UPGRADING SANITARY SERVICES

IN SQUATTER SETTLEMENTS

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ABSTRACT

This thesis describes a project consisting of the application of an "upgrading process" to an existing squatter settlement located in the Dominican Republic. The aim of the project is to upgrade the environmental quality of the community, and to improve the health of its inhabitants through the application of simple sanitary technologies in the areas of sanitation, solid waste, waste water drainage and water supply. This would serve the purpose of raising the living standard of the settlers a few steps closer to the approved standards of sanitation. The upgrading options proposed are kept within the socio-economic context of the settlement to avoid confronting the group with alternatives beyond their understanding or economic power.

The project tries not only to upgrade the physical aspects of squatter settlements, but also to communicate to the settlers a new approach to their everyday problems; to make them aware of their capacity to create new ideas; the possibility of finding practical solutions and the importance of communicating the methods learned to other settlements.

RESUME

Ceci est un projet qui consiste dans l'application d'un proces sus de développement progressif pour un bidonville situé en République Dominicaine.

L'objectif: améliorer la qualité de l'environnement de la communauté en question, en misant sur la santé de ses habitants à travers l'application d'une technologie sanitaire simple dans les domaines suivants: salubrité, déchéts solides, drainage des eaux résiduelles et, en fin, pourvoir la communauté d'un systeme d'eau potable légèrement plus en accord avec les normes sanitaires reconnues afin d'améliorer les conditions de vie.

Les divers projets pour un améliorement progressif doivent se maintenir dans le contete socio-economique de la communauté en question afin de ne pas proposer des alternatives qui soient au-delà de sa compréhension ou de ses possibilités économiques.

A part l'aspect physique du projet il faut souligner le propos essentiel: communiquer aux habitants une nouvelle approche a ses problemes quotidiens.

Les rendre conscients de leur capacité d'enoncer de nouvelles idées et d'amener ces idées a une application concrete afin de pourvoir faire part a d'autres de l'ensemble du proces sus le développement.

ACKNOWLEDGEMENTS

I would like to thank:

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Mr. and Mrs. Gagnon for all their love and interest. Montreal is home.

My parents for their continued support and care not only in this work but throughout all my dreams.

To my husband and my brother Jaime for their help and encouragement.

To my children Anna Francina and Sully Manuel for sleeping all night long.

And to my very good friend Amalia, for not sleeping at all.

DEDICATION

To my brother Manolo.

Now you must dedicate yours to me.

Maggie

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INTRODUCTION

When squatter settlements are studied, in particular those with the worst housing conditions, one finds that the houses themselves are not really the main problem that settlers face. No matter what the quality of the houses is, it is an achievement for the settlers since they have managed to provide themselves with a shelter of their own.

This is not to say that the houses do not need a great deal of improvement, but that there are other serious problems, such as the poor environmental sanitary conditions that exist in those areas, that need more urgent attention than the badly constructed houses themselves.

Poor environmental sanitary conditions affect the settlers directly, since an unhealthy environment promotes the transmission of various diseases. These conditions also have an indirect effect on the socio-economic status of the settlers, because health, once lost, brings about a lack of interest for other aspects of daily life.

The objective of this thesis is to preserve the health of the inhabitants of marginal settlements, and to promote the integral development of these communities through a process of continuous social evolution.

This objective will be attained through the application of simple technological innovations to the selected areas of work. They are:

a) Sanitation

b) Solid waste and drainage

c) Solid Waste treatment

d) Water supply

There are many different approaches that can be taken towards solving housing problems and the conditions inherent to their environmental surroundings. In this case the process of upgrading has been chosen over the others, because it does not increase the number of homeless people through destruction of the already existing resources. The upgrading approach takes advantage of all available resources, even if their conditions are well below acceptable standards. It then improves them from there on, according to the possibilities at hand.

There are inherent losses in high standard projects which are carried on without taking into account the fact that people might not be ready for them. These losses are avoided by using the upgrading approach. In some cases, the users involved in high standard projects have eventually adjusted the projects to their own living standards, rather than raise their living standards to meet the projects' expectations.

This does not imply a deliberate intent on the part of the settlers to lower living standards, but it shows that their ability to adapt to change was overestimated, and that various factors needed to change the behavioral patterns of a community were not taken into account. In short, in high standard projects, settlers and their needs were not given the consideration they deserved.

When the squatter communities have assimilated the changes that have been taking place, then, and only then, can another step forward be taken. In this way, the groups of inhabitants will not have to face options that may create conflicts with their life patterns, background and traditions.

To get to know the reality of squatter settlements, and also to make this work applicable to diverse communities in situations similar to the one described in the first part of this thesis, a study has been made of an existing community located in an urban context. This settlement illustrates the typical characteristics representative of vast areas with environmental sanitary problems. The study includes a description of the following aspects:

a) Location of the settlement

b) Physical characteristics

c) Type and quality of existing buildings

d) Social and physical organization of the settlers

e) Background and traditions

f) Income assets

This physical, socio-economic and cultural study of the settlement, permits an understanding of the life patterns, needs and limitations of the inhabitants of squatter communities. This also allows a selection to be made of the aspects that need to be upgraded, at the same time avoiding any imposition on the life style of the dwellers.

The squatter settlement named La Zurza has been chosen because it is large enough to represent all aspects of a typical settlement, and because the basic socio-economic information was available from two groups of students of the Universidad Nacional Pedro Henriquez Urena, which during 1974 and 1975, conducted surveys in the settlement.

In summary, this thesis consists of:

a) Socio-economic, cultural and physical identification and description of an existing squatter settlement.

b) Identification and description of the pertinent environmental sanitary options.

c) Upgrading proposals applied through a process of technological innovation.

PART ONE

PHYSICAL AND SOCIO-ECONOMIC DESCRIPTION OF AN EXISTING SQUATTER SETTLEMENT

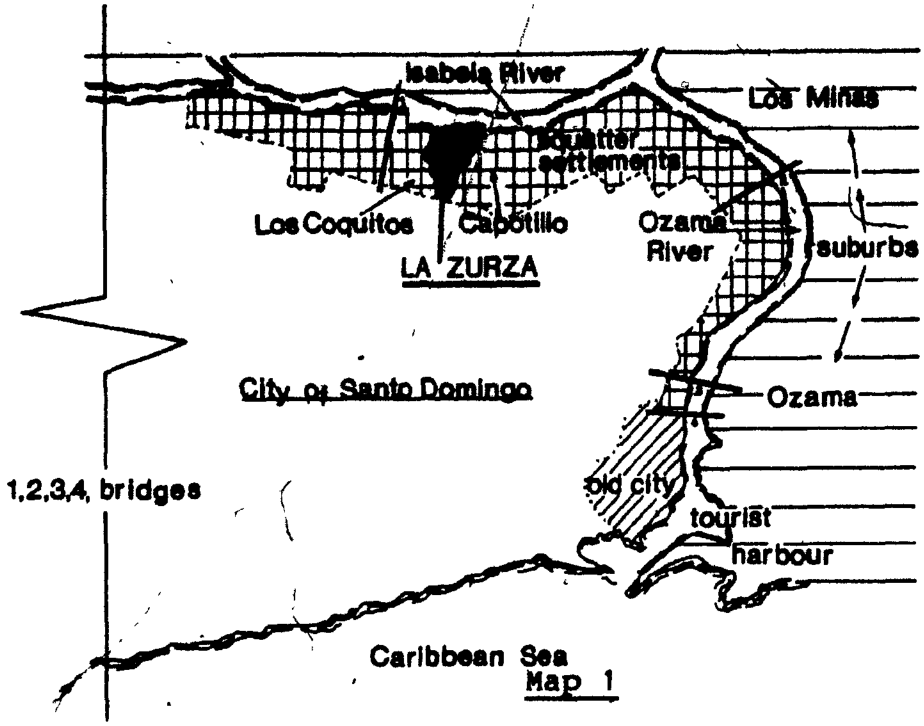
Chapter 1

LA ZURZA SQUATTER SETTLEMENT

1.1 PHYSICAL CONDITIONS

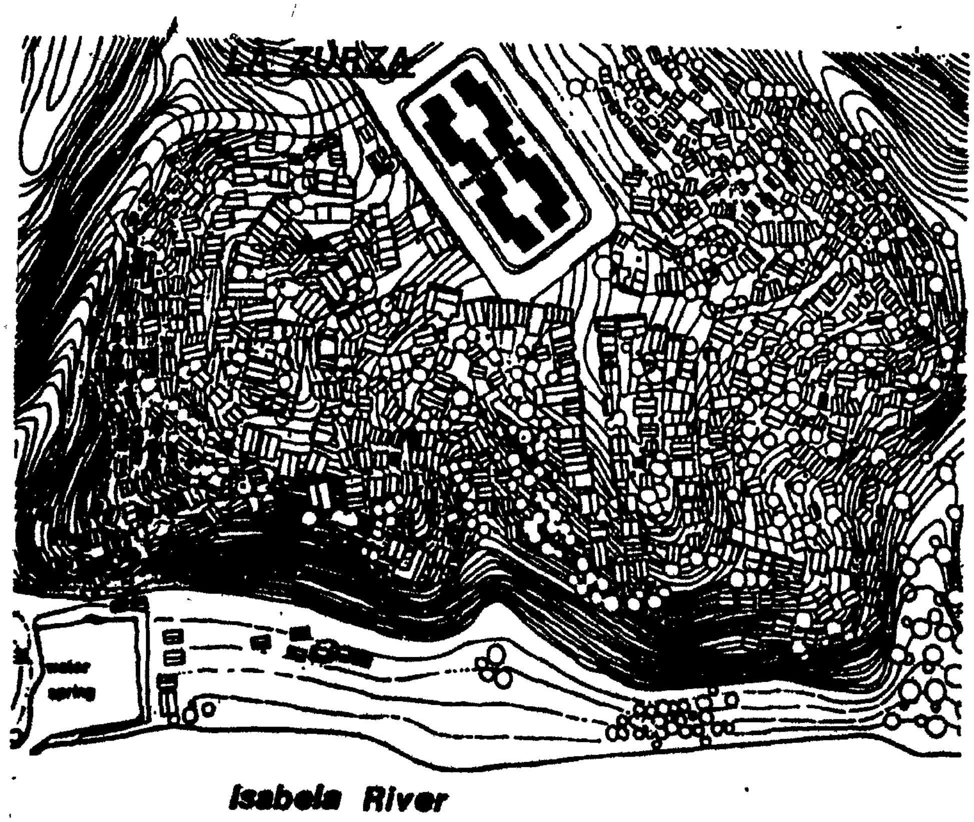
1.1.1 Location

La Zurza is a squatter settlement located in the northern part of the city of Santo Domingo (Map 1), by the side of the Isabela River. This land was owned by the family of the dictator Rafael L. Trujillo, who governed the Dominican Republic for thirty-one years before he was assassinated in 1961. In a series of interviews with Ing. Ramon Baez Lopez-Penha, Dean of the Engineering Faculty of the Universidad Nacional Pedro Henriguez Urena, it was learned that, shortly after Trujillo's death it was suggested that this land of unique beauty be kept in its natural state as a public park, as it had lots of trees and good swimming spots of which La Zurza water spring was the most beautiful (it is after this water spring that the existing squatter settlement is named). However, this land was never made into a park and over the years that followed, little by little, it was encroached on by immigrants from the rural areas who came to the city in search of better opportunities. It was not until 1965, the year of the Civil Revolution, that massive



Map 1

"La Zurza" Location in the City of Santo Domingo



Map 2 Scale 1:2500

Location of the Government Built Housing Project invasion turned this area into a squatter settlement.

During the mid-1970s a small public housing project was built (Map 2) at the entrance to the squatter settlement. It consists of four buildings, four stories high, each containing eight apartments. Since then no more housing facilities have been built in this area.

1.1.2 Topography

The area occupied by La Zurza is eight hectares. It is inhabited by 4,256 persons (1975) which is equal to a high density population of 655 persons per hectare[10]. Most of this area consists of steep slopes that make the site topography very abrupt with great differences in elevation. Figures 2, 3, 4 and 5 give an idea of how steep this land really is. Steps carved into the ground (Figs.2 & 6) may be found in many areas. Sometimes, when these are on a main path, wood is used to prevent the steps from breaking (Fig. 16). The purpose of these steps is to facilitate access to the steepest parts of the settlement. In Figure 3, if the children in the foreground are compared to the land by the riverside, the overall difference in level of the area can be appreciated. This lower part land will be called the "Low-land", as it is found at the lowest level of the site. If it is assumed to be at elevation 0.00 m, the highest level would be 45.00 m (Map 3) Figures 4 and 5 show level differences in the other areas of the settlement.

Fig. 2

Carved steps to give access on the steepest slopes.

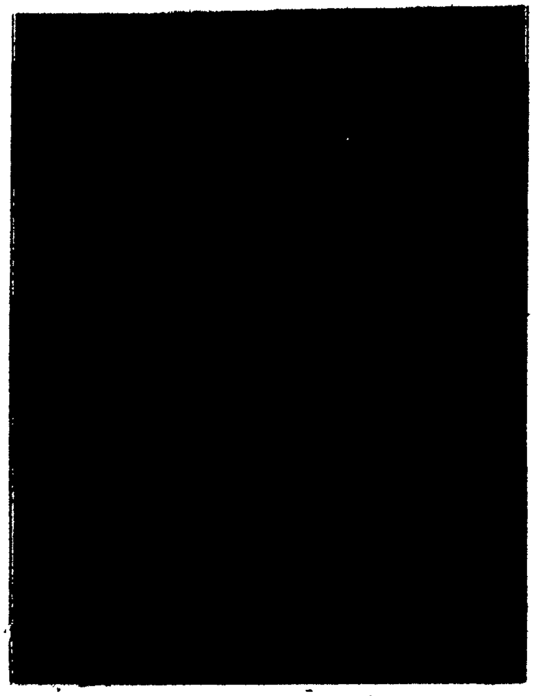


Fig. 3

Difference in level between the lowest and the uppermost parts of the settlement.

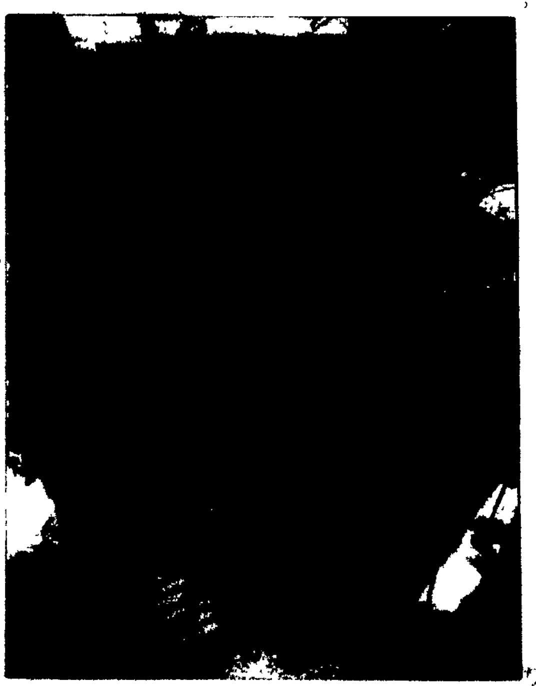


Fig. 4

One of the deepest ravines found in La Zurza.

