic] debris, which is floating in the river and blocking the river even more. When water level even raises more the bridge itself start functioning as a dam as well. This process happens throughout the urban part of the watershed and can occur at any location where the river is slows down, such as river bends, river narrowing, bridges, crossing pipes, debris and ineffective working culverts.



B.2 Socio-Economic System

B.2.1 Introduction

In this part of the thesis the socio-economic system will be described. It is reflected in a wide perspective in which human action in a socio-economic context is elaborated. Resulting from a broad definition of the socio economic system, the system is divided into three different parts. All parts will be discussed in the three different paragraphs of this section Socio-economic System. First the socio-economic situation of the region and its position in the international and the national setting will be discussed. It will give the reader an insight in the socio-economic development of the relation of the Puerto Limon to Costa Rica and the world. Furthermore a description will be given of the researched area. These aspects will result in a clear view of the socio-economic position of the researched area and its relation to the city and Costa Rica.

When reading the economic sections one must know that Costa Rica in the context of development faces some problems. On the one hand, there is a lack of equity in the distribution of the economic benefits, generated by the new processes of production. On the other hand, there is a searching for new forms of participation and organization of society (Japdeva 1998). In other words economic development is occurring, yet the equity and distribution should be watched closely.

Second the urban development of Puerto Limon will be discussed. This will be done in a historical perspective. Through the years the urbanization pattern and growth of Puerto Limon will be described. Through this an insight will be given in the settlement behaviour in the past and the impact of it on the current developmental and flood risk situation.

Finally, this section will be complemented with a description of the cultural features of Limon. The Limon culture is an interesting and diverse culture and is unique within the Costa Rican context.

B.2.2 Socio-economic situation in Puerto Limon and the researched areas

By describing Puerto Limon's position in the international setting and national setting an insight is given in the relative socio-economic position of Limon in Costa Rica and the world. Especially for Puerto Limon with its international role in the transfer of goods the international and national settings are very important. The influence of the port on the socio-economic position of the researched area is significant with such a vital economic centre nearby the city is interrelated with the port. The port cannot be underestimated as employer and economic motor for the region.

The socio-economic situation of Puerto Limon and researched area is described according to the following aspects:

- National and international setting of Puerto Limon and Costa Rica
- Socio-economic position of Puerto Limon
- Socio-economic position of the researched area

B.2.2.1 National and International Setting

Puerto Limon's role in the national and international setting is significant due to the presence of two ports. More than two thirds of Costa Rica's export is transferred through the ports of Puerto Limon (i.e. Puerto Limón and Moín). And on a national level Puerto Limon is an economic important area



because of these ports. A quick elaboration of the numbers illustrates the role of the ports in Costa Rica easily. In 2002 the GNP of Costa Rica was US\$16.3 billion (DFAT 2003) of which the total exported value of goods in this same year was US\$5.1 billion (Brunsveld 2002), or more than 30% of GNP. Moreover 75% (Japdeva 2003) of the export value is handled by the two Ports of Puerto Limon. Hence to this one can imagine the economic importance of Puerto Limon within Costa Rica.

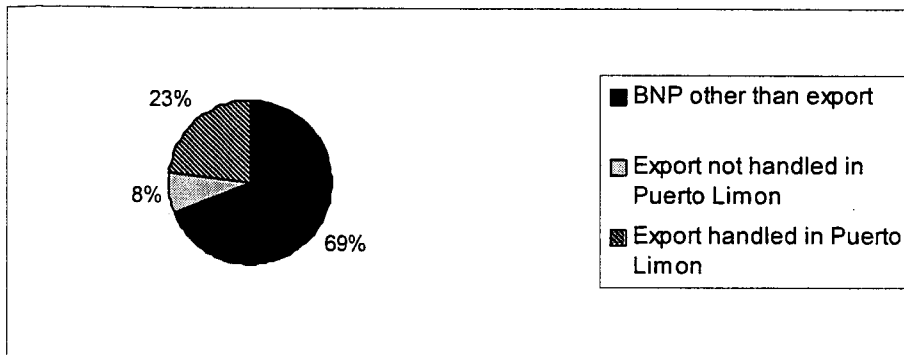


Figure 20: Export value handled in Puerto Limon in 2002 as a percentage of the Costa Rican GNP

This economic importance and the resulting international connection do not solely bring benefits to the region. The international connection due to the port function also has its downsides. A lot of wealth earned within the port is transferred to the central valley or kept within the Port authority, Japdeva, which acts quite autonomously within the region. As can be noticed from table 5 the presence of the port does not stimulate the manufacturing industry in Puerto Limon. Only 9 percent of total employment in Puerto Limon is found in the manufacturing industry. On the other hand due to the port the city has a high employment level in the service sector. Furthermore the inhabitants of the researched area who are affected by the floods are not benefiting from the port earnings. Urban projects such as Pacuare and Los Cocos are projects funded by Japdeva, the port authority. And their inhabitants are people who work for the port authorities or the oil company. They provide proper and low flood risk living conditions. Yet only to workers of these large organisations benefit of these projects. In the paragraph Urban development and the next section B.3 (Administrative and Institutional system) this phenomenon will be elaborated more on.

Besides this specific allocation of earnings Japdeva has another difficulty due to the international connection of Puerto Limon. The difficulties are caused by the high level of wages in the port. These wages are enforced by the labour unions that ask for wages on the same level as in other comparable international ports and harbours. While forgetting the low costs of living in Costa Rica and its economic position unions frequently argue for wage rises. As a result of this situation, wages of a crane operator, for example, are higher than that of Abel Pacheco, the President of Costa Rica. (La Nacion 2003a) These high wages put a heavy burden on the budgets of Japdeva. The same budgets that are used for development projects in Puerto Limon.²² Furthermore one can imagine why the figures of employment in the manufacturing sector lag behind. Puerto Limon can never exploit its situation of abundant workers if wages stay at the present high levels. This situation especially affects the people living in the flood affected areas who do not work for organisations such as Japdeva and Recope.

²² The organisational and budgets will be explained in the AIS system.



B.2.2.2 The economic position of Puerto Limon

The main economic activities in the province of Limon are found in banana plantations and, as said before, transfer of goods in her ports. "More than two thirds of Costa Rica's sea freight passes through Limon and nearby Moin".(Japdeva 2003) The goods transferred en route to the North American and the European markets, nearly half of the Costa Rican exports are transported to the United States.

Even larger is the share of the port of Limon in the export of bananas. More than 85% of Costa Rica's bananas are exported through the ports of Limon. The vicinity of the plantations to the port connects them inseparably. Their interdependence can be experienced, for example, during strikes in the port when bananas cannot be exported and the entire region is disrupted. It is the perishable character of the bananas that give the unions an extra power in their negotiations. Delay of the transfer make them unsaleable. Besides the export and the bananas the region holds more sectors. In the following table the employment distributed amongst these economic sectors is displayed.

	Puerto Limon (%)		Puntarenas (%)		Heredia (%)		Cartago (%)	
Agriculture	6.424	(24)	3.525	(11)	906	(2)	6.538	(14)
Fishing	152	(1)	3.971	(13)	13	(0)	5	(0)
Mining and Quarrying	6	(0)	85	(0)	27	(0)	95	(0)
Manufacturing industry	2.364	(9)	5.243	(17)	9.506	(23)	11.516	(25)
Electricity, gas and water	364	(1)	369	(1)	796	(2)	628	(1)
Construction	1.358	(5)	1.314	(4)	2.508	(6)	3.094	(6)
Business and reparation	3.300	(12)	3.874	(13)	7.472	(18)	8.261	(18)
Hotel y Restaurants	1.195	(4)	2.851	(9)	1.786	(4)	1.267	(3)
Transport and Communication	3.756	(14)	2.317	(8)	2.600	(6)	2.499	(5)
Financing	280	(1)	312	(1)	1.467	(4)	1.451	(3)
Immovable business	856	(3)	662	(2)	2.570	(6)	1.950	(4)
Public administration	1.950	(1)	1.604	(5)	2.517	(6)	2.294	(5)
Education	1.710	(6)	1.538	(5)	3.592	(9)	3.398	(7)
Health and Social care	1.120	(4)	1.347	(4)	1.914	(5)	1.408	(3)
Community services	1.946	(7)	950	(3)	1.373	(3)	1.034	(2)
Home with Service Domestic	544	(2)	731	(2)	1.409	(3)	1.194	(3)
Organizations extraterritorially	2	(0)	8	(0)	62	(0)	53	(0)
Total	27.327	(100)	30.701	(100)	40.518	(100)	46.685	(100)

Table 9: Employment distribution in Puerto Limon and comparable cities Costa Rica (source: IFAM)

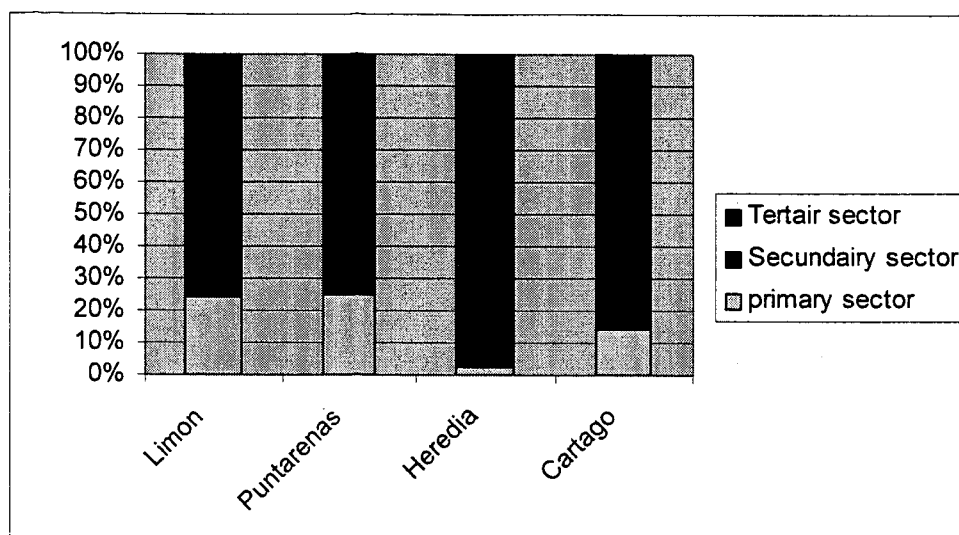


Table 10: Employment distribution (based on table 2)

As can be seen the tertiary sector in Puerto Limon as employer has a relatively large importance. Especially the ports (bananas, oil, containers) are an important employer. Yet employment in the manufacturing [secondary] sector is inferior to the large quantities of goods, which are transferred in the port. As has been mentioned before it is perhaps peculiar that factories do not settle themselves near the port where infrastructure is supplying good connection and where a labour force is abundant.

As mentioned labour in Puerto Limon is abundant, there is a high level of unemployment. In 1996 Costa Rica had a unemployment rate of 6,2%, whereas the Limon province had a rate of 8,5% (MIDEPLAN 1996). If then a neighbourhood such as Cieneguita is measured, one of the areas in the Limoncito watershed, a unemployment rate of 30% is recorded. (Centro de Recursos Local 1998) Besides this, and probably directly related to it, Limon has great problem with poverty. In Limon 20,6% of the population is regarded as poor by the IFAM (2000). While the average of poor in Costa Rica is 21,3%. Compared to the average poverty rate of Costa Rica the poverty in Limon is somewhat lower. However what should be kept in mind is that Puerto Limon is an urban region of Costa Rica, which in general are more developed and have lower poverty rates. In the following table can be seen that Puerto Limon has a much larger share of poor within their population compared to, for example, Heredia and Cartago (Both cities located in the Central Valley). It should be Limon's goal to achieve figures such as Cartago and Heredia.

	Poor ^a (% of total population)	Social Development ^b (IDS)
Cartago	19,7	66,7
Heredia	11,9	67,8
Puerto Limon	20,6	48,0
Puntarenas	38,7	54,8

Table 11: Percentage of poor people in Puerto Limon (source: IFAM^a, MIDEPLAN^b)

Besides poverty the social development lags behind significantly, as can be seen in the table above. The social poverty indicator is composed of several indicators by the Ministry of Economic Development and Planning. Factors included in the indicator are educational infrastructure, child



mortality, consumption of electricity per household, number of single mothers and level of education. The indicator is used by the ministry to compare cantons apart from economic figures.

B.2.2.3 Socio-economic situation of the research area

The researched area is part of Puerto Limon, it is delineated as the neighbourhoods of the city located in the Limoncito watershed. The general opinion in Costa Rica on most of these neighbourhoods in the lower part of the researched area (Limoncito, Cieneguita, Colina, Envaco) is that these neighbourhoods are of less economic significance in the city and furthermore a dangerous place to live.²³ Most people, including their inhabitants, see the neighbourhoods as stepping stone to move to other areas in Puerto Limon. Yet these neighbourhoods do accommodate three economically valuable areas. Almost all formal economic activity present in the neighbourhoods is found in these three areas. The first area is the connecting road to Siquirres and San Jose. Along this road one can find hotel and catering industry, such as sodas and discotheques, and many work shops and repair shops. Amongst the repair shops are several car repair shops and refrigerator repair shops. The road with its easy access and high traffic intensity is an attractive location for business. Besides this the road and most lots near it are located at a somewhat higher level than the rest of the area. The elevated position of the road gives these locations a safer location towards the water problems.

The other areas with concentration of economic activity are the Decar (cardboard department of the united fruit company) and ENVACO (industrial packaging of Costa Rica) factories. Both are businesses supplying cardboard boxes and other packaging materials for the banana industry. The present location of the factories is significantly older than most houses in the region. Therefore these facilities were built on then still available and higher grounds, unlike many nearby houses that are affected by the.²⁴

Perhaps only with the exception of these three economic centres almost all urban districts in the Limoncito watershed can be regarded as areas with socio-economic problems. In this paragraph the various neighbourhoods will be elaborated. Geographically the area as a whole can be divided into two parts, one area would be the flat swampy land, which undergo the inundation problems. And the other area would be the part that is situated on the slopes and hills in and around Puerto Limon, for the most part known as Los Corales. The population figures for the different neighbourhoods are given in the following table, the neighbourhoods marked are part of the Limoncito watershed.

²³ It is astonishing the amount of advises I received during my stay in Costa Rica. Many people fear the neighbourhoods. And stories of robbery and drugs are frequently heard. I cannot confirm since there are no crime figures available. Yet conversation with the local police and Costa Rican drug enforcement agents indicate that the neighbourhoods indeed suffer from more crime and drugs than other parts of Puerto Limon and Costa Rica. Yet it remains indications since I have not encountered any data or official comments.