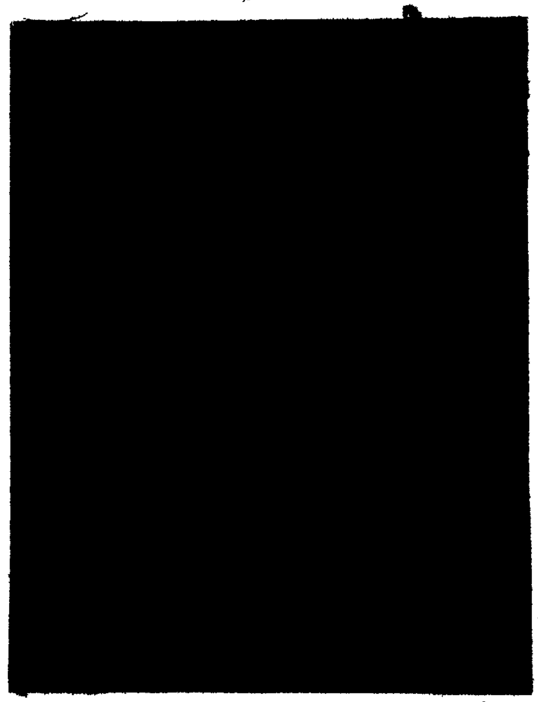
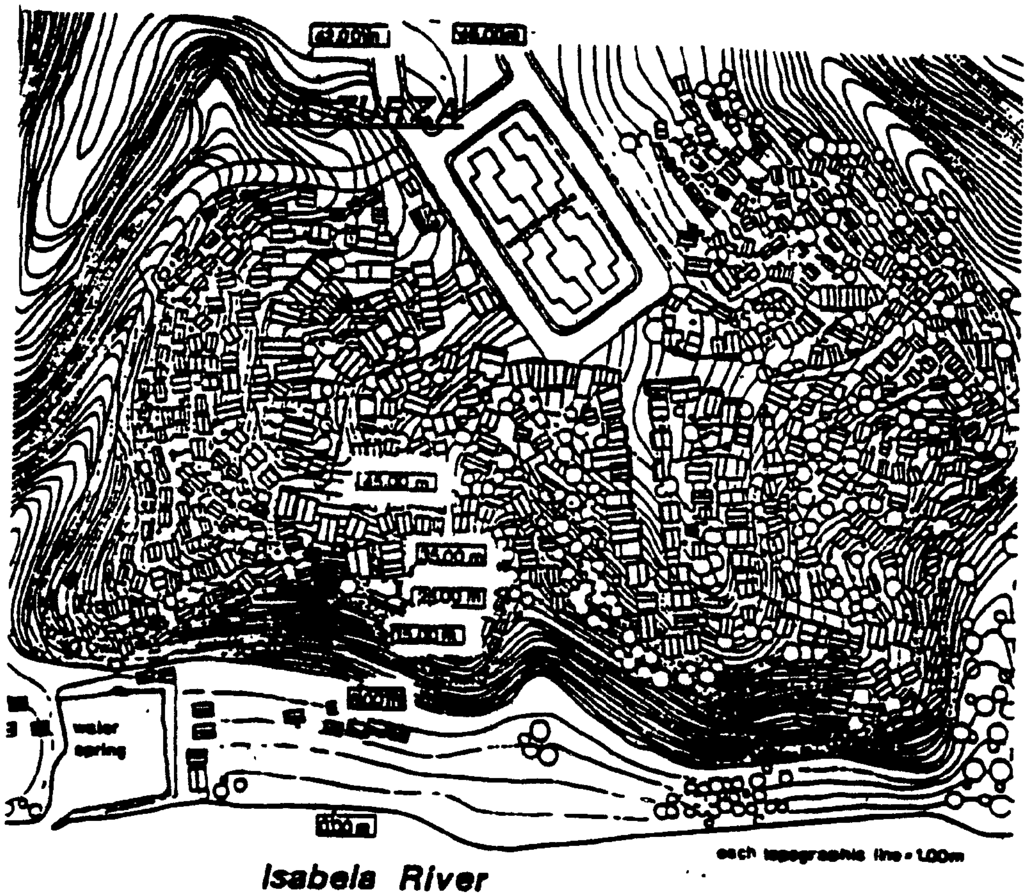


Fig. 5

Stone built retaining wall.



Map 3 Scale 1:2500

Topography

Fig. 6

Carved steps on a main path.

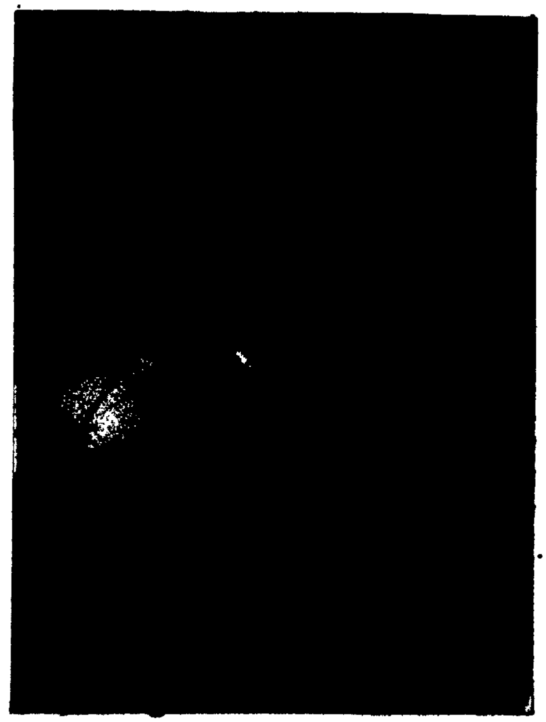


Fig. 7

Concrete retaining wall.

Retaining walls (Fig.4) are common in the area and are made out of different materials such as stones (Figs.4 & 5), car tires (Fig. 13), cement blocks (Fig. 14) and concrete (Fig. 7).

Changes in the natural topography of the terrain are due mainly to alterations made by the settlers themselves, and not to natural earth movements. These alterations are found on the steepest slopes (Fig. 8) where the settlers form terraces to build their homes. As seen in Figures 9 and 10, these terraces vary in size depending on the house to be built. In the lower left corner of Figure 9 the roof of a house can be seen; this is one entire storey below the first house.

1.1.3 Soil Composition

The soil in the area of La Zurza, is composed of 90% calcium carbonate and 10% organic clay[10]. The poor absorption capacity of this type of soil causes most of the rain and wastewater to remain on the surface of the terrain making it muddy, and dangerous to walk around. Only the steepness of the site, which allows the rapid drainage of waters (Fig. 11), reduces the problem of stagnant water pools. This "natural drainage system" causes great erosion to the terrain, however, and has created numerous ravines and gullies.

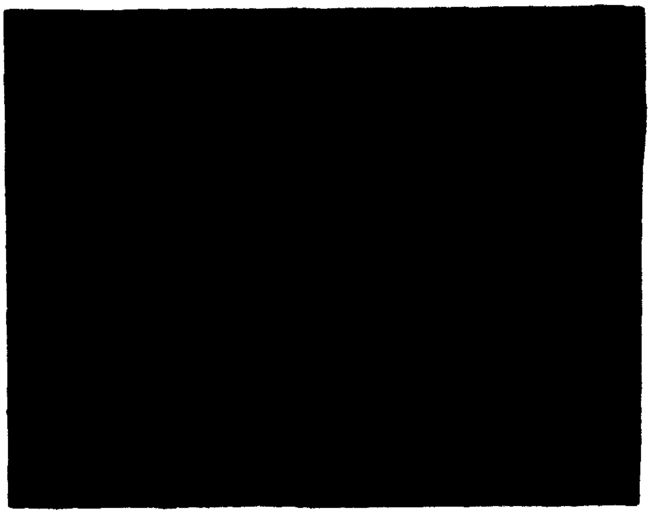


Fig. 8

Man-made construction terrace.

Fig. 9

Small house on a cut-out slope.

Fig. 10

Man-made terraces are found of any desirable size.

1.1.4 Drainage

Apart from this "natural drainage system", no other system exists. Due to the steepness of the site no stagnant water is found in the area except for that shown in Figure 12, which is on the Low-land, where the water table is high. Notice that an old foundation and part of the floor of an old house are part of the reason for this still-water pool.

Due to the over-population of the area, some houses have been built over the drainage gullies (Figs.13 & 14). In Figure 13, besides the house built over the drainage ravine, a retaining wall made of car tires can also be seen, as well as a few carved steps protected with precast concrete forms.

1.1.5 Solid Waste Collection

Drainage ravines are also used as waste disposal areas, because a formal solid waste collection system does not exist in La Zurza. Garbage is first collected in the houses, in 19 litre cooking oil cans (Fig. 15), and when these are filled they are emptied in the nearest ravine. Garbage is then washed down the hill by the draining storm and waste-waters. Because of the irregularities of the ground, much of the refuse gets stuck (Figs.13,16,17 & 18) creating a favourable environment for rats and other pests and insects, and producing a constant, unpleasant odor. Because of the site's topography, the absence of roads and the lack of

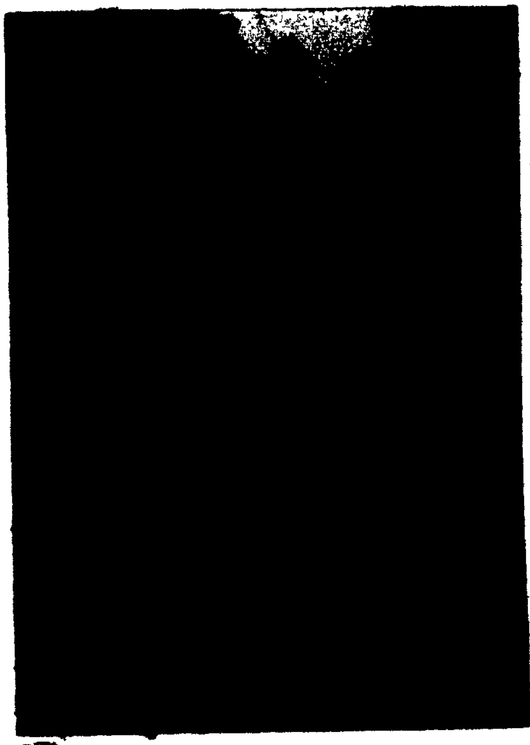


Fig. 11

One of the smallest drainage gullies found.

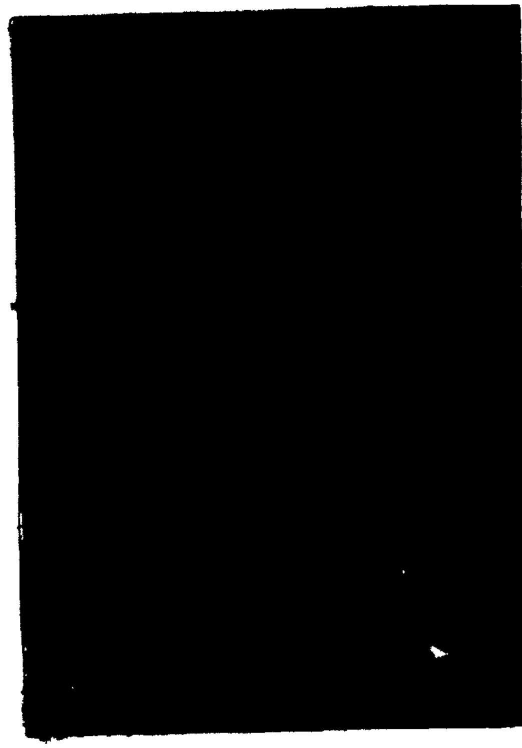


Fig. 12

Stagnant water pool on the low-lands.

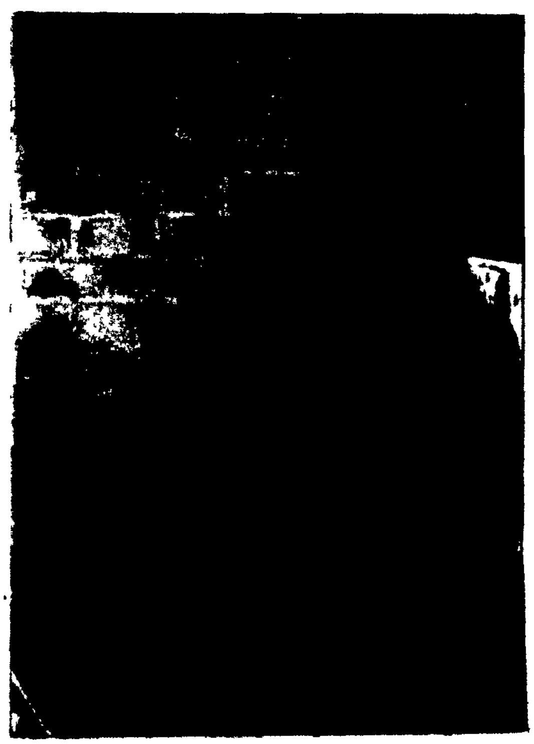


Fig. 13

House built over a drainage ravine.

Fig. 14

Retaining wall made out of car tires.

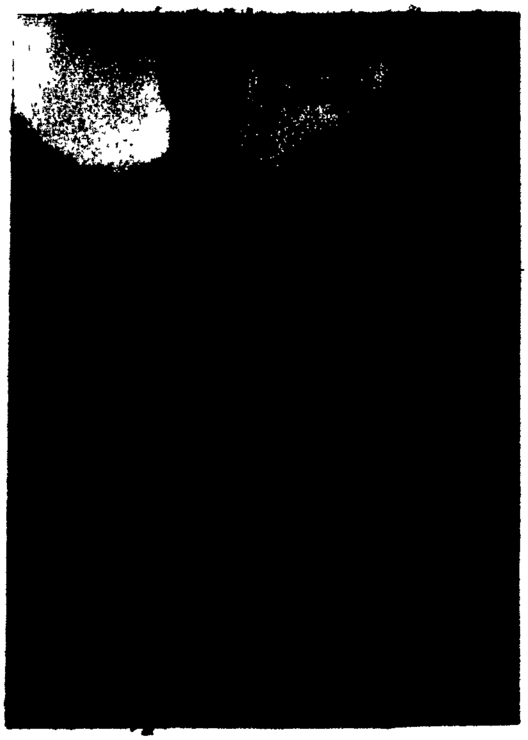


Fig. 15

Cooking oil can (19 litres) used for house garbage collection.

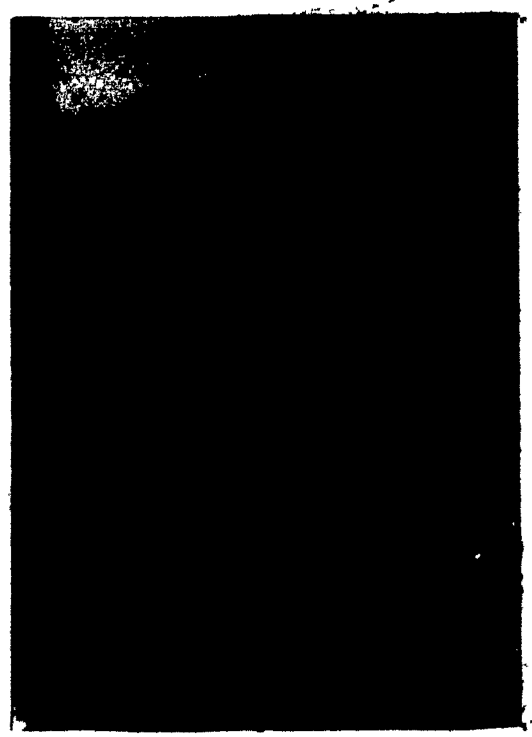


Fig. 16

Stuck garbage on a gully.

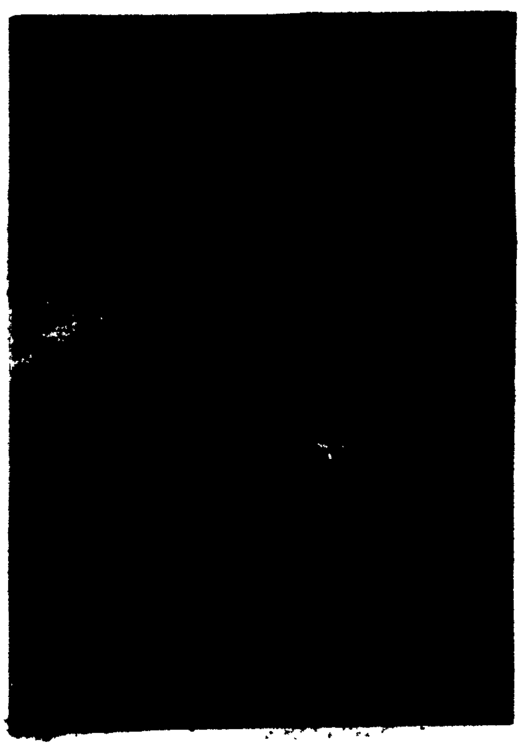


Fig. 17

Bridge over drainage gully made of tree poles.