²⁴ Decar and Envaco Employees



Neighbourhood	Population	Neighbourhood	Population
Barrio Atlantida*	475	Siglo XXI	2.066
Barrio Pacuare*	8.022	San Juan	1.641
Los Corales*	5.452	Barrio Roosevelt	1.927
Cerro Mocho	1.469	Bella Vista	1.495
Santa Eduvigs	1.542	Limon Centro	2.137
Las Brisas	553	Barrio Envaco*	3.611
La Colina*	2.391	Barrio Cieneguita*	5.547
Pueblo Nuevo*	6.653	Los Cocos*	1.106
Los Cementerios*	465	Barrio Limoncito*	6.740
Urban areas			
[neighbourhoods]:	53.292	*Neighbourhoods present in Limoncito watershed	
Non urban areas:	7.006		
Total:	60.298		

Table 12: Population distribution in Puerto Limon (source: census 2000)

In the following map the income level in the censal areas is analysed. These areas were grouped as in the census of 2000. The map demonstrates the different socio-economic situation in the different parts of southern Puerto Limon. The categorisation is based on the income level and categorized in 3 levels. However since the highest level is almost absent in Puerto Limon just level 1 is given. The remaining percentage can be regarded as households categorized in income level 2. What clearly can be seen is on the map that the areas that are affected by floods have a greater share of level 1 households (compare with picture XX affected areas)), for example affected neighbourhoods like La Colina, ENVACO and Limoncito. On the contrary a neighbourhood such as Los Cocos inhabited by Japdeva and Recope employees has clearly a smaller share of people from the lowest income group. The neighbourhood neither has flood problems, and the urban problems such as waste collection and bad road maintenance are almost absent. It is therefore interesting to see that working for these companies does have direct and indirect advantages.

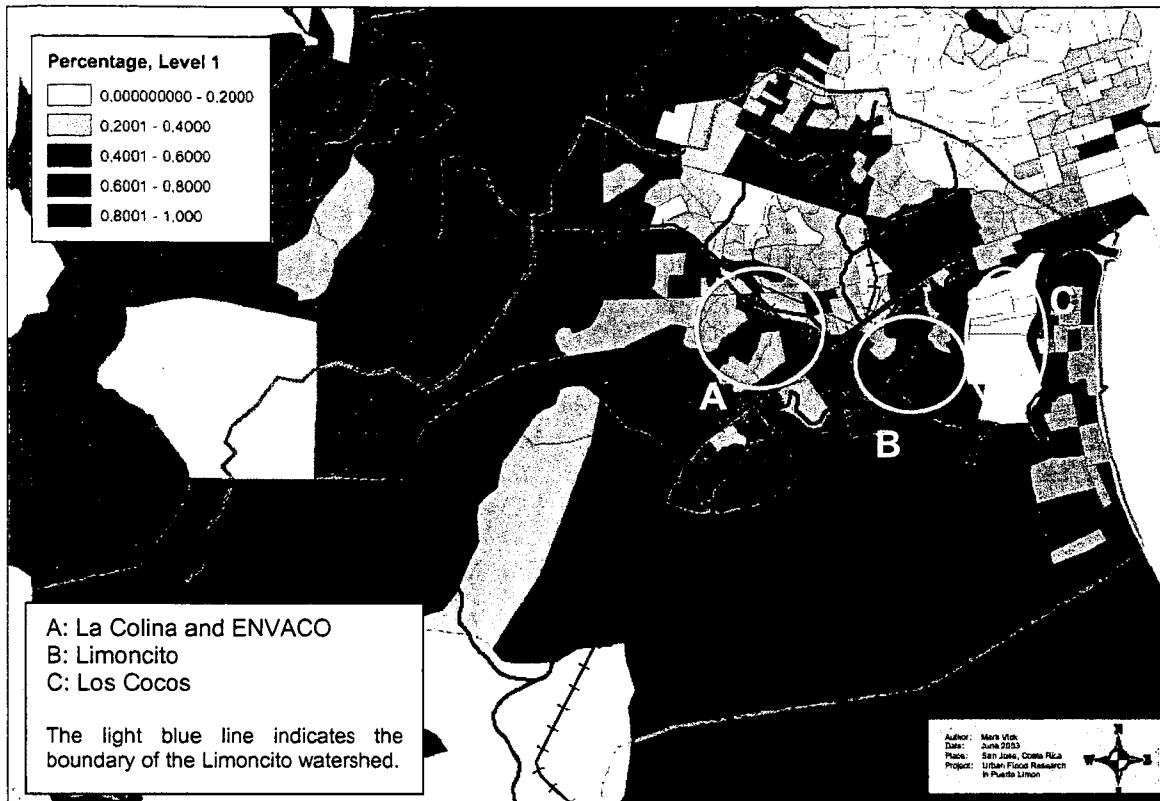


Figure 21: Percentage of households with income level 1 (source: census 2000)

B.2.3 Urban development of Puerto Limón²⁵

The urban developments in the neighbourhoods located in the Limoncito watershed seriously started when the first road, which connected Limon with San Jose, was completed. Before the completion of the road in 1965 Puerto Limon was still a small town, which served as the administrative centre of the plantation region. It held the headquarters of the international fruit companies and the service buildings such as hospitals and supply stores. In these days the town was isolated from the rest of Costa Rica. In the first part of the 21st century the only connection with the rest of Costa Rica was the railway line constructed by Minor Keith. Therefore emigration and migration was easily controlled. It was even until the 1960's that it was prohibited for blacks to travel to the central valley. It was only until the construction of the first road in the 1965 that migration from other parts of Costa Rica really set off. Besides the immigration wave of the 1970's there was another wave in the early 1990's. This wave was set of by the completion of the second road (Puerto Limon – San Jose: 160 km). In the table below the population increase is given.

²⁵ In the following text only the settlements within our research area will be discussed.



Year	Canton Limon		Costa Rica	
	Population	Yearly growth rate (%)	Population	Yearly growth rate (%)
1975	42.962	-	1.969.256	-
1985	57.387	2,9	2.638.964	3,0
1995	93.058	5,0	3.503.957	2,9
2005	127.062	3,2	4.371.733	2,3

Table 13: Demographic figures Puerto Limon and Costa Rica, 1975 - 2005 (source: INEC)

The following photo shows Puerto Limon in times before the construction of the first road to San Jose. The urban plan of Puerto Limon stayed unchanged, as in the photo, for many years. It was only until the beginning of the 70's when Puerto Limon started to expand. Before the only suburbs were Cieneguita²⁶, Camp One²⁷ (later named San Juan) and Barrio Roosevelt. Furthermore one can see on the photo that the river Limoncito had a much wider riverbed and river mouth since urban structures were absent. (compare with the situation of the river mouth shown appendix 7)

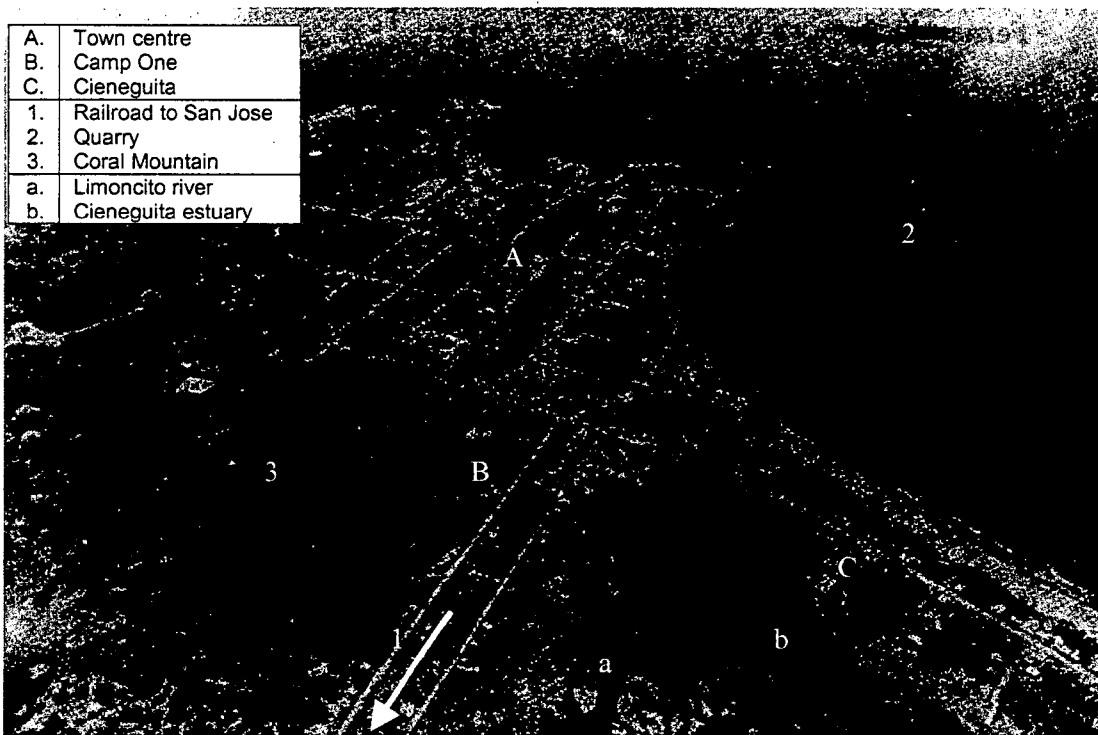


Figure 22: Photo of Puerto Limon, undated²⁸ (source: National Archive of Costa Rica)

²⁶ Some authors suspect that Cieneguita was built for the black inhabitants of Puerto Limon. And that its name is an adulteration of cien negritos (*Spanish*), which means a hundred knickers. This would possibly then have referred to its inhabitants. Nevertheless we believe that the name of the neighbourhood originates from cienága, the Spanish word for swamp.

²⁷ Camp One was the first settlement for the labourers building the railroad. Later it was named San Juan sounding more or less the same, however written Spanish. Changing of neighbourhood names for whatever political reason has happened many times, which makes working in Limon difficult.

²⁸ From analyses we can say that the picture is taken before 1953 and thus before the construction of the first road to San Jose. The analyses are based on dated pictures of port and city beachfront.



In order to understand the urban development of Puerto Limon sundry aerial photos from the National Geographical Institute of Costa Rica (IGN) have been analysed. The analysed IGN photos are from the following years: 1975, 1988, 1992 and 2000.²⁹ With a GIS map (Figure 20) based on these photos the urbanisation pattern is analysed throughout the years. The spatial analysis is complemented with an inventarisation of recent urban developments in the researched area. These developments were observed during the several visits to the watershed area. Special attention will be given to the nature of the urbanisations, formal or informal (or illegal or legal). Noteworthy is that a great part of the formal urban projects are executed by private organisations and, as one should perhaps expect, by governmental organisations such as the national and local government.

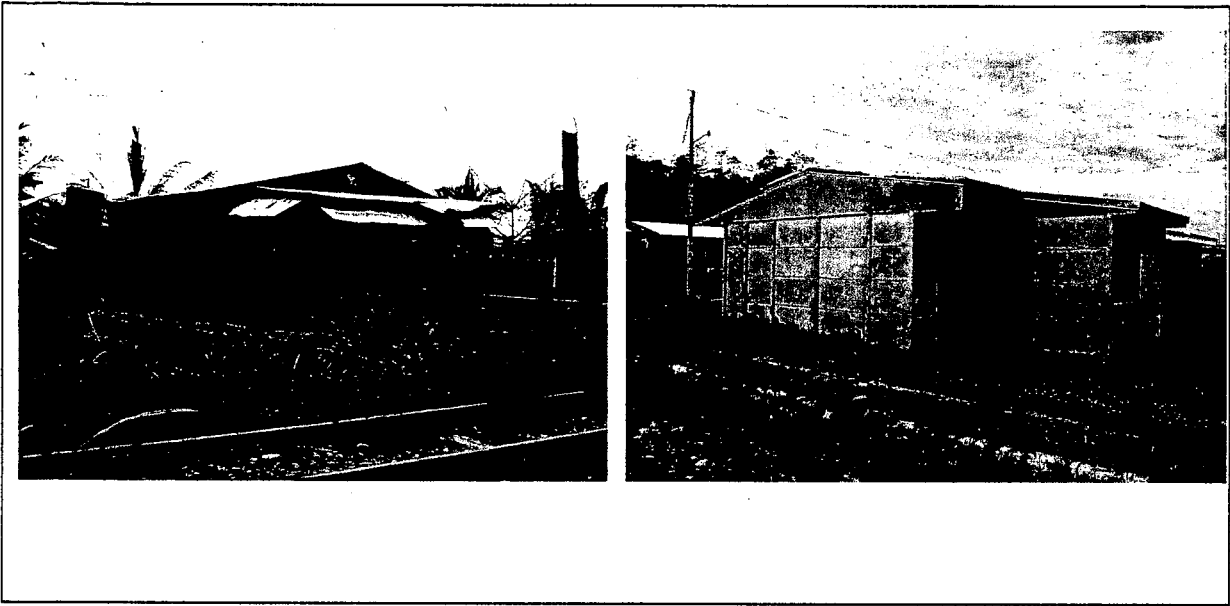
As can be seen the city in the neighbourhoods originally evolved from the town centre along the railroad lines. Cieneguita is one of these first suburb neighbourhoods, it is located on the other side of the Limoncito river. This neighbourhood was developed along side the railroad heading to the south and was somewhat isolated from the centre. The other urban area already present on the old photo (figure 19) is San Juan (camp one).

Like these two neighbourhoods, most other early settlements around Puerto Limon developed along the railroad lines. Like most other towns more inland, which also evolved along railroads lines heading to plantations. The reason that people tended to live next to the railroad lines is found in the infrastructural function of the lines. Besides, as railroad infrastructure they are often used as footpaths. Tracks often take the shortest route to the city. Nowadays the railroad paths are still used by schoolchildren heading to school and people heading to and from the city. It is interesting to see the pattern in which the different types of houses are located in the neighbourhoods. If the houses, in an arbitrary way, would be distinguished into two types. It is noted that the older houses built in the typical Caribbean style are, generally, located along the old railroad lines and that the others are located more scattered around in the area. The elevated houses are built on poles and constructed of wood. The other houses are in the area and are located more distant from the railroad. They are the newer ones and are designed like the ones in other parts of Costa Rica, characteristically built on the ground and constructed of prefab concrete elements (Figure 9 on the right). These characteristics make them vulnerable for floods and perhaps even unsuitable for the area.

The next areas that have been urbanized are Pueblo Nuevo and Los Corales. Pueblo Nuevo is a district started by the railroad company. They offered land to their employees so that they could live in reasonable conditions and close to their work. The company treated their workers well and houses were built in a sustainable way, constructed of wood and elevated on poles. Still many houses can be found from this period scattered around the old railroad lines.³⁰

²⁹ These photos were the available pictures present at ProDUS, yet more pictures are for sale at IGN office.

³⁰ These houses were built in the 1960's. We talked with some of the inhabitants and we can conclude that when the houses initially were build water problems were rare. Nowadays some of the houses undergo serious risk from the water, although they are constructed on poles.