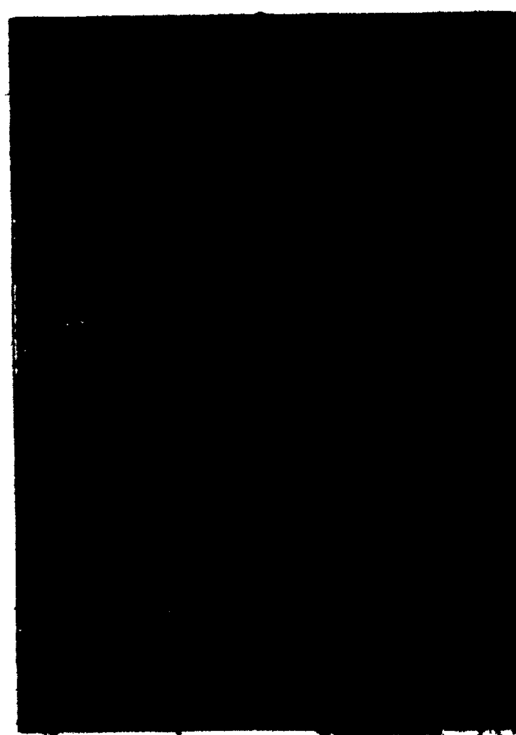


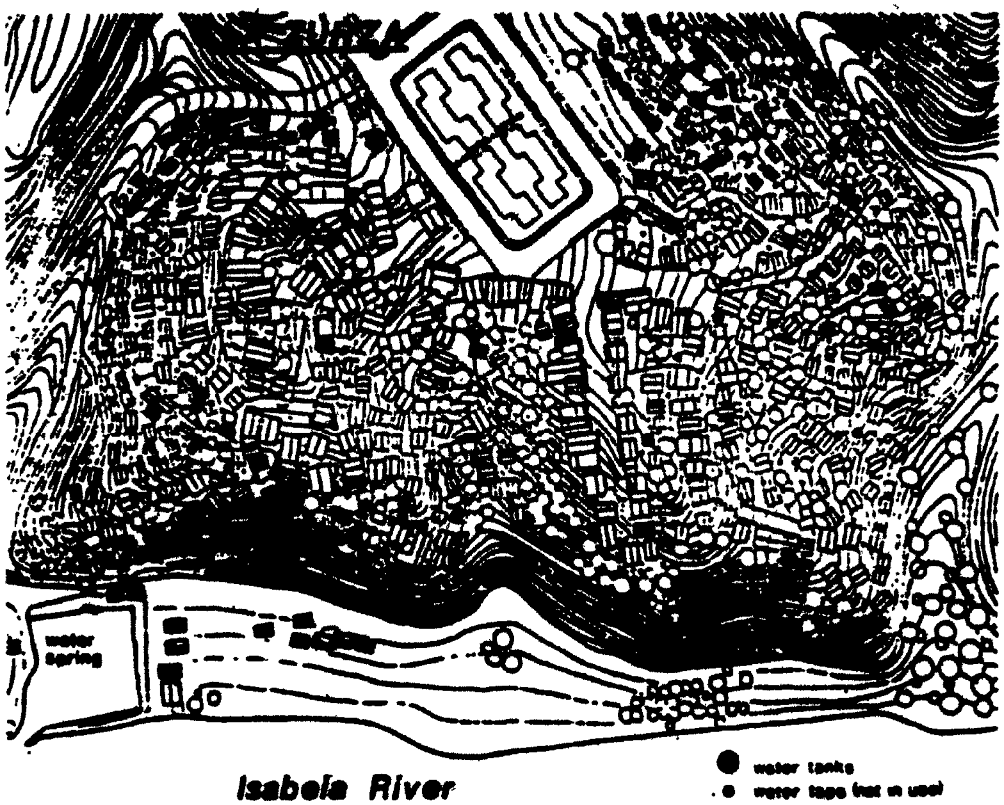
Fig. 18

Apart from the ravines & gullies the settlement is kept clean.

service from the city, this is the only alternative that settlers have for disposing of their garbage. In spite of this, as is clearly noticeable in the photographs, the rest of the settlement is kept fairly clean by its inhabitants, who themselves are also clean-looking. On Figure 39 a sign put up by the settlers reads: "Cooperate to maintain this place clean".

1.1.6 <u>Water Supply</u>

Squatter settlements rarely get any water service from the city, and even when they do, it is of the most precarious type. Water supply in La Zurza is not only scarce but also difficult to access, as the only source of potable water is located in the uppermost part of the site (Map 4). Except for a few settlers who have illegally built their own piped water lines, all have to go to the top of the hill to get water. The alternative is to use the water spring, or river water, both of which are contaminated (see page 17). The water samples analyzed, were taken by the author in two different places of the river, on the same day. One sample - half a litre of water - was taken where the river and the water spring meet, on La Zurza settlement; the other sample, also half a litre of water, was taken a few meters upstream the settlement on the opposite riverside. The laboratory reported large quantities of E.Coli bacteria colonies, and concluded that the water analyzed is not suitable for human



Scale 1:2500

Map 4

Water Resources

Fig. 19

Most common water container for water storage.

DR. V. DE SANCTIS S.
PATOLOGO CLINICO
DR. DELGADO NO. 204
SANTO DOMINGO, R.D.

NOMBRE: Margarita Alsina Rodríguez

FECHA : 17 de septiembre de 1983

ANALISIS A REALIZAR: Exámen bacteriológico en muestras de agua (1 y 2)

(ANALYSIS TO BE DONE: Bacteriological exam of water samples 1 & 2)

RESULTADO: Se aislaron bactérias patógenas

(RESULTS: Pathogenic Bacteria were isolated)

CONCLUSION : Se considera no apta para el consumo humano.

(CONCLUSION: It is not considered suitable for human consumption)

NOTA: Se aislaron colonias de Escherichia Coli en cantidades abundante.

(NOTE: Colonies of E. Coli were isolated in large quantities)

<u>Laboratory Analysis Report of</u>

<u>Water from the Isabela River</u>

consumption.

The tanks at the uppermost part of the settlement will be referred to as the Reservoir. This consists of two metal tanks each with a capacity of 9.4 m^3 (9,400 L.) of water which they receive from the city aqueduct for two hours or so per day. These tanks are fenced around and people get the water from two water taps at one end of each tank (Fig.20). In Figures 19 and 20, the containers used by the settlers to carry and store water are shown. The most commonly used are 4 litre plastic containers. As can be seen in Figure 20 the opening of these containers is too small in relation to the water tap, which causes a great loss of the already scarce water and creates pools of water right under the water taps. It is therefore not possible for anybody to get water without getting wet. This pool of water is used by the settlers, to do their laundry (Fig. 21) - the basin the woman is using is called a "batea" and is also used for bathing.

Water shortage is not only a problem for squatter settlements, but to the whole city of Santo Domingo. Throughout the city, water service is supplied (by sector) for one to four hours daily, after which period the aqueduct serves no more water to that sector until the next day, or even until a few days later. To cope with this problem, water storage facilities are found in each household. Depending on their economic capacity some use different types of tanks and take the water out with a smaller receptable, while others use similar tanks (oil drums, asbestos tanks,

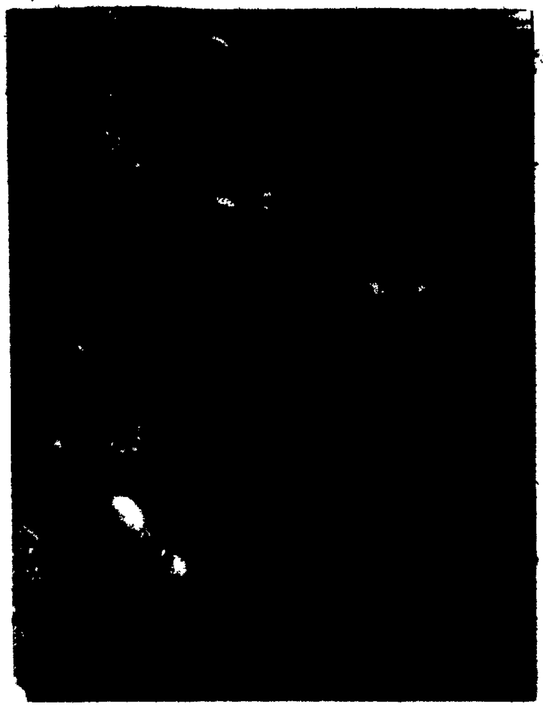


Fig. 20

Water taps from the reservoir, only potable water resource in the settlement.

Fig. 21

Women doing the laundry in standing water pool.

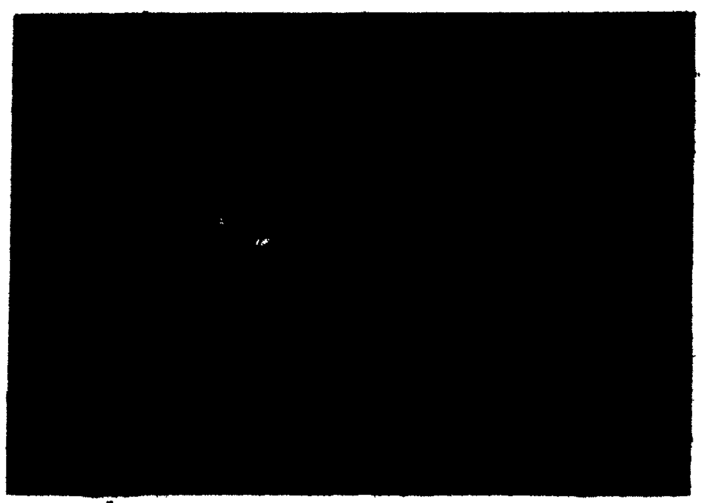


Fig. 22

Private piped-water lines laid by two different owners.

fiberglass units, etc.) but put them on the roof. A pump is used to fill them and then the water comes down by gravity, by a hose or the pipe system. Another common solution is underground cisterns which differ in capacity. These are filled and then the water is pumped to the house through the house system. With this type of solution, all water from the aqueduct goes to the cistern and from there to the taps. Those households that can afford it, build wells and connect them to the cistern so that they can fill it in case the aqueduct provides no water. When the aqueduct provides no water, cistern-trucks sell water at the rate of U S $10./22,730 litres. Municipal trucks give this service free to the poorest areas of the city.

The system of water supply used in La Zurza is not adequate as it is located very far from the vast majority of the settlers. There is a great loss of water since the taps, once opened, are hardly ever closed until the Reservoir is empty. Some settlers have built their own piped water system made of polyvinylchloride (PVC) pipes. These systems are illegally connected to the city aqueduct and are easily seen (Figs.13,17,19 & 22) as they are only partially buried. Each pipe has its own separate connections made by each owner, making the lack of community organization obvious (Fig.22). The water tap is usually placed outside the house near the kitchen area (Fig.23), and a hose is sometimes connected to get water inside the house.

A few years ago, a small system of five water taps

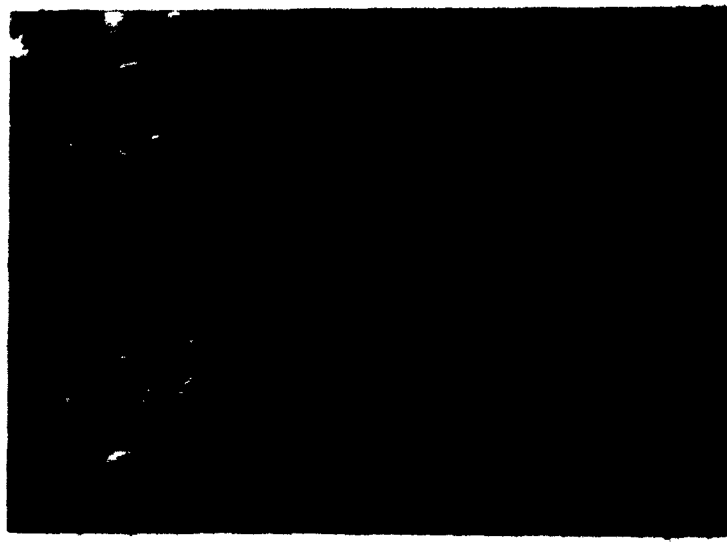


Fig. 23

Private water tap found on the lower part of the hill coming all the way down from the top of it.

Fig. 24

La Zurza water spring.

existed in the settlement. However only one was found by the author, although the probable location of the others is shown on Map 4. These taps were built by the municipality in the early 1970's, but since nobody from the municipality or from the settlement was directly responsible for their maintenance, these taps stopped functioning quite soon after their installation. This example makes very clear the importance of good maintenance.

La Zurza water spring is contaminated, but this fact does not prevent the use of its waters for different domestic uses such as, laundry, bathing and recreational swimming (Fig. 24).

1.1.7 Sanitation

Due to the high level of contamination by excreta, sanitation is the most important environmental problem facing squatter settlements. At présent the methods of excreta disposal used in La Zurza are pit latrines and open air defecation. The pit latrines used in the settlement are of the most rudimentary type, not even close to the minimum sanitary requirements. They are all of the same type, a pit dug in the ground, 2.6 m to 4.0 m deep, lined with cement blocks to prevent caving in. A seat is sometimes placed on top of the pit, around it an outhouse is built (Figs. 25 & 26). The material used for construction of the latrines are the same as those used to build the houses, i.e. palm wood,

Fig. 25

Latrines are built in the most precarious places.

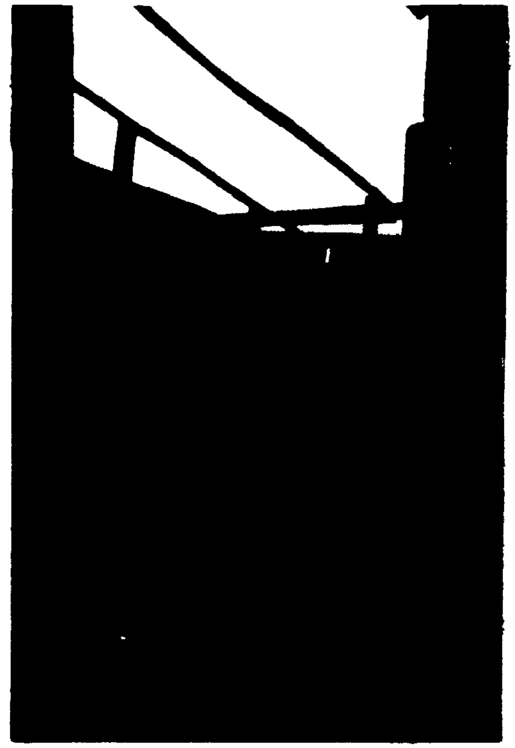


Fig. 26

Garbage can used to cover the latrine hole.

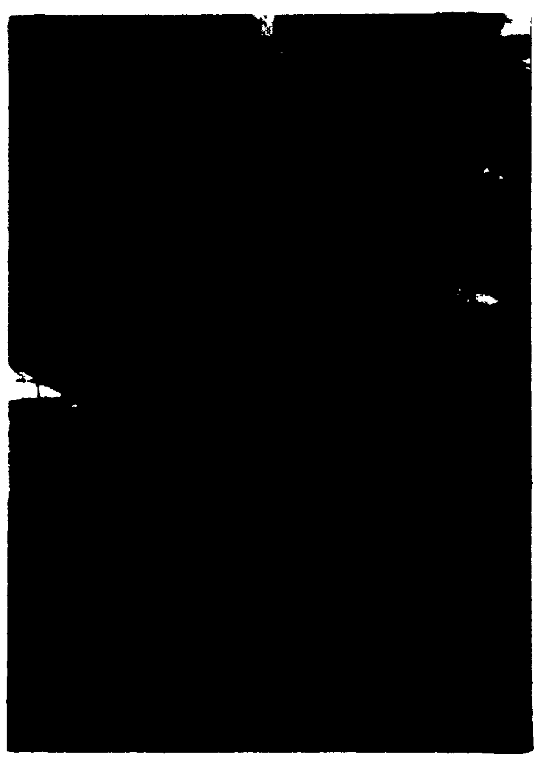


Fig. 27

Privacy is very hard to get due to lack of space.

galvanized metal, thatch, cement blocks and heavy cardboard. According to the settlers interviewed by the author (28 persons) the life span of a pit is ten to fifteen years.

The location of the pit is always in the rear with respect to the house and as far away as possible from it (Fig.27). Due to the small functional area required by latrines they are frequently located indiscriminately, and in the search for privacy they are sometimes built in places that risk the security of the users. In Figure 25, notice in the upper right hand corner the ladder that gives access to the latrine.

Lately the population density in the settlement has grown so rapidly that ownership and control over the latrines has become virtually impossible. This has created a careless attitude on the part of the settlers towards the maintenance required for the latrines, and also toward the construction of new facilities, as the inhabitants know that soon after anyone builds a unit for private use it will become semi-private.

In La Zurza there are 70 latrines to serve 657 families. This is equal to one latrine for every 9.4 families. However, as latrines are not used communally but privately and semi-privately, this leaves a great number of settlers without access to any facility. These people are forced to pratice open air defecation, a habit that in such densely populated areas, represents a high risk to the inhabitants' health.