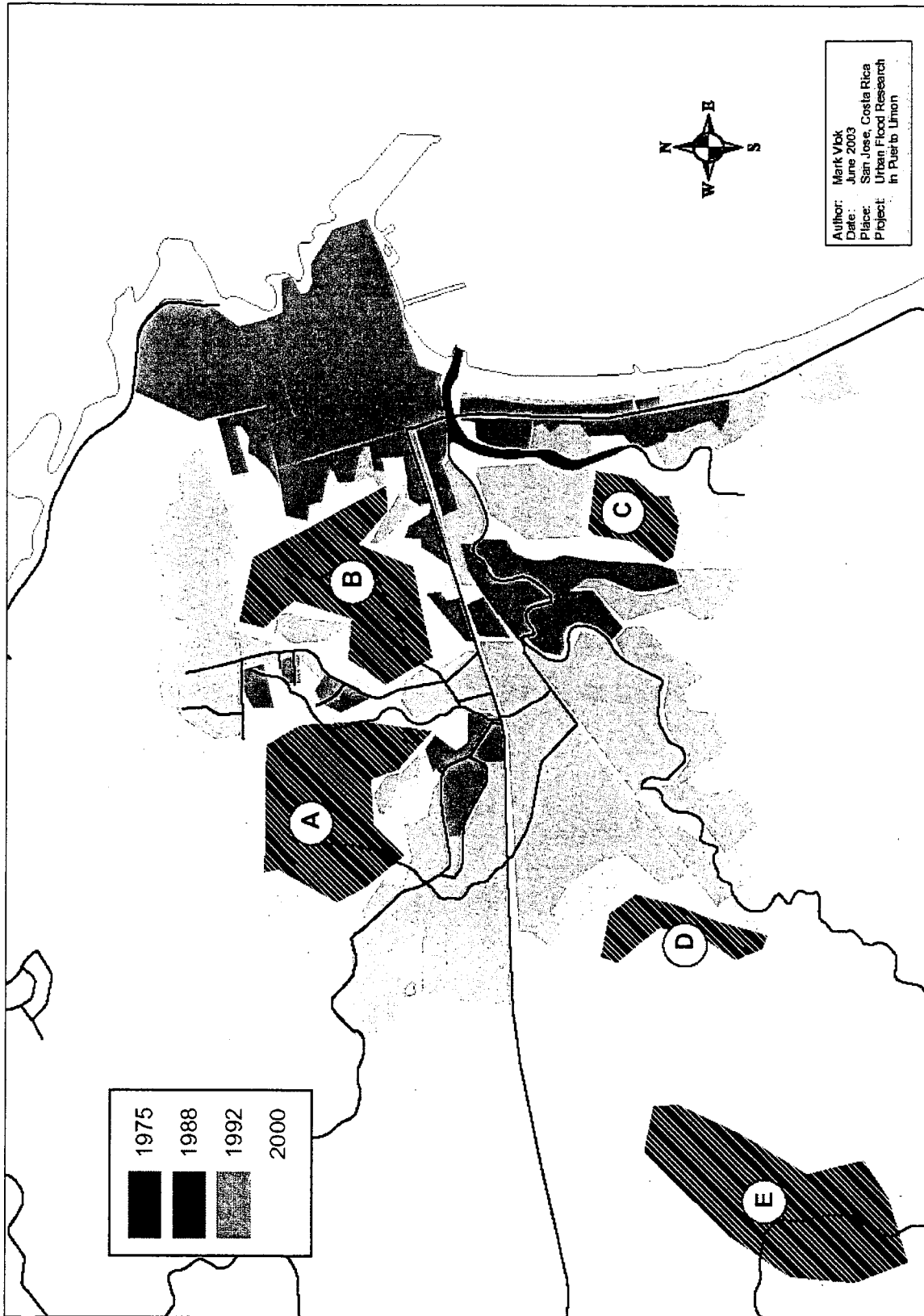


Figure 23: Analysis of Urban growth Puerto Limon



On the urbanization map can be seen that the city in the 1970's and 1980's urbanized in two particular areas, namely in the marshy area around the Limoncito river and on the slopes of the coral mountain. In appendix 4 can be seen that especially these areas are very densely populated. Why these people exactly chose to live in this area is unknown. However if the attitudes of today's inhabitants are compared with the urban development of the neighbourhoods an analysis can be made. The reasoning that people started living in these areas was adequate at the time being, however they didn't consider the sustainability of their settlement. The people often migrating to Puerto Limon didn't have much choice except to invade the land illegally. These illegal actions subsequently were tolerated by the government. This form of passiveness was and is seen often in land invading. Governments were often unwilling, unable or politically involved in the land invading themselves.³¹ In the case of Limon unwilling and unable were both occurring and still are. Even today, on the one hand the government is not acting properly on the situation. The cadastre is working with insufficient capacity and people living on illegal lots are still tolerated and supported with infrastructure such as roads and electricity.

The urbanization map also shows the areas which are being urbanized at the moment. These areas are recorded during the sundry visits to Puerto Limon and the interviews with local institutions. In the following table the districts are elaborated, the labels correspond with the labels given in the map.

Districts	Initiator	Description
A: Pacuare and Los Corales	Recope /Japdeva	Urbanized in lots sold and ordered. Houses are built in a traditional way. Reasonably expensive lots.
B: Los Corales (Bamboo)	Informal	Precarios (informal settlements) built in canyon of the creeks
C: Los Cocos	Recope/Japdeva	Proper lots, initially for the workers of Recope and Japdeva
D: Atlantida	INVU	Houses for the poorer, built with loans from INVU. MIVAH design
E: Unknown	Private investor	San Jose based private investor. Located on the hills alongside the Limoncito river.

Table 14: New urban areas in and around Puerto Limon

As can be seen in the table above still some urban developments in Puerto Limon are informal (construction by means of land invading). As other developing countries, Costa Rica and Puerto Limon has problems with squatters (precarios). These problems also affect the safety of the people living in the flood plains, since the urbanization process occurs without sufficient planning and structure. The urban situation is even getting worse, since no plan is present to fulfil the demand for land of the poorest. The people who invade land don't have land property and don't have money. This puts them in a position in which it is difficult to survive. And in which land invading is often seen an opportune action.

Besides this the legal framework regarding these problems is impedes the solution of the problems of land invading. In the Costa Rican Constitution (article 45) property is legally titled as unchallengeable. However after three months the precaristas (land invaders) gain rights. These rights are mainly based on agrarian laws. "These laws were originally introduced to allow poor, landless farmers to settle on land that was unoccupied or not in use, and claim it for themselves. The idea was to prevent the formation of the large absentee landholdings typical of other parts of Latin America, where a handful of wealthy "latifundistas" owned most of the land, and the majority had to scratch a living as landless labourers." (US Embassy 2003)

In the following map the number of "precarios" is given in the researched area. It can be noted that the precarios will only worsen the flood situation since they are built on the slopes of the coral mountain and near the river mouth and so reducing the width of the river mouth.

³¹ Delroy Barton (interview)

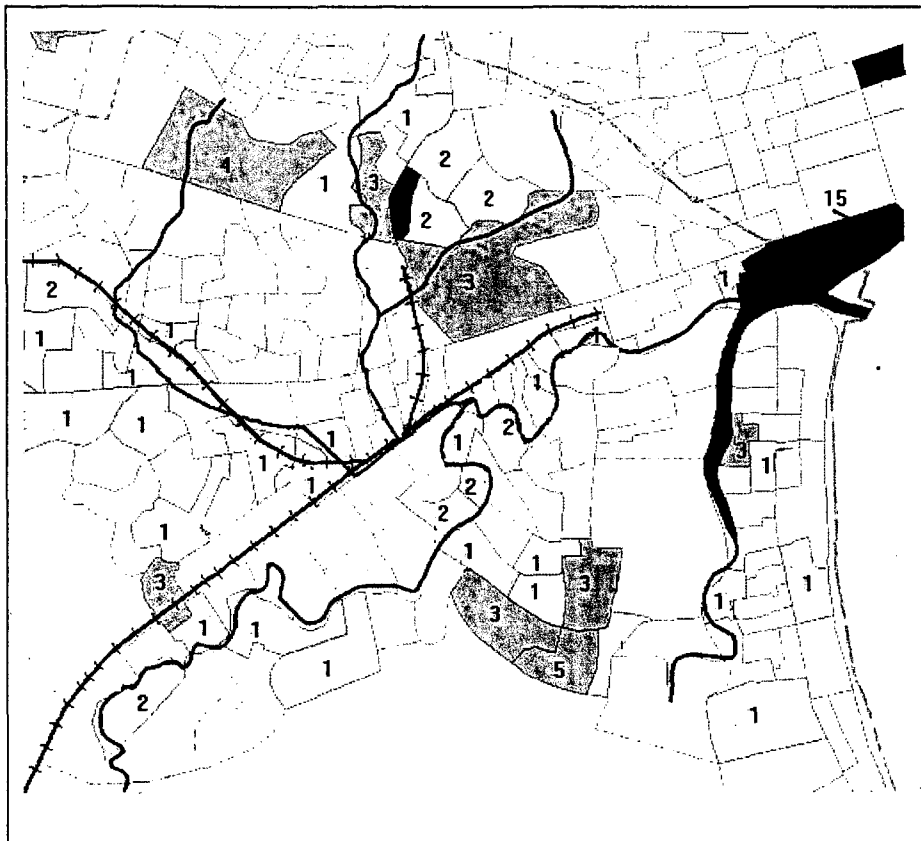


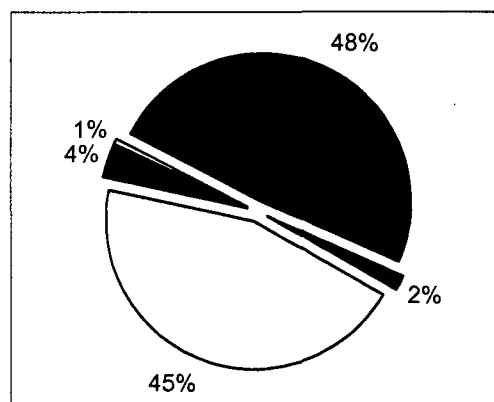
Figure 24: Number of illegal houses in the researched area (source: Census 2000)

B.2.4 Cultural character of Limon

Beautiful and typical is the culture of Limon. Being in Limon is certainly a different experience from the rest of Costa Rica. Not only the climate is different in Puerto Limon, also life and Limon's societal problems are different from the rest of Costa Rica. It is still visible that Limon has been isolated from the rest of the country for a long time. The first difference of Limon is the ethnic diversity of its population. Limon unlike other the rest of Costa Rica has a large group of Blacks. A group that in the rest of Costa Rica is very a very small minority (less than 5%). In contrast with Limon, Costa Rica is very homogenous from an ethnic perspective. The majority of the population in Costa Rica can be considered as descendents from European migrants (in the table categorized as None).

Black or African Costa Rican	27.073
Indigenous	2.183
Chinese	455
None	29.513
Ignored	+ 1.074
Total	60.298

Table 15: Ethnic distribution of canton Limon Central
(source: Census 2000)





A major ethnic group within Limon society are the Black or African Costa Ricans. These Jamaican immigrants were blacks who came to work on the banana and cacao plantations in the province of Limon. Unlike many other blacks who moved to the Americas (often in the form of slavery), these Jamaicans migrated freely to seek work as contract labourers. At the time of migration Jamaica was still a British colony under the British crown. Therefore these contract workers themselves felt superior to the local inhabitants, since of course they saw themselves as citizens of the great British. This resulted in self-assured migrants who were full of ambition. Even nowadays the education level of the blacks is on average a little higher than the Spanish speaking citizens in Puerto Limon.³²

The culture of Limon has remained different from the culture in the rest of the country. Generalizing, in music and lifestyle the people in Limon are more influenced by calypso and reggae than by salsa and boleros. The cultural difference must not be underestimated. It was only in the last decades that a road connected Limon with the rest of the country.

	Year of completion	Description
Railroad	1890	First land connection with central valley
1 st road	1965	Through Turrialba
2 nd road	1990	Through Braulio Carrillo [National Park]

Table 16: History of infrastructure connecting Limon and San Jose

These roads immediately had their influence on migration and Limon's culture, which first was only inhabited by the blacks with their shared identity and background. The migrants arriving to Limon came from the mountains more inland and were seeking work. They didn't have the Limon's ethnical background and were more Hispanic (Costa Rican) orientated. What was noticed in Limon was that the communal coherence diminished and that individuality increased as a result of the newcomers.³³ The communal coherence is seen by Delroy Barton, head of the development department of Limon, as one of the reasons for the development gap between the outskirts of Limon and the Town centre. At the same time as the communal coherence is diminishing, the culture of Limon is changing.

Besides the migration, Limon's culture is also influenced by the economic activity of commercial foreign companies. On a national level Costa Rican culture has already become more westernised. A striking example are the North American fast food companies, which are found throughout Costa Rica. In many cities in Costa Rica such a foreign restaurant is found. If these restaurants are taken as an illustration for the culture change of a region it is interesting to extend this phenomenon on the region Limon. The case is that in the complete region probably only one or two of these restaurants are found. And these are located in close proximity to the central valley. Striking is that in the Capital of the region, Puerto Limon no restaurant of this kind is found. It illustrates that culture in Limon still is little influenced by the alien cultures. However it can be expected that this situation is bound to change or is already changing. Even in the neighbourhoods of Puerto Limon, like Limoncito for example, cable television is installed rapidly. These networks for a large part transmit North American channels.

If these events, such as settlement of newcomers and foreign commercial activity, are observed in line with their impact on Limon's culture, it is not to be expected that communal coherence will return in Puerto Limon. The city will probably become more westernised and individualized. In line with Delroy Barton's observation that communal coherence is decreasing, one can expect that

³² Rosendo Pujol (interview)

³³ Delroy Barton (interview)



communal approach of problems will be less likely nowadays. Consequently strategies should be focused more on the individual. And probably less should be expected from communal initiatives.

B.2.5 Review

The economic position of Puerto Limon is very important within the national setting of Costa Rica. As shown in the foregoing paragraphs the economy of Costa Rica is for a large part dependent on the exports transferred through the port of Puerto Limon. However, this strong position of Limon does not automatically bring large economic development to the city. Several possible reasons have been indicated that could be the cause of this lack of development of the region. First of all it is difficult for Puerto Limon to attract companies providing jobs, especially in the industry sector of manufacturing. Strangely enough factors such as the strong infrastructural position and the abundance of labour in Puerto Limon have not been able to attract manufacturing companies. Prime reason is probably the position of the labour unions in the region of Limon. Since they are relatively powerful companies are cautious to locate factories in the area in and around Puerto Limon. Therefore the amount of people working in the manufacturing industry falls short. In Puerto Limon less than 10% of all labour is situated in the manufacturing sector.