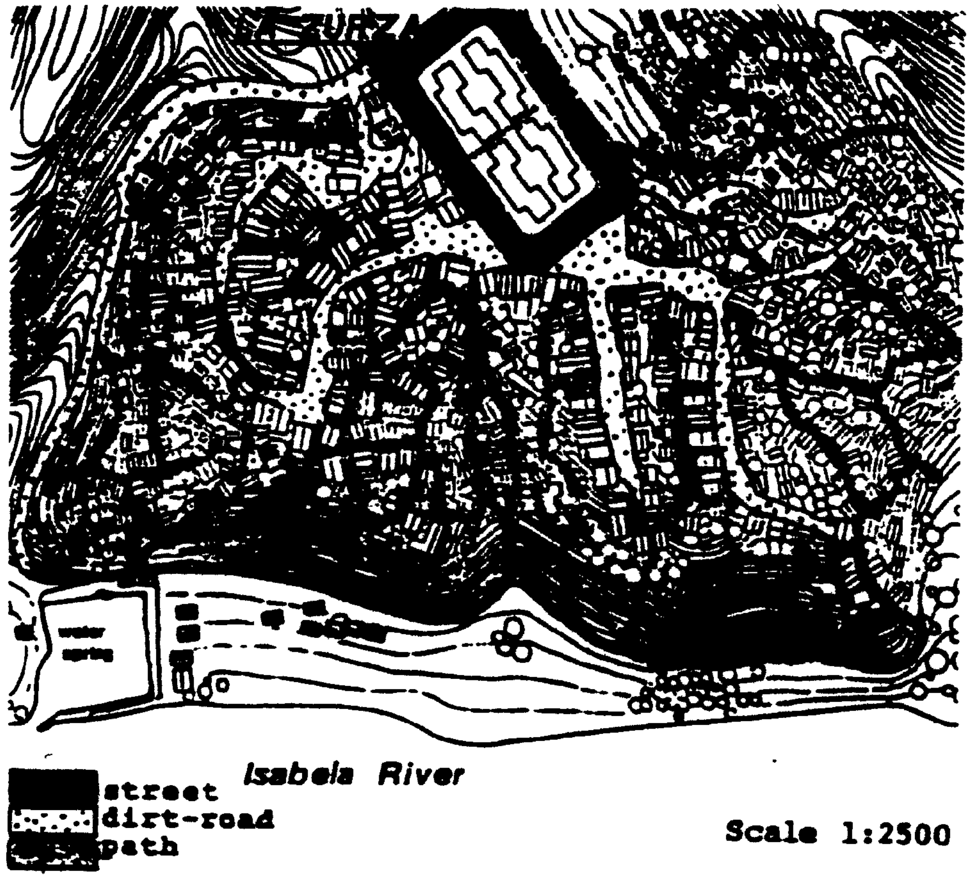
In La Zurza, indiscriminate defecation is a recent custom which started with the rapid growth of the population that took place in 1979. Precise information on this subject is not available, as many settlers will not talk about it.

During the first visits to the area early in 1979, excreta was not seen lying around, except in the ravines; the community was kept reasonably clean by its inhabitants. However, on visits later that same year, the situation had deteriorated so much that it was immediately noticeable on entering the settlement. Human waste and other types of garbage were scattered around, which could be attributed to the rapid population growth and the resulting overcrowding, which by this time had reached dangerous limits. The need for more latrines is obvious. Open air defecation is less dangerous in rural areas because of the low population density, but it is highly dangerous in urban, overpopulated areas, because of the high risk of environmental and personal contamination[23].

1.1.8 Roads

Four different types of roads constitute the road network of La Zurza. These are:- streets, dirt roads, paths and alleys (Map 5). A description of each type follows.

In La Zurza, streets are only found in the uppermost part of the settlement. They have a width of six meters and are usually paved or at least levelled with the adequate



Map 5

Road System

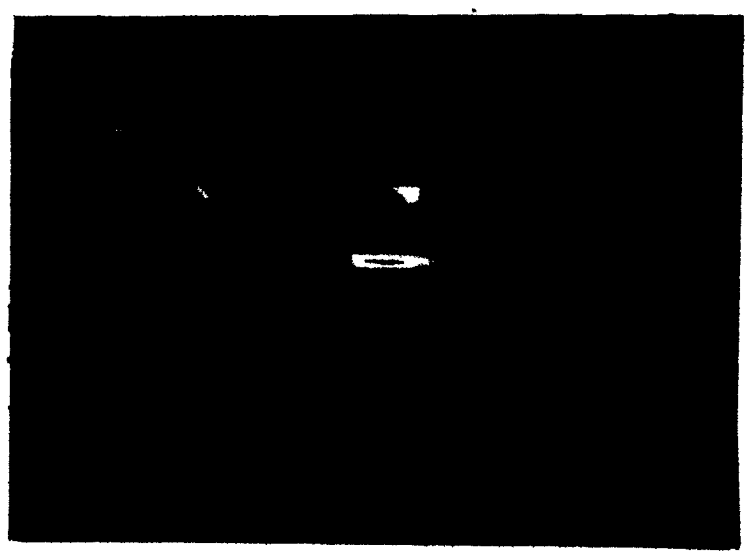


Figure 28

Street

material, but although their intended use is for automobiles, all types of other activities take place on them. They function as a playground for children, for business and for social encounters. These activities and non-motorized vehicles slow down the speed of the traffic (Fig. 28).

Dirt-roads are smaller than streets, their width varying from two to four meters. They are limited by the location of the houses on each side and have no sidewalks or gutters. Even though in an emergency they could be used for vehicular traffic they are used predominantly for pedestrians. In Figures 29 and 30 the varying width can be seen and also the lack of pavements, sidewalks or lighting, which makes it difficult to walk on them at night.

Paths may be considered as branches of the dirt-roads, generally used to join small groups of families. Their width varies between one and two meters, and they cannot be used for vehicles. Their physical condition is very poor, and threatens the safety of pedestrians. With the abrupt changes in levels this situation worsens at night when there is no lighting to see the irregularities of the ground. In Figures 31, 32, 33 and 34, different paths are shown. In Figure 31, a fence made of left-over material has been built to protect the settlers from falling into one of the deepest ravines of the area which is beside the fence. Figure 35 shows one of the many bridges that the inhabitants have built over the drainage ravines and gullies. Other bridges can be seen in Figures 5, 17, 18 and 20.

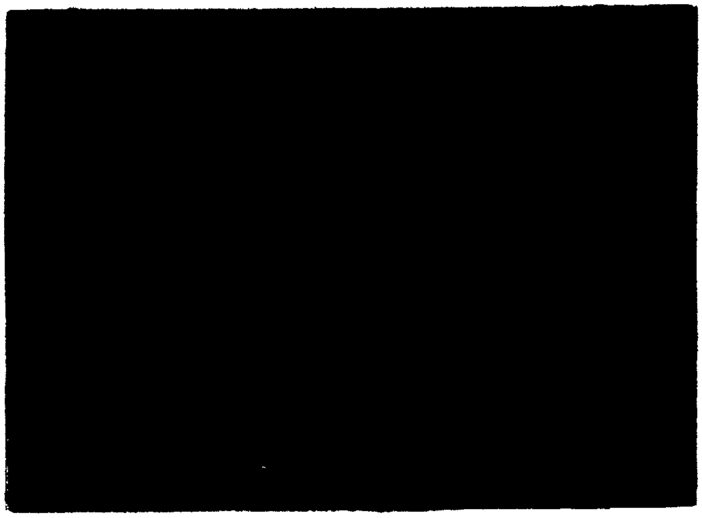


Fig. 29

Main dirt-road entering the settlement.

Fig. 30

Small dirt-road inside the settlement, notice the difference in width from Fig. 29.

Fig. 31

Path. Fence made of leftover material to protect settler from ravine next to it.

Fig. 32

Bridges like the one shown are used to pass over ravines and gullies.

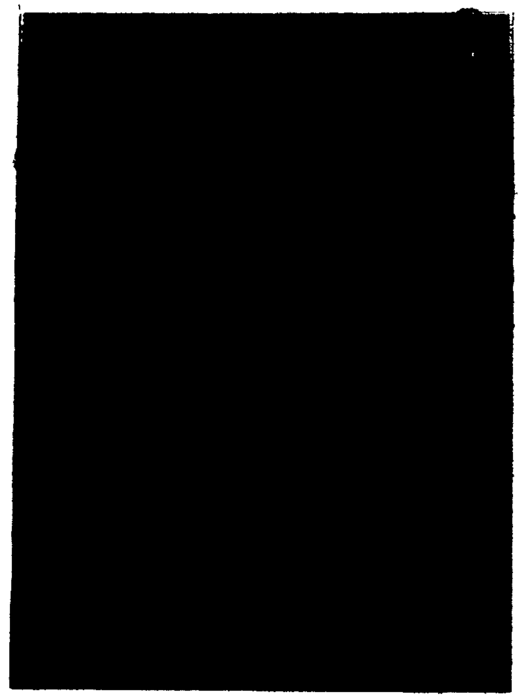


Fig. 33

Path at the foot of the hill on a rainy day.

Fig. 34

Very narrow path.

Alleys are located between houses and have a width of 0.7 to 0.8 meters. They link dirt-roads and paths and also separate one house from the other. They are dangerous and uncomfortable and create privacy problems because of the proximity of the houses (Figs. 35 & 36).

1.1.9 House Construction

All the houses in La Zurza can all be considered to be the same type of structure, but at different stages of development (Diag.1). This type of house originated in the rural area and its basic structure (Diag.2) consists of wooden posts and beams set in a rectangular shape. To these basic shapes other rooms are added according to the needs and possibilities of the owner.

The use of a rural type of housing unit in an urban environment is not surprising considering the fact that most of the inhabitants in this squatter settlement come from rural areas. The difference between the urban and the rural house lies basically in the construction materials used and in the poorer quality of the urban house. Rural houses are built mostly of organic material, while urban squatters have to substitute for these materials from construction sites, factories or small industries. The difference in quality, is also due to the security of land tenure that rural settlers have contrary to the urban squatter, who has no security at all. Even when the rural settler does not own the land where

Fig. 35

The narrow space of alleys creates great problems of privacy.

Fig. 36

Picture of a typical housing unit showing the poor condition of the adjacent alley, and the risk it presents to pedestrians, especially after dark.

Development Stage	Description of Areas	Percentage
1	One room	10.7
2	One room + 1 or 2 bedrooms	22.2
3	One room + 1 or 2 bedrs. + business	8.3
4	One room + 1 or 2 bedrs. + bath	19.6
5	Living-dining + 1,2 or bedrs. + Kit.	39.2

Diagram 1

Percentage of Existing Houses Related to their Stage of Development[10]

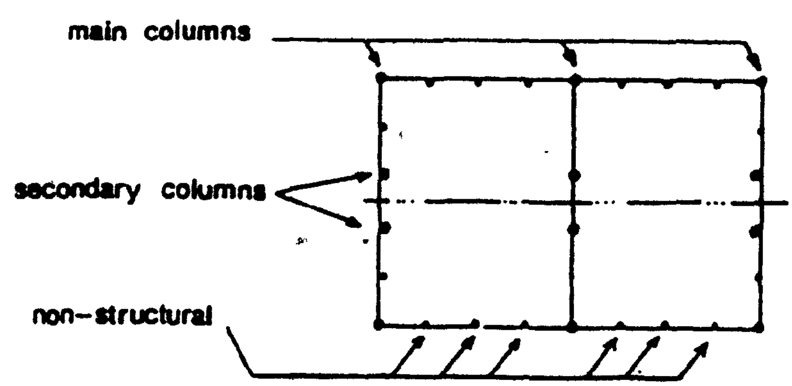


Diagram 2

Typical House Plan

he has built his shelter, he has the certainty of an indefinite tenure on the site he occupies, while urban squatters continually fear eviction from the land they have encroached. In such an uncertain situation it is clear that they are not going to invest their scarce incomes, or their efforts, in the improvement of a house that they may lose at any time.

In Figures 37 and 38 the diverse quality of the houses found in La Zurza, can be seen. Figure 37 shows a common method of construction which is to make the most visible parts of the house of concrete blocks, not only because of structural reasons, but because concrete blocks have a social status in the settlement. Once the house is finished, part of it may be rented or used for a small business. Rents range from US $7 to US $18/month/room (1975)[10], an amount which has varied very little since then, according to the fifty settlers interviewed by the author to this respect.

Map 6, shows the built area of La Zurza. The floor plans of the numbered houses, are shown on Diagrams 3, 4 & 5. The houses shown on Map 6, were selected because they are representative of the different stages of house development found in squatter settlements. They all have the same basic layout of a living-dining area plus one or two bedrooms. Even those families that have a kitchen area, do not cook inside but use the space to store kitchen utensils, a refrigerator and a table. Cooking is done right outside the kitchen door in an "anafe" (Fig. 14) which uses coal or

Fig. 37

Concrete facade, a sign of betterment for squatter settlers.

Fig. 38

Comparison of roofs in squatter settlements.

Isabela River

Scale 1:2500

Map 6

Constructed Area

Numbered houses floor plans are shown in the following pages to give an idea of the usual distribution of houses.

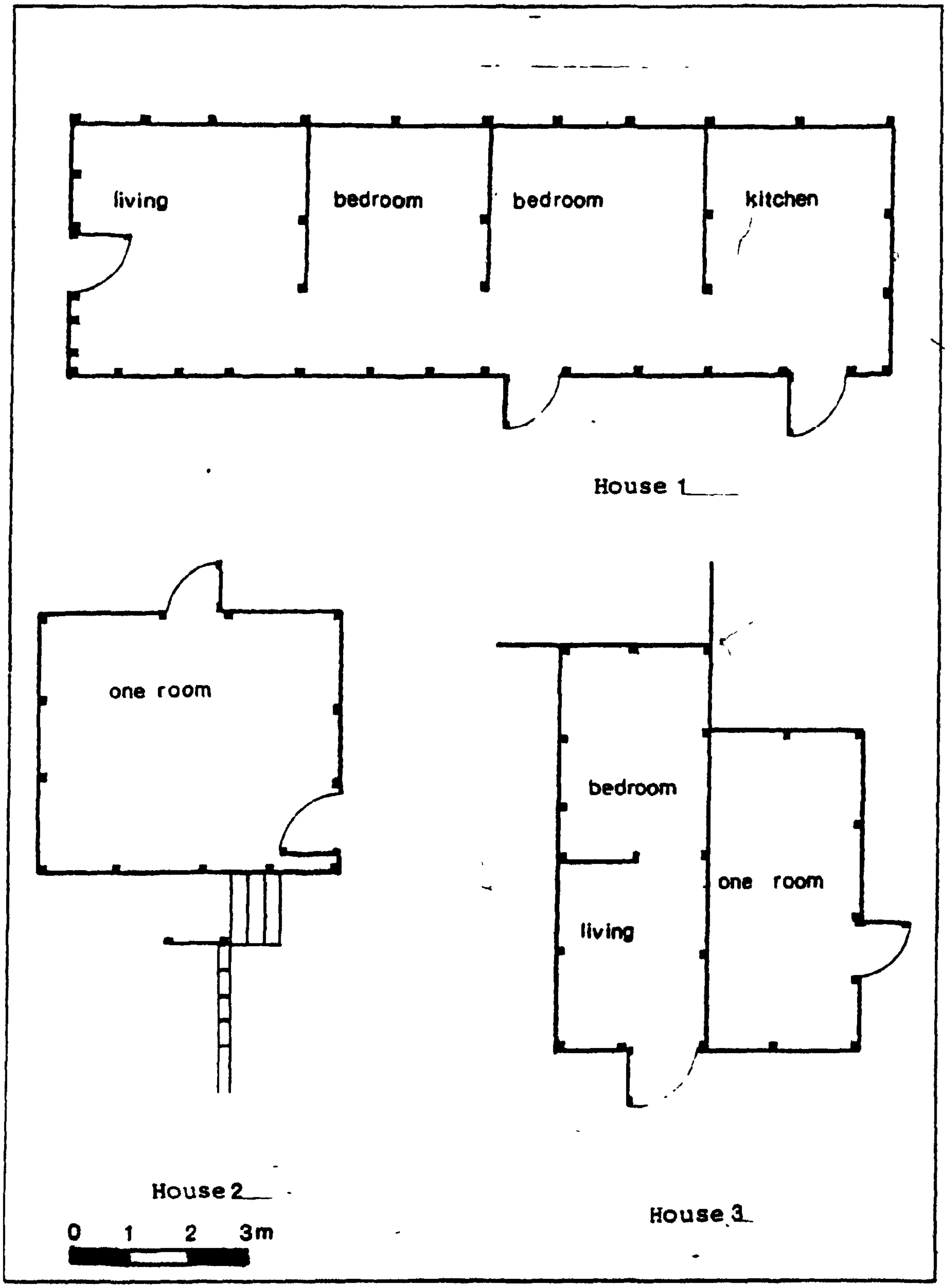


Diagram 3

Floor Plans for Houses 1,2, & 3

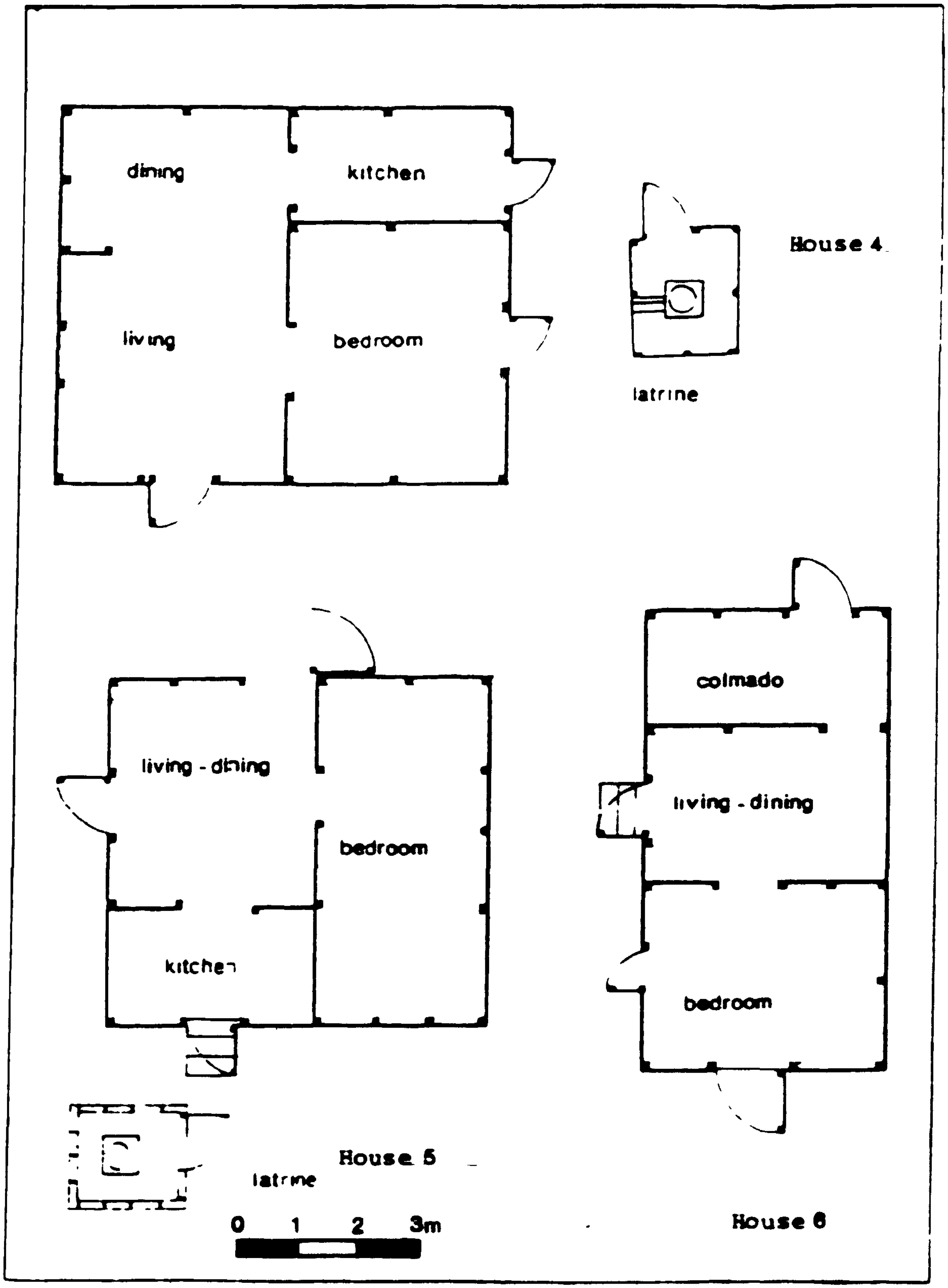


Diagram 4

Floor Plans for Houses 4,5, & 6

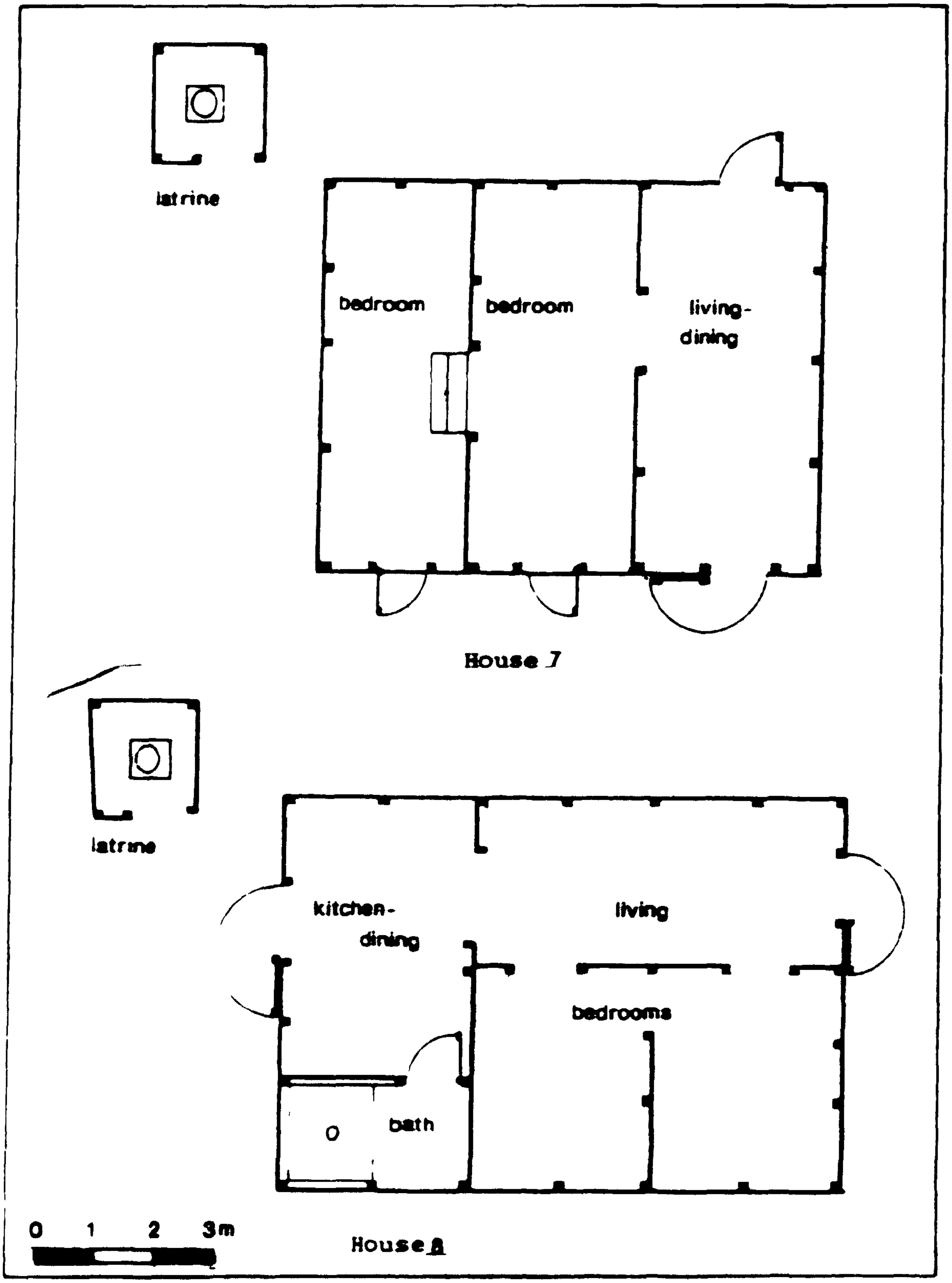


Diagram 5

Floor Plans for Houses 7 & 8

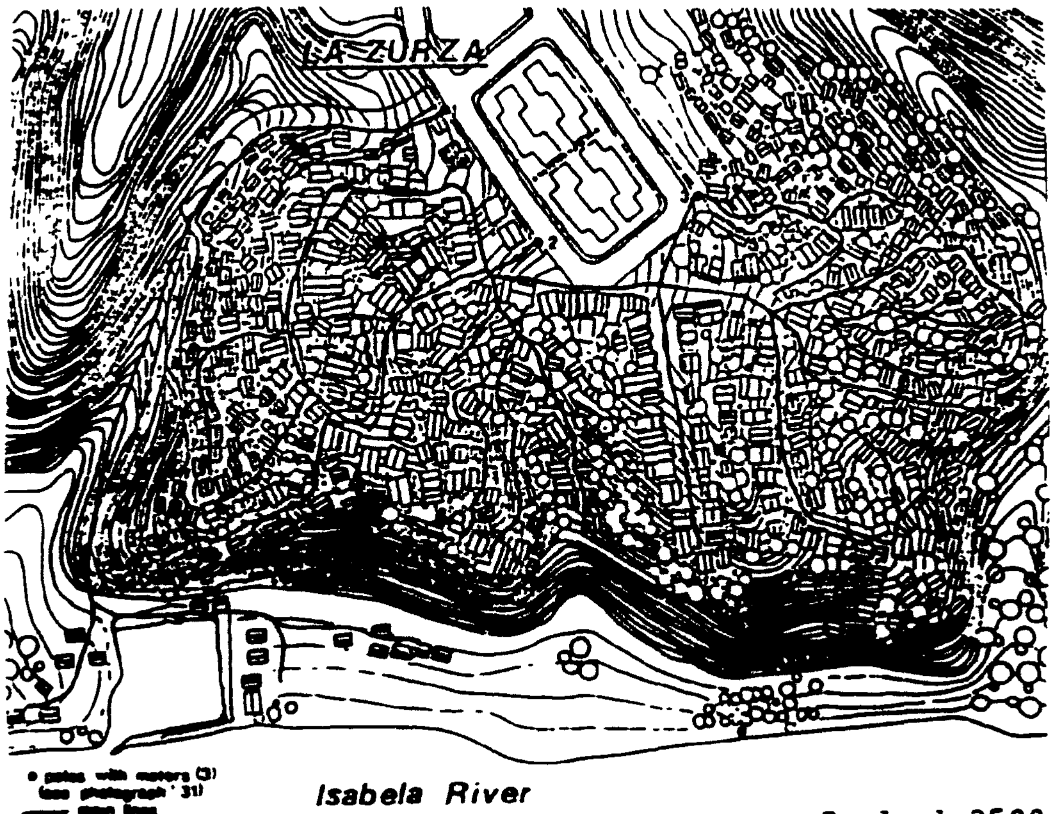
wood.

1.1.10 Other Existing Services

Most of La Zurza inhabitants have electricity in their homes. The connections have been made illegally by the settlers themselves, often in a precarious and dangerous way, constituting a high risk of fires and accidents to the users. The origin of the connection is on the upper part of the settlement near the Housing Project which was built by the government in the mid-1970's (Fig. 39). All connections are made from one electrical pole and from there taken to the farthest parts of the settlement (Map 7). In Figures 7, 39, 40 and 41 electrical connections can be seen at different places in the settlement.

Telephone and mail services are non-existant within the settlement, and the squatters have to receive their mail outside the area at a relative's or friend's house. Recently the telephone company installed two public phones at the top of the hill.

Public transportation to the city is available to the settlers of the upper parts of La Zurza, but is not very accessible for those living in the lowest areas. These people have to either go all the way uphill or go across the river in a ferry boat that charges five cents for the service. This boat is the initiative of a settler, not a service of the city, and there is no adequate landing area on either side of the river (Fig. 42).



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Map 7

Electrical Network

Source: Estructura del Entorno[10]

Fig. 39

From these meters all electrical wiring is done in La Zurza.

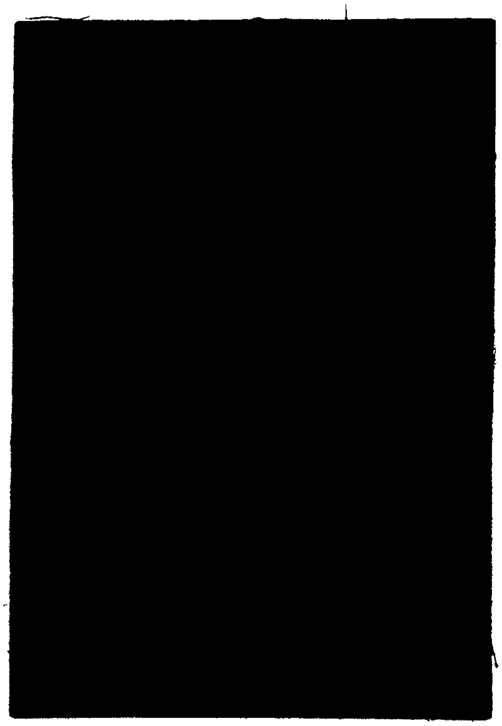


Fig. 40

Electrical wiring.

Fig. 41

Wires go all the way down to the lower parts of the settlement.

Fig. 42

Ferry boat to go across the river from the settlement.

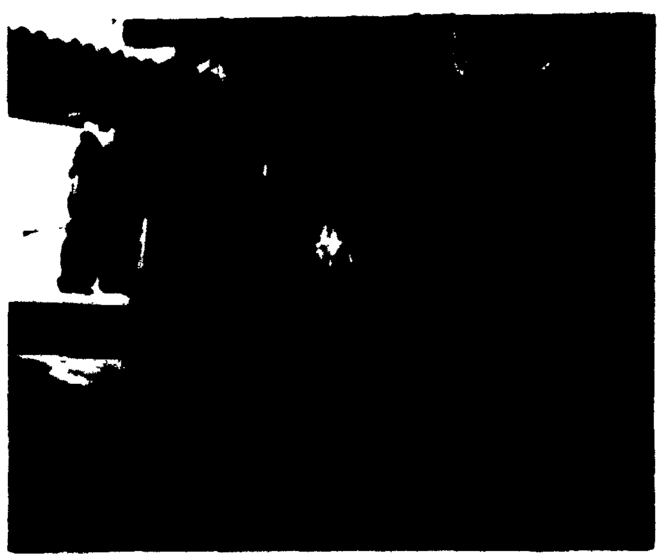


Fig. 43

"Colmado", piecemeal food store.

1.1.11 Commercial Activities

There are different types of small shops and businesses in La Zurza which supply the basic needs of the inhabitants, and reflect at the same time the living standards of the settlement. Among the shops can be found: food stores (Fig.43), pharmacies, jewellers, barber shops, beauty parlors, tinkers, and snack bars (a small table on the sidewalk where native food is cooked and sold). Most of these stores and businesses are located in the upper part of the settlement on the main street, but scattered around the settlement food stores like the one shown on Figure 43 can be found. These small stores sell everything piecemeal, i.e., a person can buy one cigarette or so many cents worth of cheese, oil, etc. (Fig. 44).

Settlers meet regularly for social activities, most of which are initiated by themselves. In Diagram 6 the most usual activities according to age are shown. These activities are held either inside the homes or in the open air, usually in the street or on dirt-roads (Figs.45 & 46).

1.1.12 Floods

The Isabela River does not have a pattern of periodic flooding, however when the climatic conditions of the area are severely disturbed, as in the case of great hurricanes,

Ages	Activities
1 - 10	They play near their homes, go to the water spring, fly kites, watch T.V. or play ball.
11 - 15	Mostly the same as before but they now start visiting and going to social gatherings.
16 - 20	They go to the water spring, watch movies, begin romances, play pool, play dominoes, play cards, watch T.V., listen to radios, visit friends and go to social gatherings.
21-and over	They go to movies, play pool, dominoes, cards and lottery, watch T.V., have drinks, participate in cockfights, listen to radios and visit friends.

Diagram 6

Recreation Activities According to Age.

Fig. 44

One egg, one tomato and two herbs, this is the normal shopping at the food store.

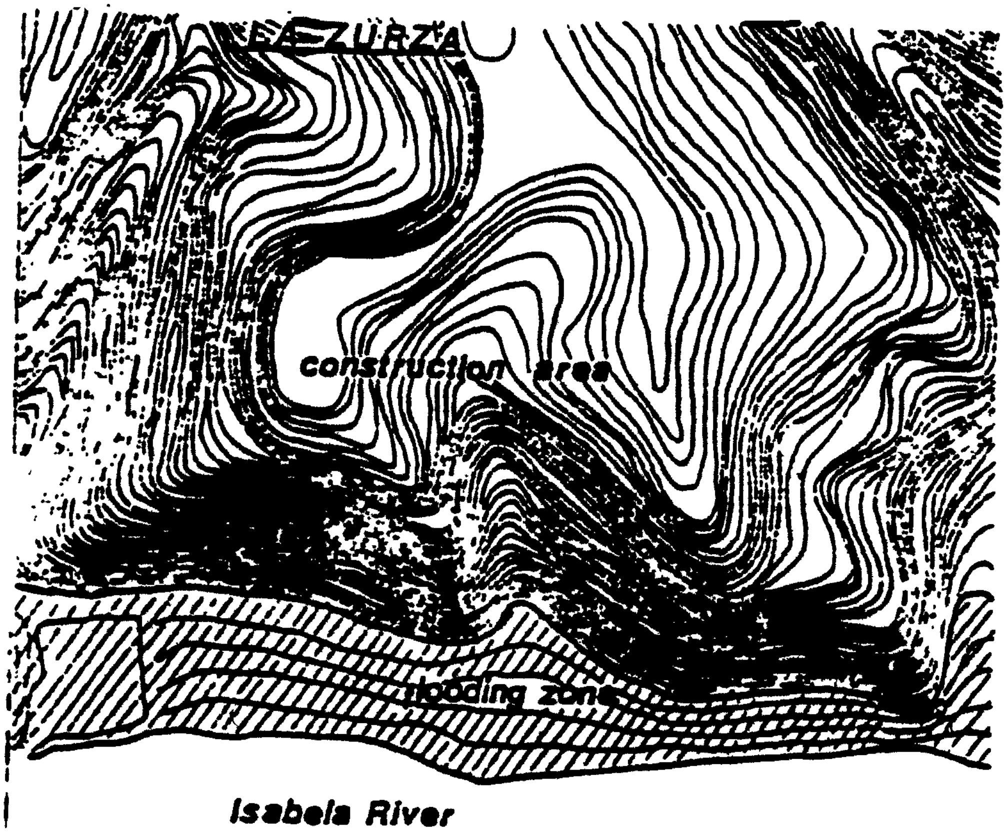
Fig. 45

Improvized presentation of typical dancing on the street.