Another aspect regarded the economic position of Limon is the dubious role of the port authority itself. They are responsible for two aspects in Limon, namely the administration of the port and the socio-economic development of the region. Where it concerns the administration of the port there is now doubt that Japdeva can carry out its duties effectively. Yet in the case of socio-economic development it is strange that an undemocratic organisation is responsible for the public welfare and administrates a large share of the resources. The reasoning for this construction is probably originating from the fact that resources generated in the region remain in the region. Through this construction it is certain that resources are allocated to developmental projects within the region of Limon. Yet, the funds remain with an institution, Japdeva, which is not democratic and therefore cannot serve the public interest effectively. The prime goal of Japdeva is remains the well being of the port, and not the welfare of Limon. As such it is strange that they are also designated the role of development stimulator.

The socio-economic equity within the city is dramatic. There is a great difference between neighbourhoods often depending on either the land was urbanized formal or informal. Ineffective planning and inferior public infrastructure such as roads and public sewerage characterize the former illegal neighbourhoods. The problem is that these neighbourhoods nowadays are legal and therefore are areas that also have the right of government attention and expenditures.

These illegal settlements come forth from the urbanization pattern of Puerto Limon, which have changed the watershed dramatically in history. In the 70's and 80's the illegal settlements changed the watershed in a way that flood risk increased. The impact of urbanization on flood risk can be accounted for by vulnerability and hazard increase. The vulnerability has increased tremendously since people started to live on locations unsuitable for habitation. These locations were already experiencing floods before settlement, yet the new immigrants were unfamiliar with their new environments and built on unsuitable locations. Moreover these new houses often were not built on poles, a technique that already had proven to be save. The urbanization pattern in Limon is dominantly arose from insufficient availability of affordable land for the new and poor migrants.

The hazard also increased with the urbanization of the area. The profile of the river was reduced, because people started to live [illegally] on the lots next to the river. Besides this the new houses without poles also blocked a swifter run-off in cases of a flood. The runoff pattern also changed since soil was hardened, this caused higher peaks in the runoff. Both factors, hazard and



vulnerability, have worsened because of urbanization. As a result the flood risk has increased significantly in the floodplain areas of the Limoncito.

Finally the cultural change of the community does not increase the probability of a spontaneous strategy arising from the community. People have become more individualized. This trend arose from the constant migration of people. Therefore a coherent community never has been established in the affected neighbourhoods. This accompanied by the cultural change of people have made them more individualized and westernised. Striking with these tendency people expect solutions from the government instead of becoming active and solving problems themselves in the form action groups. It is tendency that has its impact on management strategies in the administrative and institutional system.



B.3 Administrative and Institutional System

B.3.1 Introduction

The administrative and institutional system is the system in which the flood risk reduction strategies are carried out in order to mitigate flood risk. The actors in the system exist of individual inhabitants of the floodplain and the sundry (government) institutions that formulate, implement and manage flood risk strategies. This can exist of strategies, which function directly or indirectly and which are executed either intentionally to mitigate floods or accidentally affect flood mitigation. This broad definition is adopted here because the official institutions, which should be the ones acting on the flood risk, do not act in reality. It is experienced that in such a situation affected or interested parties seek solutions within the informal sector.

In the following sections the different actors will be described. The form of discussion is actor by actor since the structure of the institutional landscape is much more defined than the different measures, which are mostly difficult to delineate. The measures tend to involve several institutions and often they are only for a small part formulated for the purpose of flood risk management. To obtain certain coherence the different actors are discussed according to several factors. These factors are chosen on the basis of appropriateness and availability. The discussed aspects of each actor will be: Description, responsibilities, resources (e.g. financial and technology capabilities) and strategy and measures.

The order of elaboration of the institutions is in order of the levels of strategy implementation. Organisations important to the watershed can be found on three levels, namely national, regional and local. The following organisations are emphasized in this section:

National:

- National Emergency Commission (CNE)
- MOPT
- MIVAH
- MINAE
- MIDEPLAN

Regional:

- JAPDEVA
- Municipality
- Fire brigade, Red cross, and local emergency commission [other local institutions]

Local:

- Flood plain inhabitants

As noticed there is no international setting. Unfortunately the position of the Puerto Limon does not enable or stimulate international institutions to pursue actions in the region in the field of flood risk management. The situation of Puerto Limon is difficult since it is located in Costa Rica, a country that is regarded as a reasonably developed nation. The chapter evaluation will emphasize more on this situation. In the chapter the situation will be described on basis of the development relation of Costa Rica and the Netherlands. Besides this, one will notice that there are no non-governmental organisations in the list. Non-governmental organisations that focus on socio-economic development,



urban problems or flood risk management are not present in Puerto Limon at this moment. What is present is a structure of communal representatives.

B.3.2 National Emergency Commission (CNE)

The national emergency commission or CNE (in Spanish: Comisión Nacional de Prevención de Riesgos y Atención de Emergencias) was installed with the national emergency law in 1969. It was initiated after the volcano eruption of the Irazú in 1963. Within the national legal framework the CNE is a government institute assigned directly to the president's office. The activities are put forward in a legal framework which regulates the institute (Law 7914, regulation for risk prevention and emergency attention). Summarizing from this legal framework the CNE has two major responsibilities, namely the coordination of preventive actions in case of immediate emergencies³⁴ and the mitigation of emergency situations.

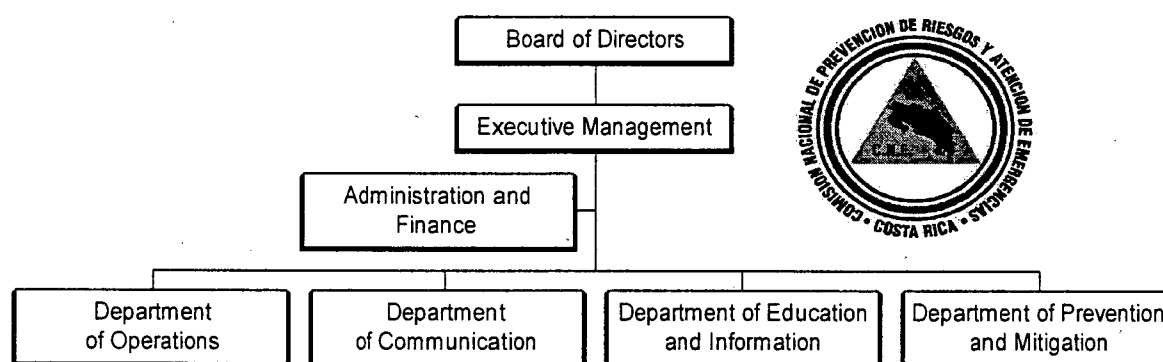


Figure 25: Organisation of CNE

The diagram illustrates the organisational framework of the CNE. The total organisation employs 160 people. The institute is lead by a governing body which consists of representatives from the following ministries: health, public works, social aid, environment, security, and the Costa Rican Red Cross. All members of the commission, except the delegate from the Red Cross, are also members of the cabinet. This makes the commission highly vulnerable to political preferences of the government in office. Primarily the board of directors has two responsibilities, one is formulating the general policy of the CNE, such as the National Emergency Plan and prevention programs. Second the board should approve the budgets of the CNE. This makes them in charge of the allocation of resources. Furthermore budgets have to be submitted and approved by the general assembly of Costa Rica as well.

In 1999 a new national emergency law was installed in order to increase the power of the CNE in the areas of mitigation and prevention of disasters. Especially through its mandate to mobilize resources from other government institutes to their own budgets for mitigation projects, the capability of the CNE should have been increased. Although the new law was promising, yet until now good results have not been forthcoming in the case of mitigation of risks. The main cause is a budgetary aspect, which should have been improved with the new law, but is still poor. In the next text this budgetary matter will be explained more in detail.

³⁴ Emergency (definition posed by CNE) is a situation created by nature or man that cannot be, controlled by normal government powers. For example volcano eruptions, floods and earthquakes.



Resources

Nowadays the institute is directly financed from the National Budget, which more or less secures a stable income. The annual budget of the institute is more or less 1000 million Colones (2,2 million US\$ in 2003).

	1997	1998	1999	2000
Budget (in millions)				
Colones	600,0	686,0	583,4	811,7
(US\$ 2003)	(1,4)	(1,6)	(1,3)	(1,9)

Table 17: Budget of CNE from 1997 to 2000 (source: Saborió 2001)

In reality this budget is used in large part for the operational expenses and it is far from sufficient to carry out the other tasks which are given to CNE, such as recovery and preventive works. To carry out more emergency preventive works the new law states that 3% of the ministries benefits (in Spanish: utilidades) should be transferred to the budget of the CNE. However until today the institutes have not contributed any money to preventive works. The public institutes state that they are non-profit institutes and thus do not have benefits. In reality, it comes down to an error in the 1999 emergency law. It should have referred to "surpluses". Yet one could question if this budgetary concept of surplus will work, since public institutes tend to spend the entire budget when threatened to loose surpluses. Furthermore if ministries would have surpluses it means that they are receiving too much and could be cut back next year. Perhaps a direct budget guarantee earmarked to specified programs would be a preferable means of financing for the CNE.

Aside from the unwillingness to transfer resources to preventive works, the institutes are also unable to make the required contributions. The following example will put the budget of the CNE into perspective. In recent years it was noted that the river Tempisque required a storage capacity that would be enabled by enlarging the storage basin and restoring the river banks, which were destroyed by the last flood. The resources to carry out this project were supposed to come from the fluvial department of the MOPT, which has an annual budget of 300 million Colones (Asamblea Legislativa 2002). Nevertheless the restoration of the river banks costs already 1.758,4 million colonnes. This example contradicts with the prime motive of the 1999 law that hoped to enforce the CNE with means to carry out preventive works. (La Nacion 2002) With the current budgets it is impossible to mitigate the current flood risk situation.

Strategy and Measures

CNE is most famous for the production of its natural emergency risk maps. In appendix 10 the CNE risk map for the region around Puerto Limon is shown. As can be seen in the map the floodplains of the Limoncito River are indicated as a potential flood risk area. The impact of the indication is getting more important. For example the Ministry of Housing (MIVAH) has linked its subsidy policies to the risk status on the map. In the Ministry of Housing section more is explained on these policy measures. Besides the production of this map, the CNE is responsible for giving out the warnings of emergencies. The organisation employs different levels to indicate the seriousness of the risk situation. Besides it has developed special communication systems to inform remote communities. In the case of the Limoncito watershed, however, this is not of any importance. Since its location is not regarded as remote.

Finally the CNE keeps records of emergencies in the form of evaluation reports. In 2003 the last report on floods for the Limoncito watershed was the report on the flood in December 2002 (Asamblea Legislativa 2002). These reports are formulated with the assistance of several ministries and the local institutes, such as the local CNE, the police and the fire brigade. The total costs for attention in the critical phase of the December floods were 99.900 million Colones (US\$ 2003: 228,6



million). However, the sundry reports on floods in the canton of Limon, never take into account the damages of specific watersheds. Furthermore if floods occur in the watershed of the Limoncito alone, they are not reported, since they generally not accompanied by large primary damages such as loss of lives and buildings. The information about these floods does end up in the newspapers, which do report damage and character of the flood. The task of taking note of floods in the region is part of the responsibilities of the local Emergency Commission.

B.3.2 Ministry of Public Works (MOPT)

One of the many responsibilities of MOPT (Ministerio de Obras Publicas y Transportes) is to “plan, construct, improve and maintain the civil defence works for the control of floods.” (MOPT 2003) However since it is one of the tasks amongst the many other tasks of MOPT only little attention is given to the flood problems. In the foregoing example of the Tempisque River it is clear that it is difficult for the fluvial works department of the MOPT to mitigate flood risk situations. In the next situation this problem will be emphasized more on the basis of the resources.

Resources

The budget of the MOPT is reasonable. However the share of fluvial works is only a small part of the total. From the budgets of 2001 the share will be shown. In 2001 the total spending of the fluvial department on the design and the construction of fluvial works was 329 million Colones, so the proportion allocated to flood mitigation is just 1 % (Fig 18).

	1997	1998	1999	2000	2001 ^a
Budget (in millions)					
Colones	34.043,9	36.763,9	44.179,6	45.666,4	51.827,0
(US\$ 2003)	(77,9)	(84,1)	(101,0)	(104,5)	(118,6)

Table 18: Budget of MOPT from 1997 to 2001 (source: Saborió 2001, ^aAsamblea Legislativa 2003)

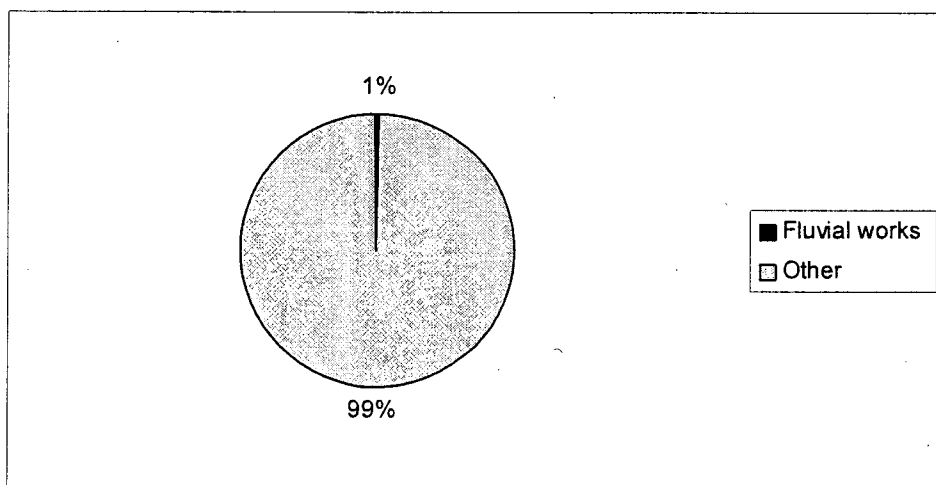


Figure 26: Share of fluvial works in MOPT budget in 2001 (source: Asamblea Legislativa 2003)

Besides the fluvial works department the MOPT is important for its equipment. When floods occur the MOPT often deploys its equipment to assist. Regarding equipment the MOPT possesses the greatest equipment (tractors and cranes) in Costa Rica. Since they have a lot of equipment the MOPT



do carry out projects on fluvial works in the Province of Limon. An example is the canalisation of the river Siquirres in 2002, which costs 26 million Colones.

B.3.3 Ministry of Housing (MIVAH)³⁵

The MIVAH (Ministerio de Vivienda y Asentamientos Humanos) is a relatively small ministry with 97 workers in 2000 and a budget of around 579,7 million Colones (Saborió 2001). The MIVAH is responsible for all housing policies in Costa Rica. However the main objective of the ministry is the supply of housing to the poorest in Costa Rica and the ones who have lost their house due to an emergency, such as a flood. The ministry itself does not execute the construction of houses, it has a coordinating role. The MIVAH appoints contractors who build the houses through contracts. Besides this it prescribes the house designs, the designs are assigned according to location and family size.

Resources

	1997	1998	1999	2000
Budget (in millions)				
Colones	1.642,4	2.056,0	2.320,0	579,7
(US\$ 2003)	(17,5)	(4,7)	(5,3)	(1,3)

Table 19: Budget of MIVAH from 1997 to 2000 (source: Saborió 2001)

As can be seen in the table above the activities of the MIVAH are declining. What is left of the budget is spent on overhead costs, such as loans. In spite of this several projects are executed by the MIVAH. Projects such as supervision on the quality of housing and researches on the socio-economic situation in squatter settlements.

Strategy and Measures

The betterment of the settlements and the housing in Costa Rica is achieved by the supply of so-called vouchers (in Spanish: bono). These vouchers are given to the people to build or repair their houses. Two groups are entitled for these bonuses. One are the poorest, they are defined according article 59 of the ministry of Housing. The other group consists of the people affected by an emergency. Once an emergency is declared as an emergency by the National Emergency Commission (CNE) the MIVAH autonomously acts by making an inventarisation of the damaged and destroyed housing. According to these lists the vouchers are distributed amongst the affected (MIVAH 2002). There are only two aspects in the new regulations. One is that a voucher can only be handed out once. And the other is that if people live in an emergency risk zone, as indicated by the CNE, they have to move in order to receive a voucher.

Furthermore the MIVAH have developed plans to subsidise only appropriate housing. In the region of Limon projects have started which prescribe houses built on poles. Unfortunately the project is set off slowly and only few projects are planned. The first project is at this moment, September 2003, built in Matina and the next is planned in corporation with the United Fruit Company in a workers housing project. The integration of the CNE risk mapping in their policy is a hopeful tendency. However it is also difficult since it does not really help the inhabitants of the Limoncito floodplain. These people hardly lose their houses due to the floods and relocation also is difficult since low-cost lots are absent in the vicinity of Puerto Limon.

There is one project of MIVAH in the Watershed, namely neighbourhood Atlantida. Unfortunately they are built in the typical common style directly on the ground. In the next figure the design of

³⁵ Based on interview with Carlos Castro, Director of housing (MIVAH), on the 10th of may 2003.



these houses in Puerto Limon is shown. Certainly these houses do not reduce the flood risk for its inhabitants

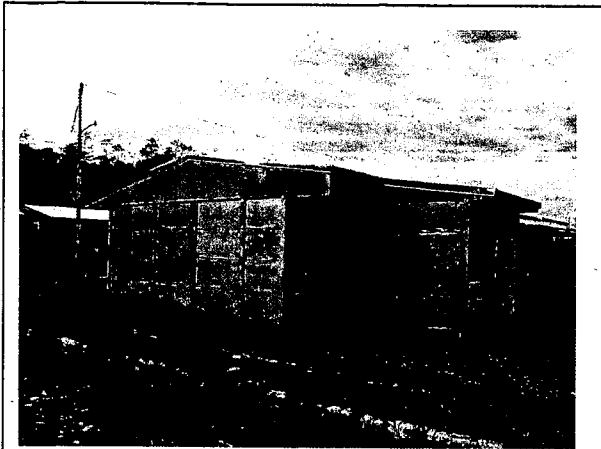


Figure 27: Typical MIVAH prefab housing design

B.3.4 Ministry of Environment and Energy (MINAE)

The MINAE (Ministerio de Ambiente y Energía) for the part of watershed management is responsible for the promotion and control of a sustainable use of the environment. Besides this the institute is the only ministry that operates on a watershed level (see appendix 2).

Strategy and Measures

Within the Limoncito watershed the MINAE has designated one area as protected area under the category of Humedales. These areas are natural areas that are important in the control of floods and the protection from storms. They are used as water storage and as refuge for wild animals. The objective of the measure is to sustain the original situation of the area of 1.096 hectares.

B.3.5 Ministry of National Planning and Economic Policy (MIDEPLAN)

The MIDEPLAN (Ministerio de Planificación Nacional y Política Económica) annually develops plans to enhance economic development. These plans are directly communicated with the president who is advised in this matter by MIDEPLAN.

Strategy and Measures

The following plans and strategies for Limon's Economic development are formulated by the MIDEPLAN (MIDEPLAN 2001). They are formulated in the National Development Plan for the four year period from 2002- 2996. These projects should enhance the economic and social development in the region of Limon and are designated to certain institutes.



Project	(values in million Colones)	2002 - 2006	Fund source
Construction of a scientific centre for marine investigation	45		National Gov.
Construction of a fishery port near Puerto Limon	450		National Gov.
Promotion of more advanced of fishing equipment	150		National Gov.
Promotion of sowing of Bamboo	100		Japdeva
Mapping the land use for the agricultural sector	200		Japdeva
Promotion of the installation of new companies in Puerto Limon	800		Japdeva
Promotion of training by companies	120		Japdeva
Installation of an institute to promote employment	250		Japdeva

Table 20: Specific strategies for the regional development of Limon province proposed by MIDEPLAN (2002)

Japdeva and the National Government fund the projects, by resources originating from different ministries. The different projects focus on different aspects, they represent the choices of the institutions for development. The following aspects can be distinguished:

- Sustainable Development of the marine environment, also related to the fishery sector; this aspect corresponds with the preference of the present mayor of Puerto Limon, who stresses the importance of the marine and coast environment.
- The promotion of substitute agriculture products such as bamboo; in Limon some projects have commenced stimulating bamboo processing.
- Promotion of small and medium businesses, important for a innovative entrepreneurial environment.

As result there is no strategy by the MIDEPLAN to change the flood situation of the Limoncito. Yet this is not the aim of this ministry. The measures that are taken concentrate on the employment situation in Puerto Limon.

B.3.6 Japdeva

One of the most prominent institutions in Limon is the harbour authority, Japdeva (Junta Administradora Portuaria y de Desarrollo Económico de la Vertiente Atlántica). Japdeva is an independent government authority active since 1963. Its name is an abbreviation for the Port Authority and economic government development agency. Its two primer goals are management of the port and promotion of the socio-economic development in the region. In the regulations the development role of Japdeva is formulated as follows:

Japdeva holds the legal mandate of “promoting the efficient and rapid integral socio-economic development of the Atlantic region....” (Japdeva 1998)

The development of Limon is aimed for by the development division through various instruments. First of all the organisation gives technical assistance to those in need. Furthermore it carries out projects itself. These works can vary from road and river maintenance to bridge construction. Aside from carrying out the projects itself Japdeva also subcontracts projects through tenders. Annually, each January, organisations can tender for a share of the Japdeva development budget for their project. An independent commission associated with Japdeva grants the funds to the various projects. These projects can vary from cultural and communal projects to security and health projects. (Japdeva 2002)



Within the region and probably within the country Japdeva is one of the institutes with high capabilities. Due to the international role their engineers cooperate in projects with other international engineers from for example Sweden and Taiwan. Besides this the organisation owns some equipment such as a crane and vessels. Amongst these available assets such as equipment and human capital Japdeva has a relatively good financial position. In the following paragraph the financial resources of Japdeva will be elaborated.

Resources

The resources of Japdeva available for the development of the region depend on the total budget of the institute (given in the table below). The budget of Japdeva is allocated in a certain proportion of 80 – 20. Where 80% of the budget is generally is assigned to the Port authority division and 20% is granted to the socio-economic development of the Limon region.³⁶

	1996	1997	1998	1999	2000
Japdeva	7.309,1	10.010,1	11.650,0	12641,2	14.892,0
soc.-econ. development (million dollars 2002)	1.461,8 (4,3)	2.002,0 (5,9)	2.330,0 (6,9)	2.528,3 (7,4)	2.978,4 (8,8)

Table 21: Budget of Japdeva in millions of Colones (source: Saborío 2001) and socio-economic development budget

In 2001 one third of the budget spent by Japdeva on communal development work was spent in the central canton of Limon (Puerto Limon). Almost half this amount spent in Puerto Limon was directed to the construction and repair of roads (Japdeva 2002). The deterioration of roads, seen in many neighbourhoods, is largely induced by the rainfall and floods. The roads on slopes, for example, are difficult to maintain and corrode tremendously since a reasonable drainage system is absent.

Strategy and Measures

Japdeva does not undertake any flood-related action in a structured and planned manner. However the organization does carry out some ad hoc actions in response to problems coming about. One of the first infrastructures built by Japdeva to mitigate floods was carried out in 1984. In this year two constructions were completed, namely the breakwater located at the mouth of the Limoncito and the canal connecting Limoncito to the Cieneguita estuary. The breakwater was constructed to prevent sedimentation at the river mouth and to accelerated the discharge of water.

B.3.7 The Municipal Government Of Puerto Limon

The Limón province is administratively divided into six municipalities, namely Limon, Pococi, Siquerres, Talamanca, Matina and Guacimo. These institutes are responsible for many matters within the canton boundaries, such as roads, urban planning, construction permissions, land registration and waste collection. The Limoncito watershed is completely located within the Municipality of Limon.³⁷

³⁶ Interview with Delroy Barton (head of socio economic development division of Japdeva)

³⁷ The municipality is officially called the municipality Limon central, Although it is named differently it is the municipality of Puerto Limon. When we speak of the municipality of Limon we speak of the municipality administrating Puerto Limon.



	Population (1999)	Area (Km ²)	Population Density	Employees	Habitants per employee
Limon province	275.819	9.188,52	30	419	658,27
Limon	82.337	1.765,79	47	184	447,48
Pococi	74.735	2.403,49	31	89	839,71
Siquirres	46.215	860,19	54	53	871,98
Talamanca	20.683	2.809,93	7	24	861,79
Matina	25.160	772,64	33	36	698,88
Guacimo	26.689	576,48	46	33	808,75

Table 22: Municipality Figures (source: IFAM 2000)

The different activities of the municipality of Limon are divided amongst the different divisions within the municipality, as shown in the following organization chart. The division that should formulate some sort of flood mitigation strategy is the Engineering division. Besides the engineering the department it also contains the land registration department, which is responsible for urban planning. Both departments will be discussed in more detail in the following part.

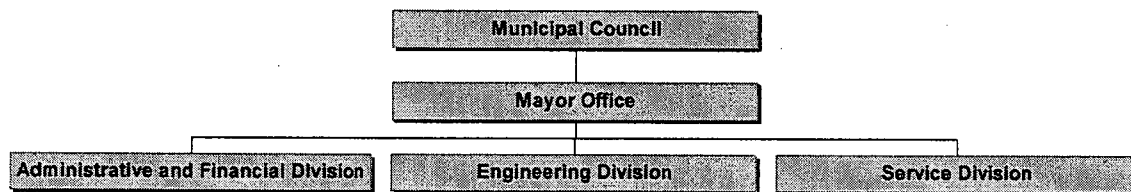


Figure 28: Organisation Chart of Municipal Government (source: Personnel Department of Municipality of Limón, 2000)

The municipal council is an elected council, which is responsible for the approval of budgets and plans. Besides this it can submit proposals. Like the national government in Costa Rica the municipal councilman can only be elected once, for a period of four years –a matter that perhaps will change in the coming years on presidential level.³⁸

With the introduction of the new municipal legal framework (*in Spanish: Código Municipal*) a few years ago the role of the different actors in the municipality has formally changed. Nowadays mayors are, like the council, directly chosen by the citizens. This brings about a situation in which both parties run elections and propose plans for the future. Within election period the mayor is chosen on the basis of a certain program and plans for the future and the council is chosen on a basis to look after procedures.

³⁸ It might be wise to change this system because a democratic system, to my believe, is not only a system in which representatives are given trust for a certain period of time. It is also a system in which representatives are rewarded for their work and are therefore be given the mandate to continue an other 4 years.



In practice situations are much more informal than described in this chapter in the following anecdote the situation of the Mayor and the council is illustrated.

The council is seriously involved in the daily procedures of the municipality. Once the engineers of the municipality went on a technical inspection. However the engineering department does not receive enough funds to have a car. For this reason sometimes the councilmen take the engineers on a tour for their inspections. Yet this brings about a mixing of interests of municipality engineers and councilmen.

Besides these funds for somewhat greater projects such as roads and maintenance are available on national level. This asks a tremendous effort of the mayor to lobby at ministries and institutions for projects and funds. And also induces informality and granting by will in the allocation of these government resources by the various ministries.

The different divisions handle the daily procedures and the Mayor can be seen as the head of daily affairs. The administrative and financial division is responsible for the treasury and the income and expenditure of the government. Within this division an important department is the taxes and payments department (*in Spanish: Rentas y Cobranzas*). This department allocates the funds and collects them from the taxpayer, the taxpayers are identified with information from the land registry department. In the following graph the tax income in the year 2000 is shown in a graph, however if it is taken into relation with the number of inhabitants the tax income is somewhat comparable to the other cantons. The tax income of the municipality mainly depends on the capability of the municipality to collect taxes and on the prosperity of its inhabitants.

Resources

The financial situation was last analysed in the evaluation report of the Costa Rican government control institute (Controlaría General 2003). They are appointed to make a national evaluation of the government institutes. In general the situation of municipality of Limón is weak. Telling is an estimate of a local councilman, who estimated that 80% of the budget of Puerto Limón is spent on salary of the municipal employees. This situation of very high fixed costs (e.g. personal costs) obviously makes the financial position of the municipality weak.

In the following table the income and expenses of different municipalities in Costa Rica have been put forward.



	Total income	Labour costs	Percentage
Limon	836.816.955,66	474.882.123,73	56,75
Cartago	3.060.079.280,29	1.149.084.345,97	37,55
Puntarenas	1.293.052.930,67	525.428.831,84	40,63
Heredia	1.517.956.123,19	463.680.300,24	30,55

Table 23: Municipality income, in Colones (Controlaría General 2003)

	Own collected income	Own collected income (budgeted)	Efficiency of Collection (perc.)
Limon	550.438.910,12	560.335.000,00	98,23%
Cartago	2.470.911.184,65	2.427.381.498,00	101,79%
Puntarenas	810.116.039,99	941.236.281,88	86,07%
Heredia	1.223.410.494,61	1.285.289.700,00	95,19%

Table 24: Municipality own collected income, in Colones (Controlaría General 2003)

	Number of inhabitants	Number of Municipal Employees	Employees per Inhabitant
Limon	89.933	198,0	454
Cartago	132.057	400,0	330
Puntarenas	89.000	210,0	424
Heredia	103.894	186,0	559

Table 25: People employed within municipality (Controlaría General 2003)

The tables above clarifies the financial situation of the four selected municipalities.³⁹ The objective is to understand the financial situation of the municipality of Limon. By listing Limon amongst the other municipalities the relative situation can be obtained. The chosen municipalities are comparable with Puerto Limon in different aspects. First of all they have more or less the same number of inhabitants and, furthermore, all are provincial capitals. Besides this, the municipality Puntarenas is a port like Puerto Limon.

To simplify the analysis of the financial situation some points have been listed for the municipality of Limon.

- Labour costs are relatively high in relation to the municipal collected income. Compared to the other Municipalities, Limon has a high burden on its budget.
- However if it is compared to the amount of municipal employees and the average wages of the employees Limon does not differ significantly with the other Municipalities.