Fig. 46

Recreational swimming in La Zurza water spring.

floodings do occur in the area of La Zurza and affect those settlers who live in the Low-lands by the riverside (Map 7). On Figures 47, 48, 49 and 50, the start of a flood which occurred during Hurricane Allen in 1980 is shown. This hurricane was one of the most powerful since San Zenon in 1930 (which destroyed the city of Santo Domingo) and Hurricanes David and Frederick of 1979 (even though Allen was more powerful than David and Frederick its effects were milder because it did not cross the island (Map 8)). On the photographs, settlers stand near the river watching it change its flow, that is, instead of the river flowing towards the sea, when it is about to overflow it starts flowing inland. When this happens, almost immediately the water starts to cover the land at considerable speed. These pictures were taken during Hurricane Allen whose effects were milder on the Island, and the flood did not go up too high. However, during the Hurricanes David and Frederick, all the houses were totally covered by the water and it took a month before they were visible again. Even though settlers have radios and televisions, they were uninformed of the events and did not know whether the hurricane was coming or had already passed. They did not make an effort to go to a safer place with their belongings, but simply stood around and watched the river flood.



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Map 8

Flooding Zone

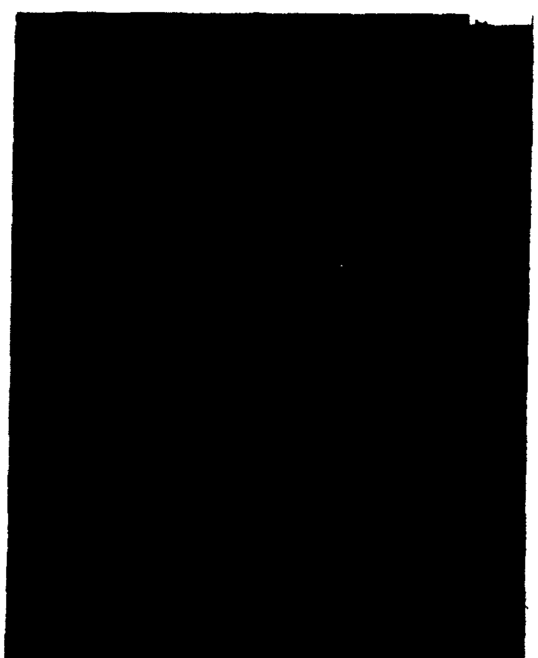


Figure 47

Beginning of a flood during Hurricane Allen 1980.

Fig. 48

Houses on the low-land by the riverside.

Fig. 49

When the flood started squatters just watched it but did nothing to salvage their belongings.

Fig. 50

The Isabela River does not have a pattern of periodic floods. This happens only in extremely disturbed climatic conditions.

1.1.13 Environmental Contamination

Urban squatter settlements constitute a transitional human ecosystem - a rural life style in an urban setting - for thousands of immigrants who bring with them their traditional sanitation habits which they keep in the new urban setting[12]. These habits, which may be appropriate in rural areas, create problems of environmental contamination when transferred to the urban context. The most dangerous type of contamination that squatter settlements present is the result of poor sanitation, which produces all types of diseases and gastro-intestinal disorders. According to the statistics, these are responsible for the high rate of infant mortality found in squatter settlements (Diag. 8)[30].

Environmental contamination, which is a rural as well as an urban problem, is more dangerous in urban areas due to the high risk of epidemics in overcrowded settlements. This type of contamination has two cycles which are:

a) The Short Cycle: contamination through direct contact with the feces.

b) The Long Cycle: Contamination through indirect contact i.e., transmission of contaminents by way of animals or by contact with contaminated food or water[21].

indicators	1973	1975	1976
younger than one year, for each 1,000 born alive.	18.9%	15.6%	14 %
from one to four years for each 1,000 people	38.6%	43.6%	40.7%

Diagram 7

Specific Mortality Rates

Source: Indicadores Basicos - ONAPLAN[30]

year	city of Sto. Dgo.	whole country
1976	2,619.00	6,641.00

Diagram 8

Infant Mortality of Children Younger than One Year

Source: Indicadores Basicos - ONAPLAN[30]

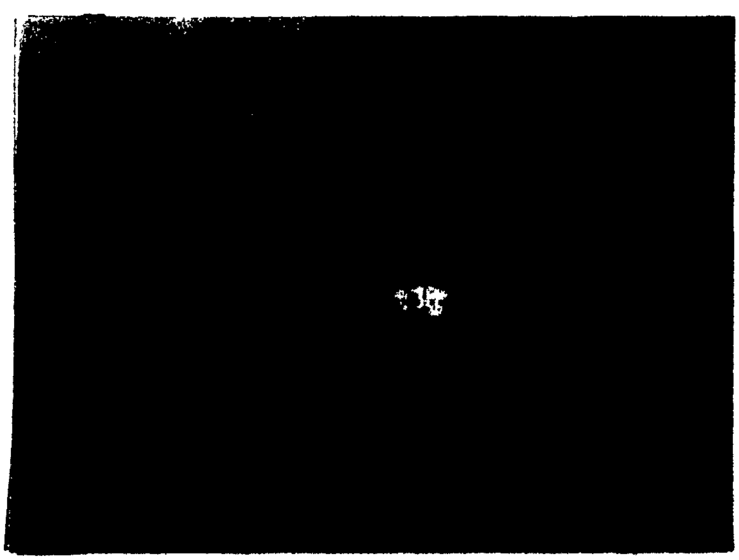


Fig. 51

Port on the Isabela River. In the background La Zurza squatter settlement.

Another problem facing squatter settlements is contamination of the environment by organic and inorganic waste[28]. During the visits made to La Zurza the amount of waste produced by the settlers was calculated by the author based on the receptacle to collect it - each household produces about 0.012 m^3 or 3.6 kg. of waste per day which is equal to 0.56 kg. of waste per capita per day. This tallies with a World Bank guide, Environmental Management of Urban Solid Wastes in Developing Countries, which estimates that low income countries produce waste at a rate of 0.05 to 0.60 kg/cap/day[13]. In La Zurza there are 665 families which at a rate of 3.6 kg. of waste per family per day produce 2,400 kg/day of waste that has to be collected, treated and disposed of. At the moment, no collection or treatment exist.

Another important problem of environmental contamination affecting La Zurza, is air pollution, due mainly to a cement factory located on the west side of the settlement, and to other smaller industries found in the immediate surroundings[9]. As this problem affects not only La Zurza, but also a vast area of the city of Santo Domingo, its solution is beyond the scope of this thesis.

The Isabela River is polluted not only because of the squatter settlements found along it, but also because of the industries, the residential areas upstream and the port found a few meters from La Zurza (Fig. 51)[9]. During this project nothing will be done to treat storm water before it reaches the river. It is unfair to make the poorest people pay to clean the river, while more powerful sectors, also responsible for the river's contamination, remain unconcerned about the problem, and do nothing to stop contaminating it. By implementing this project, squatters are actually taking the first step to protect the river, since, by eliminating open air defecation, they are eliminating the most dangerous pathogenic agents from the incoming waste waters. No further effort can be made by the settlers unless other sectors decide to take some action to clean the contaminated waters of the river.

1.2 SOCIO-ECONOMIC CONDITIONS

1.2.1 Income Levels

The economic structure of squatter settlements belong to the lowest level of the national scale, the inhabitants having incomes (Diag. 9) of US $1 to US $100 per family per month[1]. The average National Income per capita (1976) in the Dominican Republic is US $215 per month[1] while more than half of the population of La Zurza earns below US $50 per month[10].

Historically these income levels have varied very little, but the power of the Dominican Peso has greatly

National Income per capita	Year	US$
	1976	213/year
Average Family living expenses	1976	94/year
*LA ZURZA income distribution	1975	1/100/year
	earn in US$	
% of the population	from	to
60	1	50
31	51	75
9	76	100

Diagram 9

National Income Per Capita

Compared to Squatters' Income

Source: Oficina Nacional de Estadisticas[1]

*Estructura del Entorno[10]

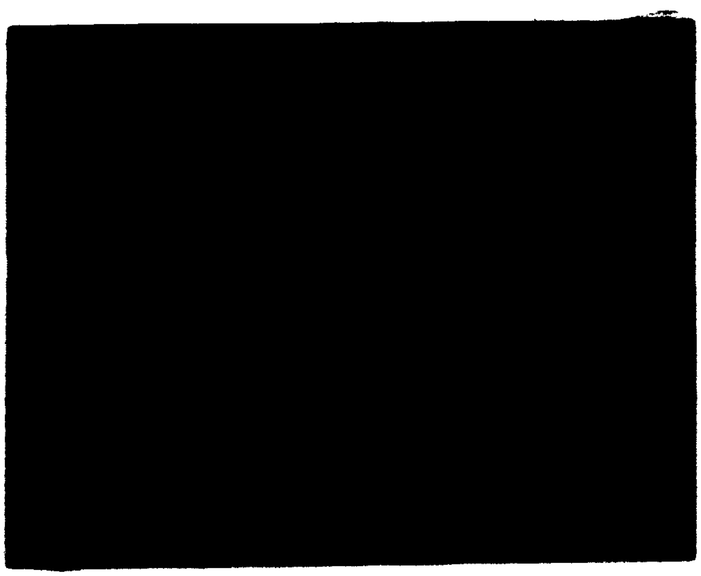


Fig. 52

Tricycles and Push-carts for

Street Vending

decreased during the last few years, so that while in 1975 a Dominican Peso was worth ninety American cents, today it is worth only fifty cents.

1.2.2 Employment

The main source of steady employment in the immediate surroundings of La Zurza are: the Dominican Cement Factory, the Asbestos Industry and two or three smaller industries. Further away from the settlement the main employment sources are the seaport of Santo Domingo and many construction sites. For women the most common source of employment is as a domestic servant, or as a "canastera" - a woman that goes around the city selling vegetables, fruits and spices. However, this type of job is being taken over by men who instead of using a basket to carry the merchandise, use a tricycle (Fig. 52). Some men are also employed as house servants, drivers, gardeners and waiters, but unlike the women, they are not required to live in the employer's house.

1.2.3 Population Data (1975)[10]

Inhabited area of La Zurza:		6.5 hect.
Number of inhabitants	:	4,256 persons
Population density	:	654.8 pers./hect.
Number of families	:	665
Persons per family	:	6.4

Number of houses : 657

Construction density : 101 houses/hect.

Families are composed of the parents and their children, which are numerous, and perhaps a close relative who lives with them on a permanent or semi-permanent basis.

1.2.4 Education

There are two small primary schools in the settlement neither of which function in a permanent or consistent manner, since they have been supplied with only some equipment by the Ministry of Education, but have no teachers. The positions of teachers have been assumed by any willing settlers who have some degree of education. This situation is far from ideal, since very often the settlers filling in for teachers have not even finished high school. Also, since the teachers do not get much pay, they stop teaching as soon as they get a better job. Less than 60% of the children of La Zurza go to school, and many of them go to schools outside the area[10].

1.2.5 Health

The birth rate in the Dominican Republic is one of the highest in the world, i.e. 3%[30]. Infant death rate is also very high, especially in children younger than four years (Diags.7 & 8), although after this age, life expectancy increases greatly[30]. ·The most common causes of sickness are: diseases resulting from fecal contamination, contaminated water, poor diets and lack of hygiene (which in most cases is due to ignorance). The most common diseases are respiratory, nutritional, infectious gastro-enteric, and venereal.[10]

Compared to their income, squatter settlers' expenditure for health care is high, and even though the Estate Health Centers are free of charge, as are the Public Health Services, their capacity is well below the actual demand for them. This situation is worsened by the high prices of medicines.

1.3 CONCLUSIONS

In La Zurza the main problems with which the inhabitants are faced are environmental sanitary problems due to the lack of service from the city. Specifically these are:

a) Inadequate disposal of human waste.

b) Lack of a garbage collection system.

c) Lack of an adequate system for storm and wastewater drainage.

d) Insufficient and inconvenient service of water supply.

These problems lead to:

a) Fecal contamination of the environment.

b) Organic and inorganic contamination of the ground and the creation of favourable conditions for rats, fly breeding and other harmful animals.

c) Risky conditions for the settlers, considering the site's abrupt topography, as the soil when wet gets extremely slippery.

d) Use of contaminated water for human consumption.

All these conditions create an unhealthy environment that negatively affects squatters' health.

Because of the limited resources of the community and because of the scarcity of funds, the possible solutions to the aforementioned problems remain far from ideal. Apart from the economic limitations other drawbacks affect the improvement methods used. These are:

a) High population density.

b) Water shortage.

c) Settler's rural behavioral patterns in an urban setting.

d) Abrupt topography of the site.

Considering not only the economic but also the physical and social limitations, the systems selected to improve the environmental sanitary conditions of the settlement should be applied through an upgrading approach, thus avoiding confronting squatters with options beyond their economic and intellectual capabilities. This approach permits the application of the selected solutions in stages, spreading their costs over longer periods of time and also it starts improving from the existing conditions, no matter how minimal standard they may be considered.

Resources for the improvement of squatter settlements are very scarce and in some cases non-existant, for very few countries have considered marginal sectors as part of their development plans. As agreed upon in the U.N. Interregional Seminar on the Improvement of Slums and Uncontrolled Settlements[12], any attempt to improve these communities must use the settlers participation as a resource. Not just because of the scarcity of support from other sources but also because by participating in the improvement of their area, dwellers will begin to climb up the ladder of transition between the rural and the urban context.

Presently in the Dominican Republic no attention is being given to the improvement of the living conditions of squatter settlements. The issue has not been raised in any serious approach, consequently this project has no past experience to relate to. It is unique in that sense, and so it is modest in its scope, not reaching for goals too far beyond the community, as at this point, no official or public organization in the country is making any significant investment in these marginal areas.

PART TWO

PROPOSED TECHNOLOGIES TO UPGRADE ENVIRONMENTAL SANITARY PROBLEMS

Chapter 2

SANITATION

2.1 INTRODUCTION

The second part of this thesis deals with the technologies and systems which will be used to upgrade the environmental sanitary conditions that exist in this squatter settlement.

The selection of the systems is based on a study of the existing squatter settlement environment. This study comprises the first part of this thesis, and has permitted an understanding of the real limitations and aspirations of the settlers, while avoiding interposing outside expectations which would create different needs.

The selected technological innovations are intended to create a process of continuous social evolution in the community through the application of technologies that are comprehensible to the users. The areas of interest of this work are:

a) Sanitation

b) Solid waste and drainage

c) Solid waste treatment

d) Water supply

The selected technical options provide squatters with the necessary systems to improve their living environment, not so as to reach the high standards established by conventional sanitary norms, but at least to improve existing conditions.

The selection of a specific scheme to be implemented is not simple as it involves several inter-related factors that must be carefully considered for the project to be successful. Some of these factors are:

a) Economic limitations

b) Social and cultural patterns

c) Settlers know-how and required supervision

d) Available materials

In the La Zurza the factors to be considered are:

a) Scarce water supply

b) Inefficient municipal waste collection system

c) Settler's rural socio-cultural background

d) High population density and limited road system

e) Steep and abrupt topography (to carry something down is easier than to carry it up)

Taking into account the above factors, the proposed options must:

a) Use the minimum of water.

b) Use "rural" techniques and systems, as these fall into the socio-economic and cultural environment of the community.

c) Make solid wastes go down the hill through the ravines and gullies, to be collected in the Low-lands at the foot of the hill.

d) Use a simple system of waste treatment.

To obtain an organizational pattern which works with the selected upgrading systems, La Zurza's area has been divided in four sectors (Map 9) each containing about 160 families.

The project will be developed in two stages, and each stage will last ten years.