³⁹ These municipalities are used throughout the report to put the municipality of Limon in a Costa Rican perspective. The four municipalities are have been chosen from the in total 87 municipal governments in Costa Rica. In order to make a comparable



Strategy and measures

The responsibility for the livelihood in the neighbourhoods is for a large part the responsibility of the municipal government. Actually their capabilities are far from reaching. Financial resources and high-educated people are little available. In the case of Puerto Limon the availability of well-educated is probably closely linked to the availability of resources. In 2002 a GIS specialist was working on a project to systematically analyse the geographical situation of the city. However this year this person was sent off since resources were not available for this project anymore.

The waterways are actually the responsibility of the municipality. However in reality the municipality is unable to carry out maintenance works. On a political level the mayor seeks solutions by cooperating with the MOPT and Japdeva. However there own engineering and cadastre departments are often not used in these projects. The reason for this remains unclear, yet it is odd to see that municipal departments are left unknowingly.

There are two measures that influence the flood risk situation directly, namely the solid waste policies and the land-use policies. This latter policy is dictated by law to be carry out by the municipal government. The important part of this urban law is the zoning of the land. In Puerto Limon all rivers that are shown in Figure 9 have been zoned as rivers in the Urban Plan. This means that it is prohibited to built within 10 meters from these rivers.⁴⁰ In reality this policy is poorly executed and it lacks the municipal government of will and capability to see on this law. Often illegal land invasions are tolerated since these people do not have the resources to live anywhere else.



Figure 29: Illegal buildings the end of the Limoncito river

The other measure is the tax towards solid waste. It is paid on a individual basis and therefore citizens feel little incentive to pay this tax if their neighbours are not paying neither. The consequence is that neighbourhoods get less attention form the waste collectors since they pay less tax. Whereas probably these neighbourhoods need more attention of waste collection since the waste obstructs the waterways in these neighbourhoods. In general it is very difficult to develop and carry out anticipating strategies for the municipality. They hardly have the capacity to carry out their daily tasks.

⁴⁰ In 2001 such a plan carried out in which also all rivers were zoned consequently it is illegal to built within 10 meters of these rivers.



B.3.8 Other Local Institutions ⁴¹

The other local institutions involved in flood management are the fire brigade of Limon, the Local Red cross and the local emergency commission. These three organisations, in practice, only act when a flood has occurred. They provide assistance like the fire brigade and Red Cross, or administrate the damage like the local emergency commission. At the time of this study these three institutions were presided by the chief of the fire brigade, Capitan Hernandez.

The local commissions supply the data on emergencies to the CNE. They are more or less responsible for the recording of floods and damages. In the case of the Limoncito floods the events are not seen as emergencies by these local institutions and therefore no recordings are made. In case of big floods neither good recordings are made because in these cases the other areas are seen as more important, since big floods usually mean that floods occur in the entire region. There are various reasons that could be a reason for this point of view. First of all the floods are a yearly returning event and therefore are not seen as sudden unexpected events. The people are familiar with the floods and know what to do when they occur. Second the impact of the floods is not noted directly. There are no houses destroyed directly and generally there are no deadly casualties. Consequently the flood events are not recorded and no extraordinary aid is provided.

B.3.9 The Floodplain Inhabitants

As elaborated on before the inhabitants are also emphasized on as flood risk managers. It is because of government incapability that individuals start taking measures that mitigate flood risk. What makes this group different from the other actors present in the AIS is that they are not a homogenous group, each individual has his or her own resources and his or her own situation of flood risk. Besides this the inhabitants are different since they do not act in a public interest, whereas the other institutions in the AIS should act in democratic and bureaucratic manner. To describe this group a small survey has been carried out (for full elaboration see appendix 9) accompanied by various interviews. The most important outcomes have been set out in the following graphs.

The first question put forward was how many floods the respondents thought there where in their neighbourhood per year. As can be seen in the graph the majority of the people estimated that their neighbourhood was [is] flooded more then twice a year. What was striking during the execution of the survey was the difference in responses between neighbours. The flood problems are so local that one household can have problems 7 times a year while their neighbour hardly has any problems. This strong deviation is probably a result of the great diversity of housing designs and the fluctuating level of the surface. Another aspect that intensives the difference between flood risk throughout the area is the presence of blocking structures. These structures are so dominantly present that they can influence water levels tremendously on a local scale. On should think of low bridges, blocked culverts or elevated roads, railways and footpaths.

⁴¹ Based on interview with Capitan Hernandez, head of the fire brigade of Limon

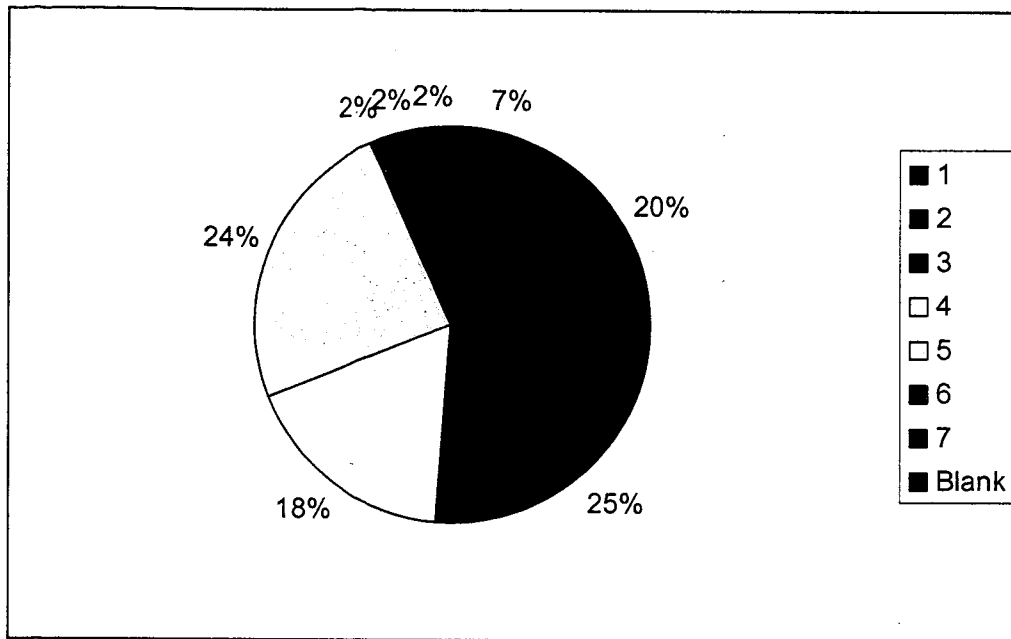


Figure 30: By flood plain inhabitants estimated yearly flood frequency (3 censales, total of 45 respondents)

	1	2	3	4	5	6	7	Blank
Censal 1 (15 respondents)	13	26	7	27	27	0	0	0
Censal 2 (idem)	7	13	33	20	20	7	0	0
Censal 3 (idem)	0	19	38	6	25	0	6	6
Total (45 respondents)	7	20	25	18	24	2	2	2

Table 26: Estimated yearly flood frequency, censales and total

Associated with this diversity of flood risk on a local scale, is the effect that the floods have on the inhabitants. Two questions have been put forward to discover the effect of the floods on the floodplain inhabitants. The first question is whether the people have ever experienced damage to their [present] house due to the floods. And the other question is whether they have had damage to their personal belongings due to a flood. As can be seen in the graph below 62% of the people have had damage on their house more than once. The damage that respondents described were damages to floor, foundation, walls and to window- and doorframes. The effect of such damage must not be underestimated since it is the deterioration of capital stock. Furthermore a house is often the most important possession. In most cases the house is completely owned by the inhabitant.

	No damage	damage
Censal 1 (15 respondents)	47	53
Censal 2 (idem)	33	67
Censal 3 (idem)	33	67
Total (45 respondents)	38	62

Table 27: Percentage of people with damage on their house due to floods, censal and total

The second question was whether people had suffered damage to their belongings and whether they had lost any items. It showed that 58% of the people had lost something due to a flood. In most cases respondents had lost items such as furniture or electrical equipment, like refrigerators and washing machines. To overcome the returning water damage many inhabitants have placed their electrical



items on blocks. Another reported measure was the installation of a framework, which provides a temporarily storage location for the electrical items.

	No damage	Damage
Censal 1 (15 respondents)	60	40
Censal 2 (idem)	27	73
Censal 3 (idem)	40	60
Total (45 respondents)	42	58

Table 28: Percentage of people with damage to personal belongings due to floods, censal and total

Noted from the foregoing two questions people are undoubtedly affected by the floods in their lives, consequently a large part of the respondents would like to move a location with less flood risk. Of all [45] respondents 71% wanted to move to another location in order to avoid the occurring floods. However the ability to move is often absent. Most houses are owned and fully paid for by the owners (71%). For these people it is difficult to move since the house cannot be sold and therefore money is not available for investing into a new house. The unattractive environment with its flood risk makes these houses worthless on the real estate market. The reason that houses are often owned of their inhabitants is that they are often inherited from parents.

Measures and Strategy

This section will focus on the measures to mitigate the flood risk. Many different measures are taken by the floodplain inhabitants to mitigate the flood risk. Since is hard to stop when the flood is already there, people take measures in advance. Of the 45 respondents in this survey 47% have indicated that they have taken technical measures to mitigate flood risk [technical modifications on and around the house]. In the following list the different measures are put forward.

	Out of the 45 respondents
Raised there floor	16
Constructed a wall around the house	8
Constructed a new house on poles	1
Constructed a second floor	1

Table 29: Measures taken on the house to mitigate flood risk

In the survey the floodplain inhabitants mentioned these four measures. Some respondents even installed two modifications. Around 4 people, for example, installed a wall around the house and raised the floor. Some people even took measures several times, such as raising the floor various occasions. This number is of course is not noticed in the survey. Yet some measures have their limits, for example some people have exhausted the possibilities of raising their floor, since the space between roof and floor is getting too small. This is a direct consequence of the method used, which does not involve more then just a top layer of concrete on the existing floor.

In the following photo one of the most innovative walls installed by an inhabitant can be seen. This wall is constructed on the outside of a lot located along the road to San Jose. In recent years the water problems has worsened significantly. In the small ditch water rises within half an hour up to half way the wall. The water is transported all the way alongside the road before it is flown through a culvert. What can be noticed here is that waterways have changed their flow direction since culverts are blocked⁴². It is something that happens more often and is changing areas into storage areas in case of rainfall instead of running off the water directly. The wall presented in the photo was installed after raising the garden a few times. However since this did not work the owner installed a wall with valves. These valves have been installed to run off the water from his lot into the ditch. The level of

⁴² Based on interview with the owner and designer of the constructed wall



the valves is exactly on the level of the soil on the other side of the wall and is connected to small ditches that drain the garden. Another construction can be seen on the next lot. Were the bridge has been raised together with the wall. It is illustrating for the increasing water levels that have been occurring throughout the years.

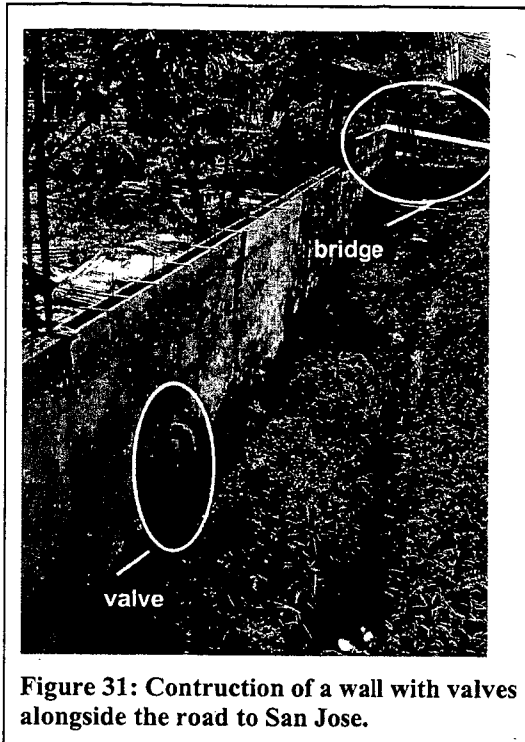


Figure 31: Construction of a wall with valves alongside the road to San Jose.

The informal actions taken by people are increasing, however unfortunately not always in a very helping way. Often structures do not serve the common [public] interest since people have built towards their own interest neglecting the existing situation. An example is the numerous bridges that have been built by groups of people to make their [former informal] house accessible. These constructions should be not underestimated in their dimensions and their influence on the hydraulic situation of the watershed. Bridges are built too close to the water surface and obstruct the water to flow in case of water level risings. The municipality obviously does not feel responsible for these constructions and the people are often unable or unwilling to carry out the appropriate maintenance or reconstruction works.

B.3.10 Review

In the administrative and institutional setting there is no clear planned strategy towards reducing flood risk. Besides this the different institutes hardly cooperate in managing the watershed. Even institutes operating in the same area and with coinciding goals, such as Japdeva and the municipality, are taking actions individually without cooperation. The organisations take measures individual and generally do not perceive the goal of flood risk reduction. As a result the only actors with a real flood risk reduction strategy are some of the citizens. They are the predominant actors that take measures immediately reducing their individual flood risk. Nevertheless they take these measures individual and there is no general interest for them. Consequently on a community level their measures can have a negative impact on flood risk, since water storage capacity in cases of floods are getting scarce. Furthermore the measures are uneconomic since every person takes measures individually.



Although there is no integrated flood risk reduction strategy, there are some policies present for the Limoncito watershed that do influence the flood risk. In the following list some of the measures concerning the Limoncito and flood risk reduction are given that have a positive effect on the flood risk situation in the watershed.

Measure		Institution
<i>Technical measure</i>	Installation of breakwaters	Japdeva
	Installation of a canal	Japdeva
	Periodical maintenance of waterways	Japdeva, MOPT
	Installation of individual technical measures	Citizens
<i>Ecological measure</i>	Designating area within Limoncito as wild live refuge	MINAE
<i>Economic incentives</i>	Subsidies on geographical appropriate housing design	MIVAH
<i>Regulation measures</i>	Solid waste tax	Municipalities
	Land registration	Municipalities
	Zoning of land (prohibited to built within 10 meters from river)	Municipalities
<i>Institutional arrangements</i>	Responsible for the coordination in case of flood emergency	CNE
	Responsible for the indication of possible flood prone areas	CNE
	Responsible for ecological sustainability of the watershed	MINAE

Table 30: Review of flood risk reduction measures

In the above stated there are some measures taken by different institutions. The question however is if measures are executed by the right institute. Japdeva and MOPT, for example, simply carry out maintenance works because they have the technical equipment and capabilities. They are not responsible for the watershed, since it is completely located within the municipal boundaries. However since the municipality does not have the sufficient resources the MOPT and Japdeva occasionally assist them with the public works.

The zoning of land where the municipality has a strong influence is carried out poorly. Especially the poor execution of the Land-use policies in the past has brought about a terrible situation in which the river is not given enough space to flow. The failures have especially occurred in the enforcement of this policy. The identification of the zones has been carried out only the preservation of the zones has failed.