2.2 SANITATION

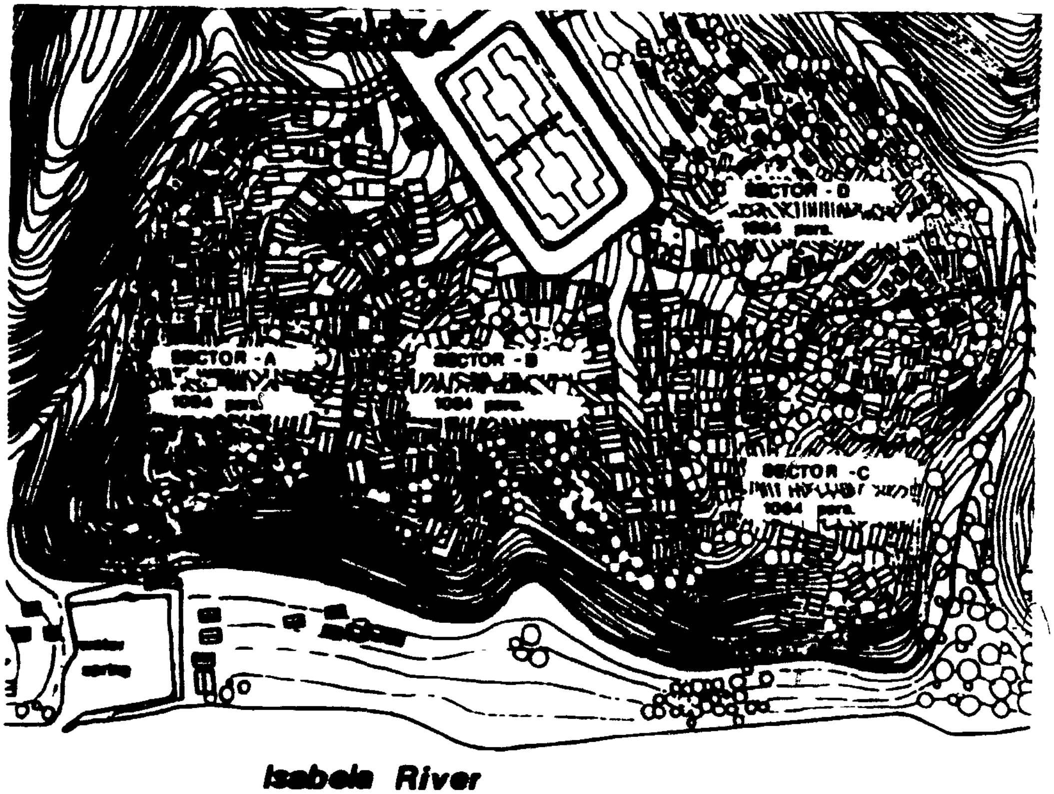
The actual system of human waste collection used in La Zurza cannot be transformed into a more acceptable system over a short period of time due to socio-economic reasons. The settlers cannot afford the costs of implementing a new and expensive system, and neither are they culturally ready to accept a sudden change from the methods they have always used, For these reasons only small changes will be made which aim:

a) To stop the problem from growing.

b) To improve the existing system.

c) To educate the settlers in the use and construction of improved latrines.

Because of water shortages, economic limitations, problems of cultural acceptance and the settlers' limited know-how, the present system - rudimentary pit latrines - will be expanded for those settlers that do not have access to a facility.



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Map 9

Sectors

No.	Hours	Latrines	Users	Fam./latrine	Users/latrine
A	16	70	4,256	10	64
B	5	70	2,550	6	36

Diagram 10

Number of Users of Existing Latrines During Regular and Peak Hours

During the visits made to La Zurza it was found that there are 70 latrines in the settlement, that is one unit per 10 families or 64 persons (Diag. 10-A), which is higher than the standards set by the <u>Planning and Design Manual of Appropriate Sanitation Alternatives</u>[14], that recommends 25 to 50 persons per seat.

a) The peak use hours are from 6:00 A.M. to 8:00 P.M. and from 7:00 P.M. to 10:00 P.M., which means that 60% of the population (2,550 persons) uses the latrines during those five hours (Diag. 10-B).

b) The existing latrines in La Zurza are not public but private or semi-private; this means that most of the units are not open to the passerby.

Assuming that 20% of all existing latrines are private - 14 latrines - (Diag. 11), and that the remaining 80% are used semi-privately by five families (32 persons) per unit, there are in La Zurza 56 latrines to serve 280 families (1,792 persons). This means that 371 families do not have access to any latrine. Therefore 2,374 persons or 56% of La Zurza's population practice open air defecation. The goal is to have one latrine per 3 families, or one latrine per 19 persons.

According to the World Bank[14], one latrine seat should efficiently serve 25 to 50 persons; Wagner and Lanoix recommend a maximum of 15 persons. The goal for one seat per 19 persons falls between both recommendation; the decision was taken based on the pit design (Section 2.3.2), since increasing the number of users will result in an extremely large pit.

2.3 STAGING

2.3.1 Stage One

The steps for this stage are: upgrading of 28 of the 56 existing semi-private latrines and construction of the 48 communal latrines.

To solve the problem of open air defecation during this first stage, communal sanitary facilities will be built for settlers who have no access to a latrine. There is no intention of implementing communal facilities as a long term solution to the sanitary problems of the community. These proposed as an immediate solution which serves two purposes: public education, and the elimination of the practice of open air defecation. Installing these communally-supervised facilities during this stage will give the opportunity to the settlers to become acquainted with the new improvements, thus learning how to use and maintain them.

In each of the four sectors into which La Zurza has been divided (Map 9) twelve-seat communal latrines will be installed (Map 10). This is a total of 48 improved public latrines in the whole area. Each seat will serve 50 persons, a number that is at the limit of that recommended by the World Bank.

In communities where water shortage is one of the main drawbacks no sanitation system requiring water is advisable as it will reduce the already scarce supply of water for activities that cannot do without it - cooking, bathing, washing, thus creating an even more unhealthy environment and causing the implemented system to fail.

Of the existing dry systems, ventilated improved double-pit latrines (VIDP) (Diag. 12) have been selected because they meet the minimum sanitary requirements. At the same time settlers are kept within their way of life, not being confronted with alternatives which may risk failing due to lack of understanding and acceptance. Double-pits are used which do not need to be relocated because indiscriminate construction of pits is not possible as the settlement is overcrowded and building space for any facility is becoming more and more scarce. Both communal and semi-private units will be of the same type because of the reasons mentioned and because communal facilities will also serve as a training facility to teach settlers their correct use, construction and maintenance. The needed supervision would be provided by the Ministry of Public Health and Social Assistance.

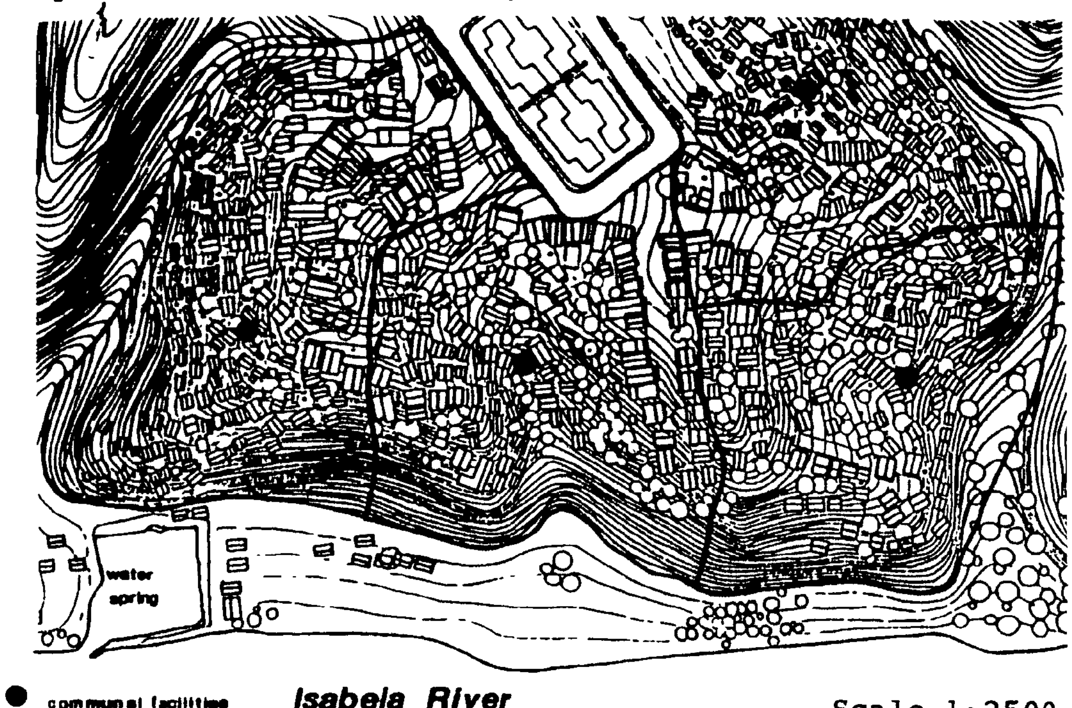
These double-pit latrines will be used alternatively - first one pit will be used for a year and when it fills then it will be sealed while the second pit is used. At the time when this pit is almost filled, the first one is emptied to start using it again[27]. The composted material from the pit will be taken to the composting depot for further degradation; it should not be considered as active waste as it has

	Settlement		Sectors	
Population - persons	4,256		1,064	
Existing Latrines	No.of Units	No.of Users	No.of Units	No.of Users
Total	70	1,882	17.5	470
*Private	14	90	3.5	22.5
*Semi-Private	56	1,792	14	448
Open Air Defecation	-	2,374	-	593.5

Diagram 11

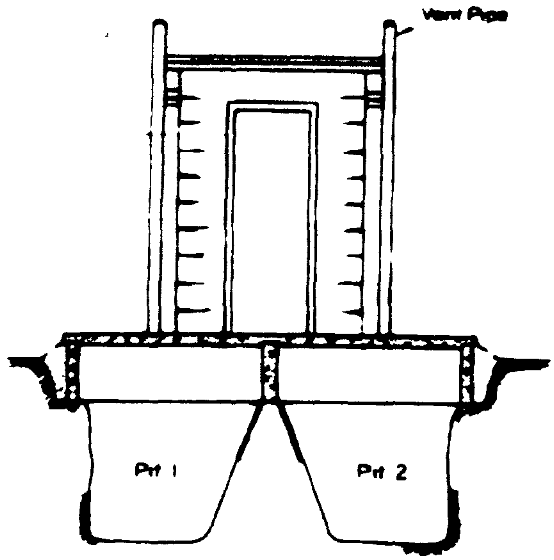
Number of Units and Users per Latrine Type

*Assuming 20% of existing latrines are private and that semi-private units are used by five families each.

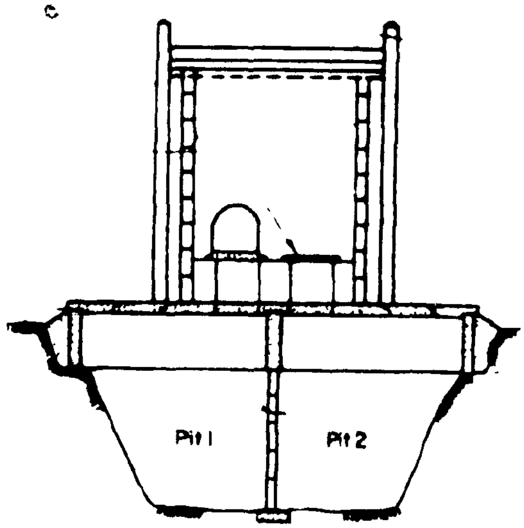


Map 10

Location of Communal Facilities



Standard Design



Optional Design

Source: Environmental Sanitation Reviews

No.6 December 1981.

Diagram 12

VIDP Latrine

The improvements to be made to the existing latrines are:

a) Construction of alternative pits, to stop indiscriminate use and contamination of the land.

b) Use of ventilation pipes, to stop bad smells and fly breeding inside the latrine outhouse.

c) Construction of appropriate seats and lids, to prevent direct contamination of the users and to control odors.

These improvements aim for a more efficient use of the land occupied by latrines, a reduction of bad odors and fly breeding, and the elimination of open air defection.

On Diagram 12 the design of both communal and semi-private latrines is shown. The main difference is the depth of the pit, which for communal latrines will be seven meters and for semi-private latrines will be four meters. The difference is based on the number of users and the required capacity for one year composting within the pit.

2.3.2 Stage Two

During Stage Two the upgrading steps to be taken are: improvement of the 28 existing latrines that were not improved during Stage One, the construction of the 113 semi-private latrines needed to reach the goal of one latrine per three families, and the installation of bathing showers. The reason why 113 latrines are needed to reach the goal of one latrine per three families, is that, from the 217 units needed, the 56 existing semi-private latrines and the 48 communal ones must be deducted, that is a total of 104 latrines (217 - 104 = 113).

The 48 communal units can be counted as semi-private latrines, because at the end of this stage communal latrines will not exist anymore and the communal latrines will be transformed into semi-private facilities, each to be used by three families.

Bathing showers were not introduced before because even though the technology and the space required for the showers was available, the settlers were not considered to be ready for the correct use of them because of their lack of education regarding hygiene; this knowledge that should be acquired during Stage One. The proposed shower (Diag. 13) is made of a 19 litres cooking oil can. One of its sides is totally removed and the other is perforated with small holes to let the water out; a simple valve is made with a piece of the removed side and a piece of plastic material, both attached to a wire. When the can is full of water, the pressure keeps the valve in place, and when the user wants the water to pour, the valve is pushed up and hung on to the side of the can, this shower can be put in any place which offers enough privacy to the user. The cost of the shower is minimal as it is made of leftover materials and does not need any special parts for its functioning.

All the technologies described in this chapter represent an improvement over the existing situation, but their aim is mainly directed to prevent greater deterioration of the environment and of the settlers' health.

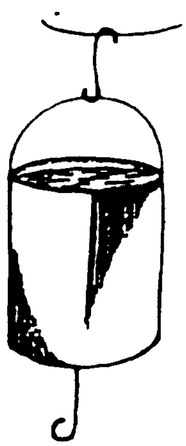


Fig. a

19 liters cooking oil can filled with water. It is hung over the person, when water is needed the valve is simply pushed up (fig.b).

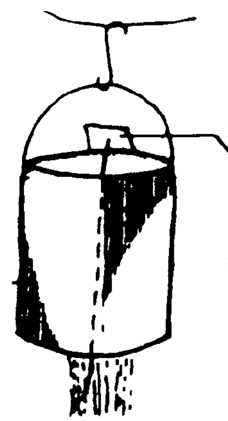


Fig. b

valve; when it is up, the water comes out through the perforated bottom

The valve is made of a piece of metal from the same can, a piece of plastic attached to it and a wire to move it.

Diagram 13

Shower

Chapter 3

SOLID WASTES AND DRAINAGE

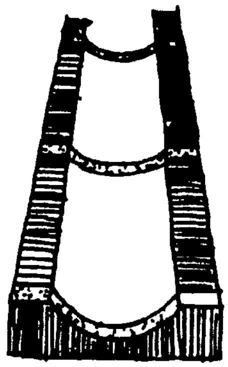
To deal with solid waste in the settlement two systems will be implemented: one to collect the garbage and another to treat it on site. The objective is to reduce the need for a municipal service (which in any case does not exist) and to minimize the hazards that decomposing wastes represent to the health of the settlers by destroying the disease causing agents present in the refuse.

3.1 WASTE COLLECTION

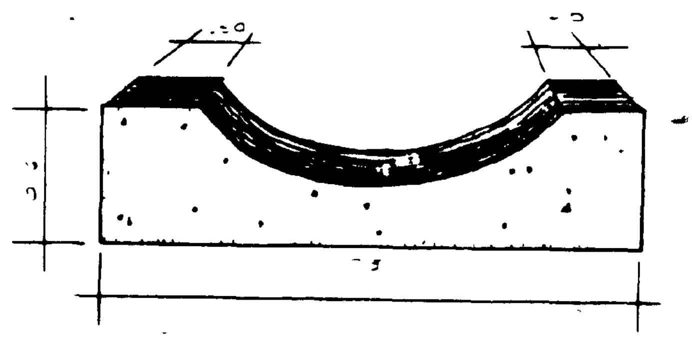
After studying La Zurza's actual system of waste collection, it was decided that the best alternative, considering the settlement's physical and socio-economic structure, was some kind of simple improvement. At present, wastewater and rain cannot wash down all the refuse that is thrown into the ravines since garbage gets stuck in the irregularities. An improvement to this "natural" system of waste collection could be made by paving the bottom of the existing ravines with an adequate and easily available material. The two objectives are: first, to stop the formation of stagnant water pools in the ravines' irregularities, thus avoiding problems such as flies, rats and mosquitoes breeding, and second, to enable garbage to be thoroughly washed down to the foot of the hill, where it can be collected.