C. Prescriptive Part

C.1 Evaluation

In the evaluation the three systems will be assessed, according to the foregoing descriptive parts. The focus will be the character of the damage of the floods, in order to put the situation into perspective.

	Social or Human Effects	Physical Effects	Economic Effects
Primary Effects	Some decrease of income since inhabitants are unable to work	Loss of ground quality due to contaminated water Structural damage due to water problems	Probably in the case of a large flood very high. It was calculated for the flood of November 2000 in Limon that the repair of bridges, roads and the damage to agriculture cost Costa Rica about 0,17% of the GDP.
Secondary Effects	Diseases are common after a flood. Even dead have been reported. Commonly due to the contaminated water	Damage is often not repaired and the state of buildings and roads are decreasing due to the water problems	There is hardly any investment activity so they cannot be withdrawn. The people who are living here do will probably not leave since they do not have the opportunity to leave.

Figure 32: Evaluation of the flood damage in the Limoncito watershed

What can be seen is that the impacts of the floods in the Limoncito watershed are often not directly visible and therefore not recorded. Both the deterioration of capital, the hesitation to invest in flood prone area and the contamination of soils are difficult to notice. Furthermore direct causalities and fatalities are generally not present. Yet diseases often emerge days after the flood, when they are not directly linked to the flood. As a result the area is neglected in the integrated flood risk research and management. And moreover flood risk reduction strategy focusing on this watershed is absent

It is difficult to compare different emergencies; nevertheless in the following figure the flood is put into perspective with other floods. The figure is only to give a feeling of the situation and those not say anything about true factors. What the Figure emphasizes is that the risk situation in compared to other rivers in the region is different. The probability of floods is much higher (probably 3 to 4 times) and the damage spectrum is different and less dramatic. Houses are not swept away and people do not die directly. Yet the impact of the water on the deterioration of physical capital and the pollution it brings into houses is damage less visible. However with the occurring frequency it has a great impact on the situation. It is the accumulation of effects that make the problem greater than the individual flood damage

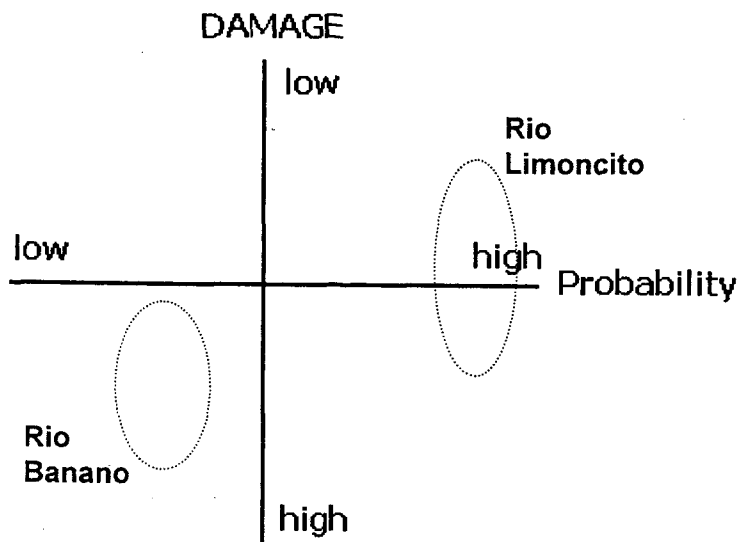


Figure 33: Flood risk situation

The flood risk situation and flood damage pattern are influenced by the factors emphasized on in the descriptive part of the report. In the next chapter “conclusion” the constraints, problems and opportunities forthcoming from the research will be elaborated on.

C.2 Conclusion

The conclusions are drawn from the different reviews and the foregoing evaluation. It focuses on the constraints, problems and opportunities to reduce the flood risk in the urban areas of the Limoncito watershed.

The flood risk in the urban areas of Limon is illustrated by the numerous occasions that the Limoncito River exceeds its riverbeds. If then is considered that this area is densely populated and that more than half of the citizens in Puerto Limon live in this region then the flood risk reduction should be considered as an important aspect on the political agenda, moreover if the quality of the water is looked upon as well. However neither on a local level as on a national level flood risk management is prioritised. Even regulations such as urban planning regulations are executed poorly and thereby increasing flood risk.

It is impossible to reduce the flood hazard to low probabilities. As long as people want to live on the Atlantic side of Costa Rica one has to keep in mind the dangers of floods. Nevertheless a reduction of the flood risk is possible. The frequency occurring at this moment of 3 floods a year is far too great. Especially the risk of local urban flash floods can be reduced significantly.

From a hydraulic point of view the flood risk is too high, since run-off is not efficient. Small dam ups in the river cause significant water level risings up stream. This is not well understood by the institutes and the inhabitants in the watershed. The amount of dam ups is tremendous in the watershed. The block ups vary from garbage to pipes crossing the river. Often these small block ups can be removed easily. By doing so this would already reduce the flood risk significantly. Most important is to run-



off the water as quickly as possible by reducing the number of block ups in the waterway and by shortening the length of the waterway.

The length of the waterway is very long in the present situation, especially in the lowland stage the river meanders through the urban area. The canal built by Japdeva as a bypass is a good start. However it is not working sufficient since flood risk still is high. It is worthwhile considering if more radical shortenings would be recommendable. In particular in the southern area of the watershed where population is less dense and the canal of Japdeva is already present possible by-passes could be installed.

Another aspect that has a considerable effect on the flood risk is the narrowing of the river by illegal housing. Although these houses are not recorded they are still being built. The municipality is not being strict enough towards these illegal actions. They would help the community by following existing regulations on land-use. The municipal employees indicate that they do not have the appropriate equipment to execute these laws. Nevertheless the employees at this moment hardly act active on the enforcement of land-use regulations.

The land-use in the entire watershed is causing tremendous problems. And it cannot be expected that flood risk will stagnate or reduce in the near future as a result of the future urbanisation developments. At this moment private companies develop neighbourhoods on the hills of the watershed. This will worsen the situation significantly, because forest and marshes are replaced for typical Costa Rican houses in which nothing of the soil is left open to infiltrate water. Besides this the municipality is lacking all power to control or overlook the situation of urban development. It is especially worrying since these neighbourhoods are located between the canal and the existing urban areas. Meaning that the water from these areas will run-off will through the flood prone areas, this will increase the pressure on the capacity of the waterways. The present urban development of Puerto Limon should be considered as a threat to the flood risk reduction in the watershed.

The neighbourhoods facing flood problems often also have other problems, such as bad infrastructure, high unemployment and insufficient public facilities. It is an interesting point if areas with flood risk attract the lesser fortunate or that the lesser fortunate are unable to better their situation. Fact is that these flood prone areas used to be informal settlements, yet since many years have passed the dwellings should be regarded as legal, as Costa Rican law also indicated them as legal after 10 years. The government should give more attention to these neighbourhoods from a perspective of equity. One of the public facilities lacking in the flood prone areas is the public sewerage. The different types of systems at this moment present in these neighbourhoods heavily pollute the water of the Limoncito River. These contaminated waters are partly discharged onto the coastal shores in the vicinity of Puerto Limon. Since coastal management is a focus point of the Mayor of Puerto Limon it should also be his priority to bring down these contamination levels. If the coast would be managed integrated the discharge would be of importance when planning the coastal management strategies.

The responsibilities of the watershed and the flood risk reduction are unclear. Because the river is completely located within the boundaries of the canton of Limon they should be responsible. Yet they are hardly capable to manage the watershed, not to mention the capabilities to notice possible threats to the flood risk situation.

At this moment maintenance and technical flood risk reduction measures are carried out in structured manner. Often there is informal contact between the municipality and the MOPT or Japdeva to execute works. Due to this there is no rational periodic maintenance. Furthermore there is no cooperation between the Japdeva and the municipality of Limon. It is unbelievable that these two institutes do not cooperate, especially in the field of socio-economic development of region. Besides



this Japdeva have the capabilities and the resources to assist the municipal government in the management of the watershed.

As most other institutes the municipality has great problems with their resources. As a result it is very difficult for them to execute projects, more than 80% of their budgets are spent on salaries. The lack of resources and ignorance within institutes with problems in the watershed make it understandable that only a few institutes are active in reducing the flood risk. Therefore it is hard to pinpoint responsible actors across since resources are scarce.

Citizens take a particular role in the flood risk reduction in the watershed. Since the government is acting insufficient in flood risk reduction, inhabitants have started to protect their own houses. The informal risk reduction measures are numerous [more than 50% of the respondents have taken technical measures] and it is expected to improve since many inhabitants indicate that they are saving for such investments. The investments are stimulated because the inhabitants cannot move. They often own the house and selling the house is impossible because it is worthless located in the flood prone area, therefore long-term investments are made.

The individual measures have significant negative side effects. Whereas they reduce the flood risk of individuals they do increase flood risk of the community. In the case of a flood the water is getting less space with the installation of walls, inundation therefore will shift to new areas or raise higher. Besides this the individual measures are economically inefficient. Instead of many small investments, the flood risk would reduce more efficiently if large investments would be made with a public interest. However therefore the government needs to accumulate resources through the installation of taxes.

C.3 Recommendations

From the conclusions in the foregoing chapter can be drawn that flood risk is bound to worsen. In order to reduce the flood risk situation and better the socio-economic situation in the watershed the following recommendations are made.

- The **national government** should implement a legal framework in which watersheds are managed and coordinated on a watershed level by an appointed institute. Such a framework could furthermore clarify responsibilities across institutions and allocate resources. Besides this knowledge and experiences on flood risk reduction measures can be interchanged between watersheds.
- If the **national government** wants to improve flood risk management, more funds should be made available. These resources should be collected with actors and consequently should be earmarked to watershed managing related measures and checked on their effectiveness. The essence of this recommendation is that initiating measures is not enough; they should be controlled as well on their effectiveness.

On a local level the greatest steps can be made in the reduction of flood risk.

- The **municipality** should take all responsibility for the watershed management. And at the same time they should claim the resources necessary to carry out this task. They are the institute that can serve the public interest the best in Puerto Limón. It is a difficult task since resources in all institutions are low.
- Furthermore **Japdeva** should cooperate more with the municipality, and perhaps even transfer knowledge to the municipality. This way the municipal government is enabled to reduce flood risk and enhance socio-economic development.



- On a short term the **municipality** should strengthen their capabilities to enforce the land-use policies, especially since land is getting scarce in and around Puerto Limon. The land-use policies are of vital importance for the reduction of flood risk. Furthermore the municipality should play an active role in the urbanization pattern of Puerto Limon, by determining appropriate urban development locations taking into account flood risk reduction.
- Executing a 'plan regulador' as argued also by national law should appoint possible urban areas that take into account flood risk reduction. Therefore the execution and implementation of such a plan is essential. Funds should be made available for such a plan.
- Subsequently the people inhabiting the illegal zones near the rivers should be stimulated to move, by offering cheap land as a replacement. On the long term these people can never stay in these houses, especially since they have negative effect on the flood risk on a community level. Compulsion should be a consideration to move these people.
- In the urbanization plans of Puerto Limon the municipality should acknowledge its special situation. This implicates that housing design should be appropriate to the location. Like the MIVAH the municipality could install regulations regarding housing design appropriate for flood prone areas.
- In an ideal situation the flood prone areas would only have houses on poles, like in the early years of Puerto Limon. These houses on poles would give space to the river in case of floods and furthermore decrease the vulnerability of the inhabitants. The MIVAH, INVU and the municipal government should stimulate these building designs by information and regulations.

For the hydraulic situation the **municipality** can take simple and effective measures. These measures will probably have the most direct effect on the short term for flood risk reduction.

- First of all there should be an inventarisation of the waterways. This does not have to be a complicated task, since the inventarisation can focus on the actual block ups in the river.
- Closely related is the installation of a measuring system for floods. By recording water levels on different places in the neighbourhoods a better understanding of the floods can be obtained. Simple recording of water levels on walls should be sufficient.
- The municipality should prioritize flood risk reduction in her policies; so on the short-term flood risk can be reduced easily. This involves the removal of pipes, bridges and the cleaning of culverts. These actions are not costly and can be carried out with simple techniques. These appropriate measures should follow from the inventarisation made.
- To manage the watershed more effectively a network of responsible citizens should be installed. These appointed citizens should clean up nearby waterways and could record flood levels on the walls of their houses.
- Finally the water quality should be improved. This probably is a long-term measure, since the installation of a public sewerage is costly. The municipality should specify the need of such facilities within the national government. Although it is costly it will bring many positive effects to citizens and business in the researched area.

As noticed throughout the report the municipality, like other institutions, has many responsibilities and is not capable to carry them out due to insufficient funds. Since municipal taxes are uncommon in Costa Rica municipalities keep struggling with their budgets. The municipality of Limon should first of all generate more funds by increasing taxes. These taxes should be earmarked directly to measures. By doing this the public can directly evaluate if their contributions have been spent to their satisfaction. In the case of flood risk special watershed taxes could be installed to carry out flood risk measures. As noticed the people do invest individually, nevertheless the raising of tax could make flood-reducing investments possible on a larger scale and measures that are focused on the public interest of flood risk.



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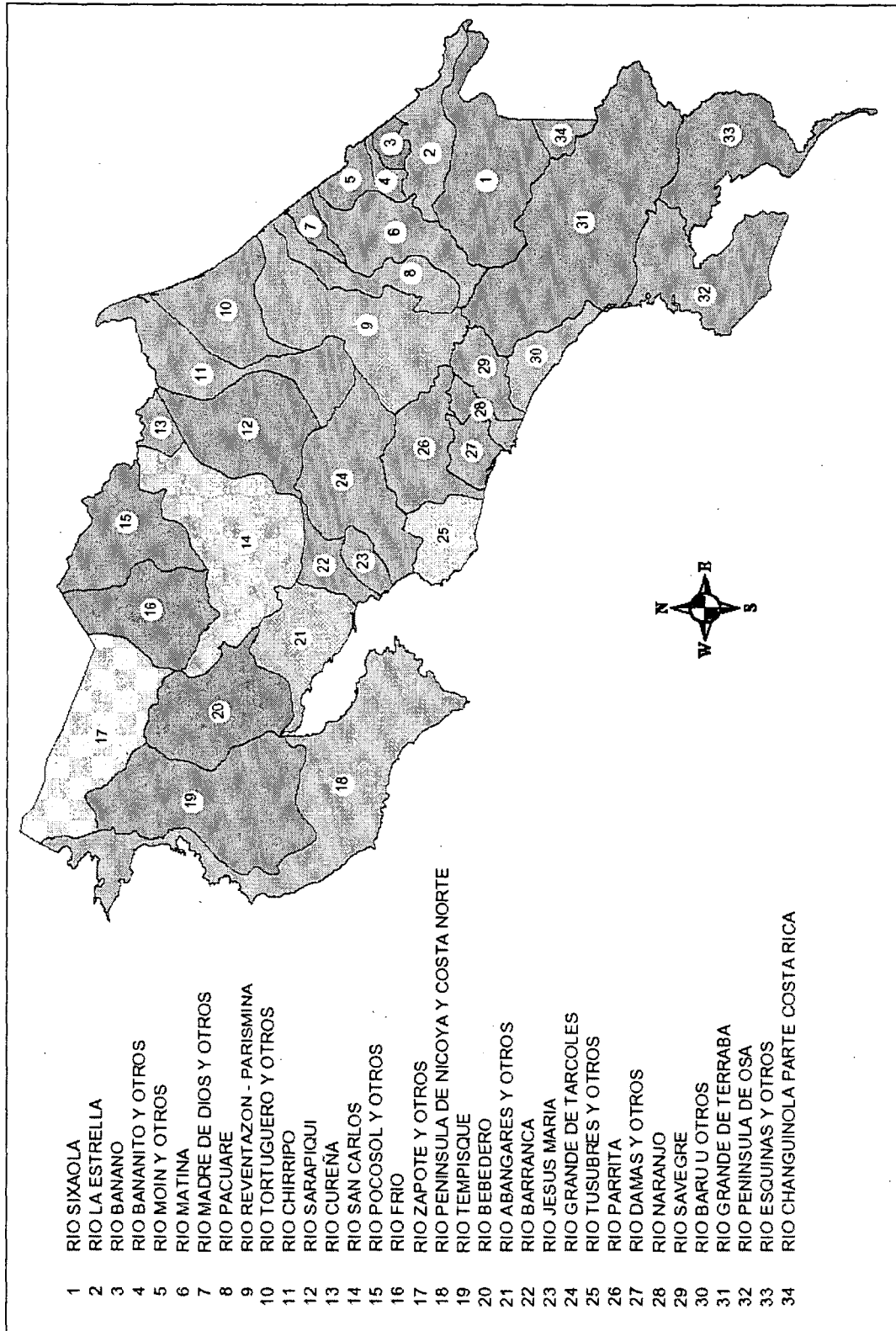
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If you would like to receive a copy of one of the above indicated M.Sc. theses, please contact:

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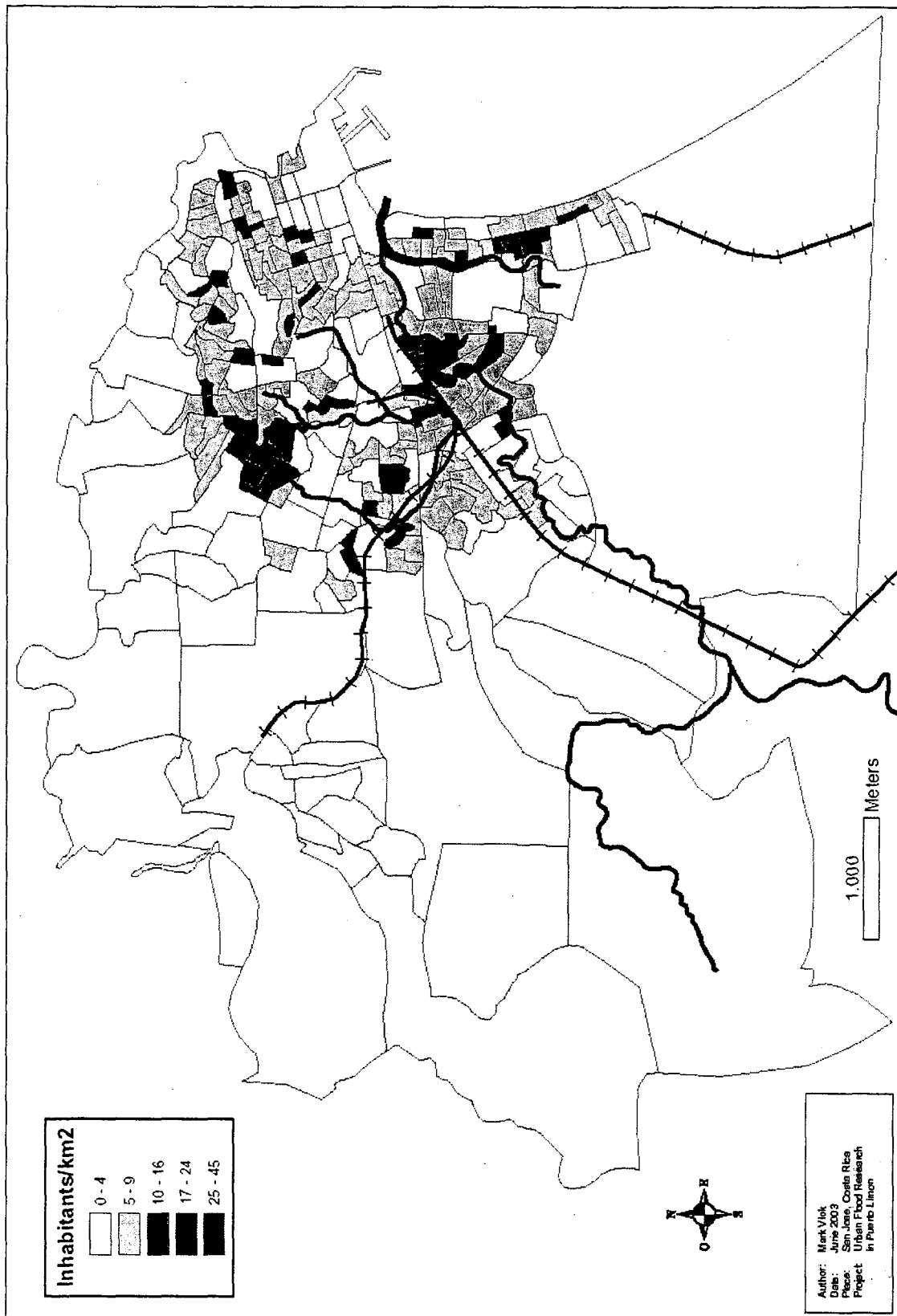
Appendix 2: Costa Rica Watersheds



Author: Mark Vbak
 Date: June 2003
 Place: San Jose, Costa Rica
 Project: Urban Flood Research in Puerto Limon



Appendix 4: Population density





Appendix 5: Photos of Culverts

Culvert I: Quebrada Chocolate

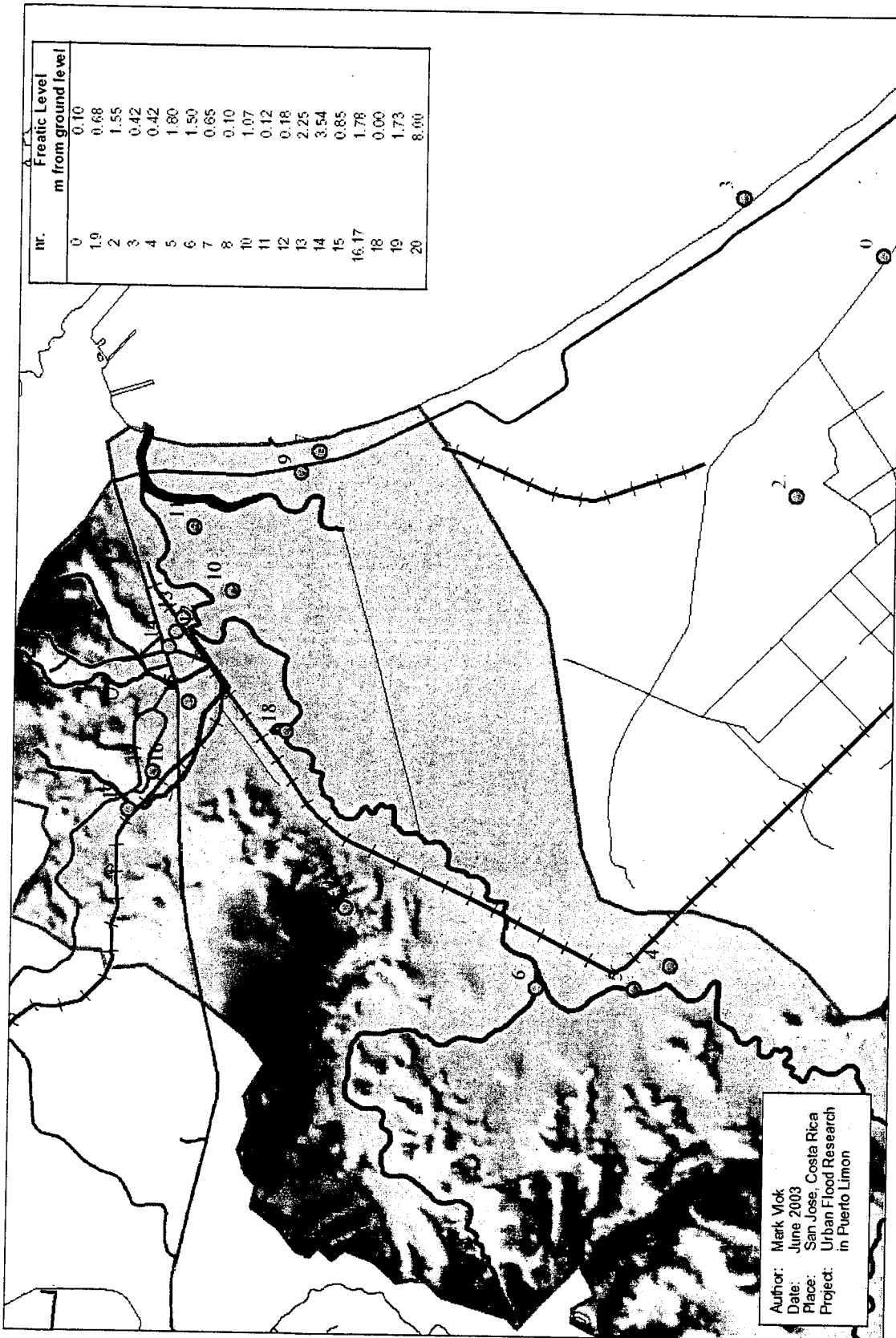


Culvert II: Quebrada Bamboo



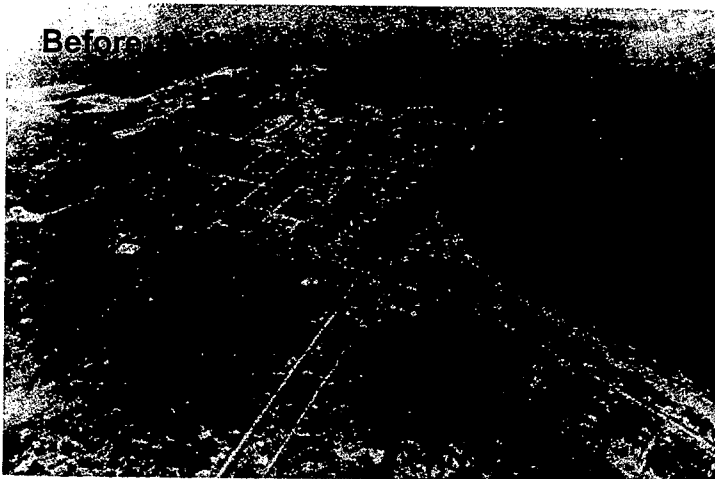


Appendix 6: Ground water levels





Appendix 7: Limoncito river mouth





Appendix 8: Aerial map





Appendix 9: The Survey

<p>1. ¿Es hombre o mujer?</p> <p>Hombre..... <input type="radio"/> Mujer..... <input type="radio"/></p>
<p>2. ¿Cuántos años cumplidos tiene....?</p> <p style="text-align: center;">Años __ __</p>
<p>3. ¿Número de años que ha vivido en esta casa?</p> <p style="text-align: center;">Años __ __</p>
<p>4. ¿Número de años que ha vivido en este distrito?</p> <p style="text-align: center;">Años __ __</p>
<p>5. ¿Número de años que ha vivido en Puerto Limón?</p> <p style="text-align: center;">Años __ __</p>
<p>6. ¿Esta vivienda.....</p> <p>...Es propia totalmente pagada?.. <input type="radio"/></p> <p>...Es propia pagandola a plazos?..... <input type="radio"/></p> <p>...Es alquilada?..... <input type="radio"/></p> <p>...Está en un precario?..... <input type="radio"/></p> <p>Otra (cedida, prestada) <input type="radio"/></p>
<p>7. ¿Cuántas inundaciones se han dado mientras ha vivido en esta casa?</p> <p style="text-align: center;">Número __ __</p>
<p>8. ¿Cuántas inundaciones cree usted que ocurren normalmente en esta zona?</p> <p style="text-align: center;">Número por año __ __</p>
<p>9. ¿A qué nivel llegó el agua durante la inundación en <u>noviembre del año pasado</u>?</p> <p style="text-align: center;">Metros __ __ sobre nivel de suelo</p>
<p>10. ¿Por cuántos días estuvo inundada esta zona en <u>noviembre del año pasado</u>?</p> <p style="text-align: center;">Días __ __</p>
<p>11. ¿A qué nivel llegó el agua durante la inundación en <u>mayo de este año</u>?</p> <p style="text-align: center;">Metros __ __ sobre nivel de suelo</p>
<p>12. ¿Por cuántos días estuvo inundada esta zona en <u>mayo de este año</u>?</p> <p style="text-align: center;">Días __ __</p>
<p>13. ¿Cuáles considera usted que son las causas de las inundaciones? Iden Identifique in orden de importancia descendente de 1 a 6 (1 indica la principal causa de inundacion)</p> <p>No limpian bien los ríos..... <input type="checkbox"/></p> <p>Aumento de las lluvias a lo largo de los años..... <input type="checkbox"/></p> <p>Construcción de más casas en Puerto Limón..... <input type="checkbox"/></p> <p>Las personas viven muy cerca de los ríos..... <input type="checkbox"/></p> <p>Mucha basura en y alrededor del río..... <input type="checkbox"/></p> <p>Deforestación (tala de árboles)..... <input type="checkbox"/></p>

14. ¿A tenido daños en la infraestructura de su casa (paredes, piso, etc.) por culpa las inundaciones?

No.....

Si..... Describa los, _____

15. ¿A tenido la perdida parcial (dañado) o total de objetos personales por culpa de las inundaciones?
(ropa, muebles, artefactos eléctricos)

No.....

Si..... Describa los, _____

16. ¿Cuántos refrigeradores ha perdido debido a las inundaciones?

Número _ _

17. ¿Le gustaría cambiarse a otra casa para evitar las inundaciones?

No.....

Si.....

18. ¿Dónde lleva o mueve sus pertenencias durante una inundación?

No mueve.....

Mueve dentro de la casa.....

Mueve al techo.....

Mueve a otra casa.....

Otra lugar..... ¿A dónde? _____

19. ¿Durante una inundación que hace para prevenir que el agua entre en su casa?

20. ¿Ha realizado algún arreglo o modificación en la construcción de su casa para evitar que las inundaciones la dañen?

21. Realizará alguna modificación en su casa para prevenir los daños de las inundaciones?

Este año.....

En el próximo año.....

En los próximos años.....