By paving the ravines, (Diag. 14-A), the free access of the surface water into them is maintained, which allows easy cleaning during the wet seasons. Because of the small amount of water available for domestic and bathing purposes, residual water from the houses will never have enough strength to wash down all the garbage during the dry season. When there is not enough water to wash down all the garbage ravines will be swept by hand, which is a procedure known and accepted in the Dominican Republic where traditionally, at all social levels, each homestead sweeps its part of the sidewalk every day.

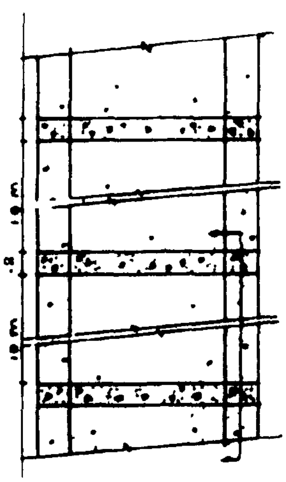
To pave the ravines, their bottom surface will be smoothed out and sisal-cement, will be poured on it; every ten meters, a header will be placed (Diag. 14-B) to support the weight of the chute. Paving will be done from the foot of the hill upward and all construction joints will be made at a header, (Diag. 14-C). Sisal-cement was preferred to other alternatives as the materials are easily available and its use has been well accepted in rural areas from where the great majority of the settlers come. The chutes will be cast right on the previously smoothed ravine's bottom. This technique has been preferred over precast units, because of the steepness of the terrain and the weight of the chutes,



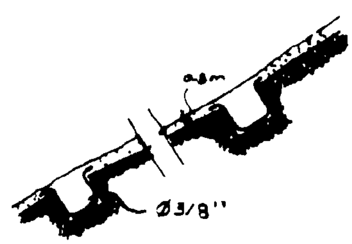
Paved Ravine



Header



Plan of Paved Ravine



Section A-A

Diagram 14

Elements of Paved Ravines

which even if reduced in size - 1.75m wide by 10.00m long - will require eight sections between headers to make them easily transportable by hand. The intermediate joints would create problems of leaks and cracks in the system. Another problem for precast units is the variable width of the gullies and ravines.

3.2 SOLID WASTE TREATMENT

3.2.1 Site

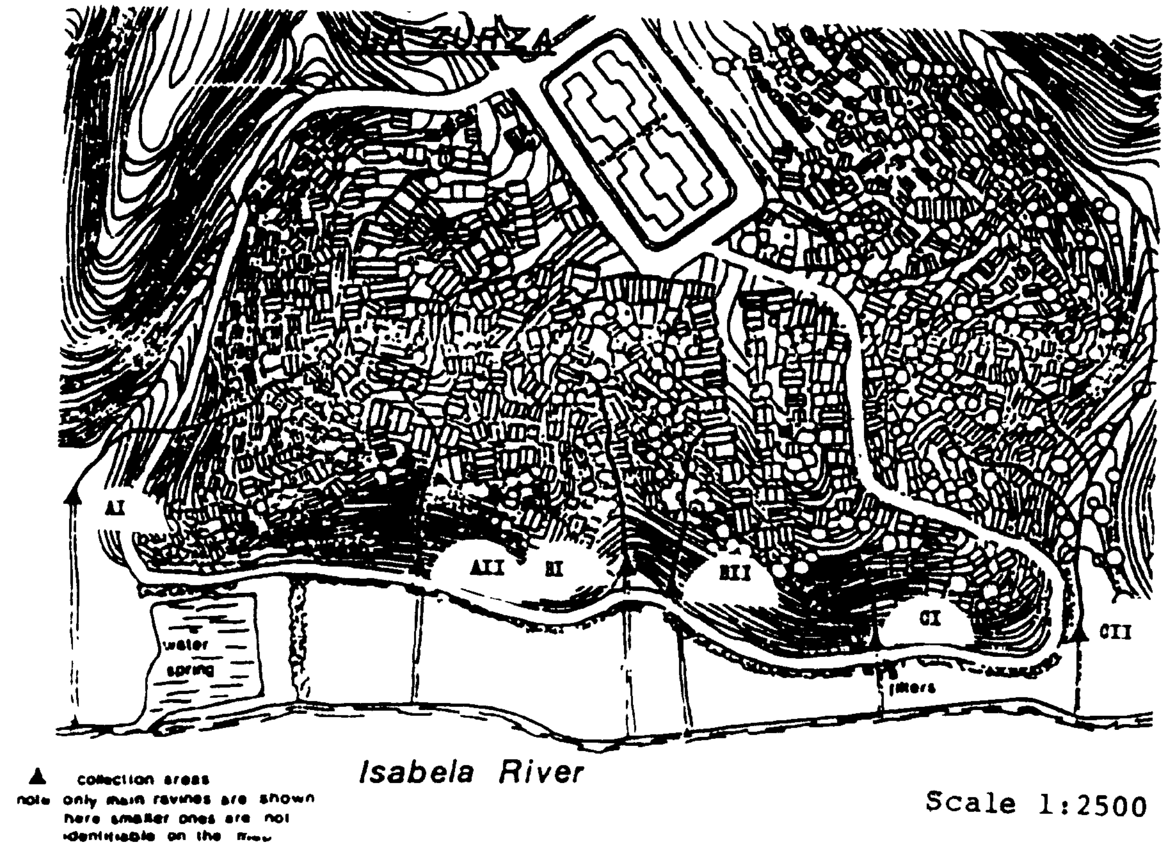
Before discussing the subject of solid waste treatment, a site must be chosen. La Zurza's area is at present over-populated, which implies that any site selected would require an eviction of some houses. The stretch of land between the river and the foot of the hill (the Low-land), has been selected (Map 11) because of the following reasons:

a) The configuration of the terrain; it is the only flat land.

b) Location; all garbage from the settlement will be collected at different points at the foot of the hill (Map 11).

c) Its population density, is lower than that of the rest of the settlement because it was the last area to be built on.

d) The area is subject to flooding which is less dangerous for the composting depot than for housing.



<u>Map 11</u>

<u>Ravines and Waste Collectors</u>

3.2.2 Process

Solid waste treatment processes can be classified into: composting, landfill and incineration. In selecting a waste treatment process technology, implementation, operational and maintenance costs of the system must be carefully considered. If any of those factors fail to be understood or correctly implemented the selected system will not function adequately and the main purpose for treating the waste will be lost. Both incineration and landfill require relatively expensive technology, or large landfill areas. For this settlement, where waste is mainly composed of organic matter, (as surveys conducted by the author showed), the composting process seems best, as it is economically and technologically feasible. Considering the settlers' know-how, the limited availability of land and labour-intensiveness, a manual aerobic composting process has been selected.

Composting is the natural process of decomposition or stabilization of organic matter by biological action, which in recent times man has attempted to control and directly utilize for sanitary disposal and reclamation of organic waste material[8]. Manual composting is proposed. Although there exist totally mechanized composting plants, these are out of the economic reach of this community. There are two different processes of composting: aerobic decomposition and anaerobic fermentation. Aerobic decomposition takes place, when organic material is decomposed in the presence of oxygen - there is no objectionable odor when the process is properly carried on. Anaerobic fermentation happens in the absence of oxygen; the intensive reduction of organic matter by putrefaction is usually accompanied by disagreeable odors[8]. Most of the refuse to be composted in La Zurza is organic matter. According to Gotaas, good fly control is almost impossible in anaerobic conditions for this type of refuse, unless it is done in closed tanks[8]. The preference for aerobic composting over anaerobic, is due to the following reasons:

a) It does not produce objectionable odors if properly done.

b) The destruction of pathogens is faster and surer.

c) Fly control is easier.

Of the existing aerobic composting methods, stacks have been chosen and not pits, because:

a) Stacks, even though more labour intensive in operation than pits, have a smaller initial cost. The settlement has inexpensive labour available, but limited economic resources.

b) Pits are not suitable for ground with a high water table, which is the case for this site. Construction and lining of pits to make them waterproof would raise the costs of building the treatment plant.

c) Stacks often develop higher temperatures than pits, thus making the composting process faster.

d) Stacks are less likely to become water logged during rainy weather than pits.

e) Where no nightsoil is present on the compost material stacks are more satisfactory than pits.

The program for sanitary upgrading (Page 61) plans to eliminate the habit of open air defecation, and thereby the presence of excreta in the refuse is expected to be minimal.

Climatic conditions (temperatures, rain and wind) do affect the composting process but need not deter it if the correct measures are taken[8]. In the Dominican Republic there are no extreme temperatures (Diag. 23), and only winds and rain need to be considered. Due to the settlement location, the area selected for the composting depot is well protected from winds and subject only to a mild breeze coming from the north-east during the night. Only when there are climatic disturbances in the area does this breeze increase in intensity. Since the composting process, when properly done,is odorless, winds do not constitute a problem.

Rain is the climatic factor that affects the composting process the most, since it rains quite often in this area (Diag. 24). A simple roof can be provided to protect the stacks; the type shown on Diagram 17 provides a good option as it is made of "cana" leaves, an easily obtainable organic material, and the technique needed to construct it is known by all settlers.

3.2.3 Drainage and Waste Collectors

There is no separate system for the collection of storm and/or wastewater. They are both collected through the same chutes as the solid waste. Apart from technical and economic considerations, the main reason for using a combined system in this project is the fact that storm and wastewater are the forces that will carry the solid wastes down to the foot of the hill, where they will be collected at different points (Map 11).

The collecting units will consist of a catch basin at the bottom of the hill (Diag. 15) which will collect the garbage but will allow excess water to drain onto the inlet channel towards the river. The garbage accumulated in the collectors will be collected every day (the amount of waste produced in La Zurza per day, is equivalent to the amount needed for one stack about $8m^3$). No storage place will be needed, avoiding in this way the costs of an extra facility and of the labour required for the operation.

The filter beneath the collector is used to stop the particles of refuse which may fall through the mesh, but it does not purify the water. Since residual water re-use is not considered and the river is already highly contaminated (page 17), all waste water will be allowed to drain towards the river through the drain channels.

From the collecting units, solid waste will be taken to the composting depot and placed in stacks. The layout

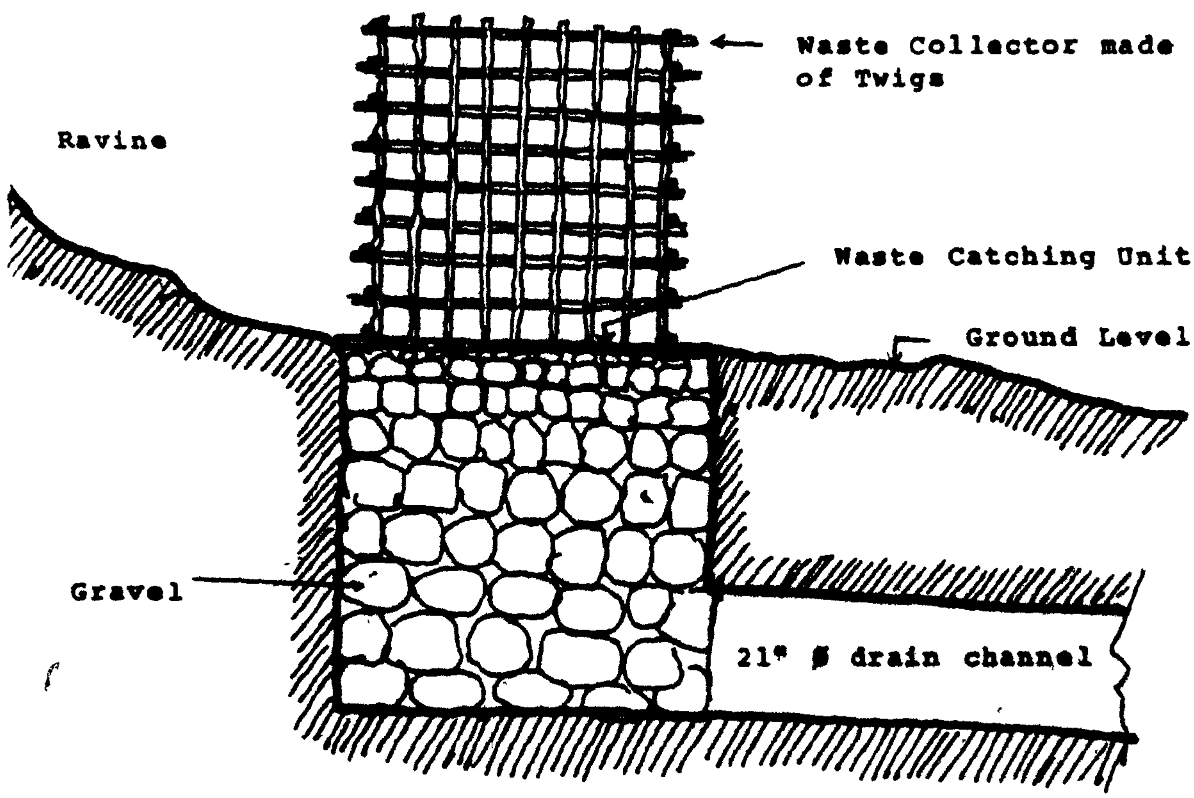


Diagram 15

Waste Collector

selected, is the one used by Wilson in East Africa (Diag. 16)[8]. In this scheme the initial stacks are placed in each corner. After a month the stacks are turned for aeration forming two, instead of four stacks, because of the considerable shrinkage of the material during the composting process. New initial piles can then be placed in each corner, and when the time comes for a second turn, the two first stacks are turned into one in the center of the layout and the four initial ones turned as before into two stacks, and so the process continues.

Segregation of the material is not needed as the garbage produced in the settlement is almost totally composed of organic matter. Shredding of the material can also be eliminated from the process to reduce costs, as only rarely will it be necessary and then large pieces can be broken up manually.

All composted material will be disposed of elsewhere as settlers do not have any use for it, and there is no significant market for the compost nearby. For the disposal of the composted material, the municipality should provide the necessary transportation (one truck load every day), and for this purpose a small road will be built to give access to the composting depot (see page 86). The municipality could get back some of the expenses of picking-up the compost from the depot by selling it for agricultural or gardening purposes.

3.2.4 Composting Depot

The composting depot (Map 12) will need nine units like the one shown on Diag. 16. Every day, enough waste is collected in La Zurza (7.9 m^3) to make one stack, 2.5 m x 2.5 m x 1.3 m, in size, which equals about 8m^3. As every unit holds four stacks, eight units will be needed to have enough space for one month after which the first two stacks are turned into one and two new ones are placed. Because of the high water table of the site, a base must be provided where the refuse to be composted can be stacked. Different materials could be used for this purpose - concrete, rocks, asphalt, or "Rejon" (crushed stones tightly packed together, and covered with light concrete to make it smooth). In the D.R. this is a well known and widely used material in place of concrete where economy is a must, and its price compared to normal concrete is $1.50 cheaper per square meter of floor (Annexe 2). Each of the nine stacking units will be 100 m^2 in area. Around the four sides a drainage channel built of sisal cement will be built to prevent the formation of standing water pools. These small channels will drain into the main drainage channels coming from the waste collectors towards the river.

Over each of the nine stacking units a thatch roof will be built, supported by a wood structure of the same type used for the construction of rural houses, wood beams, over pole columns (Diag. 17). Between each unit there must be enough

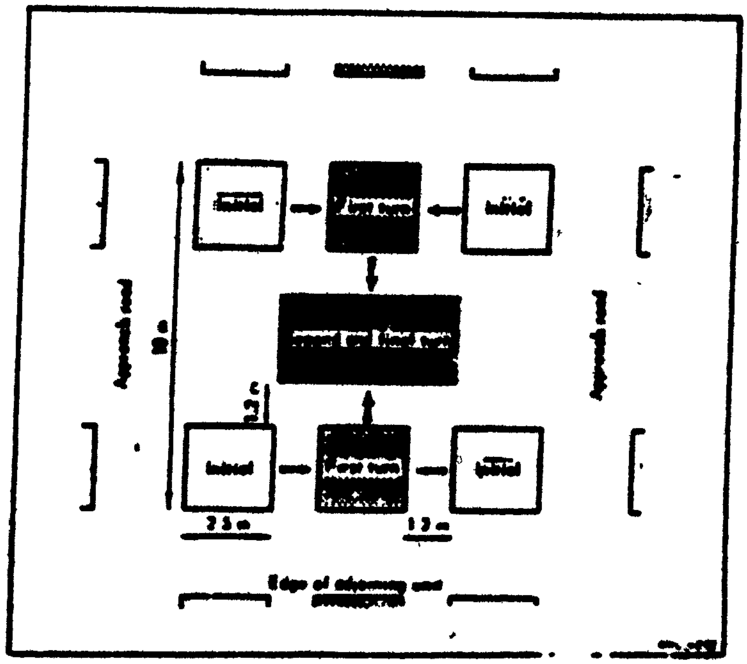


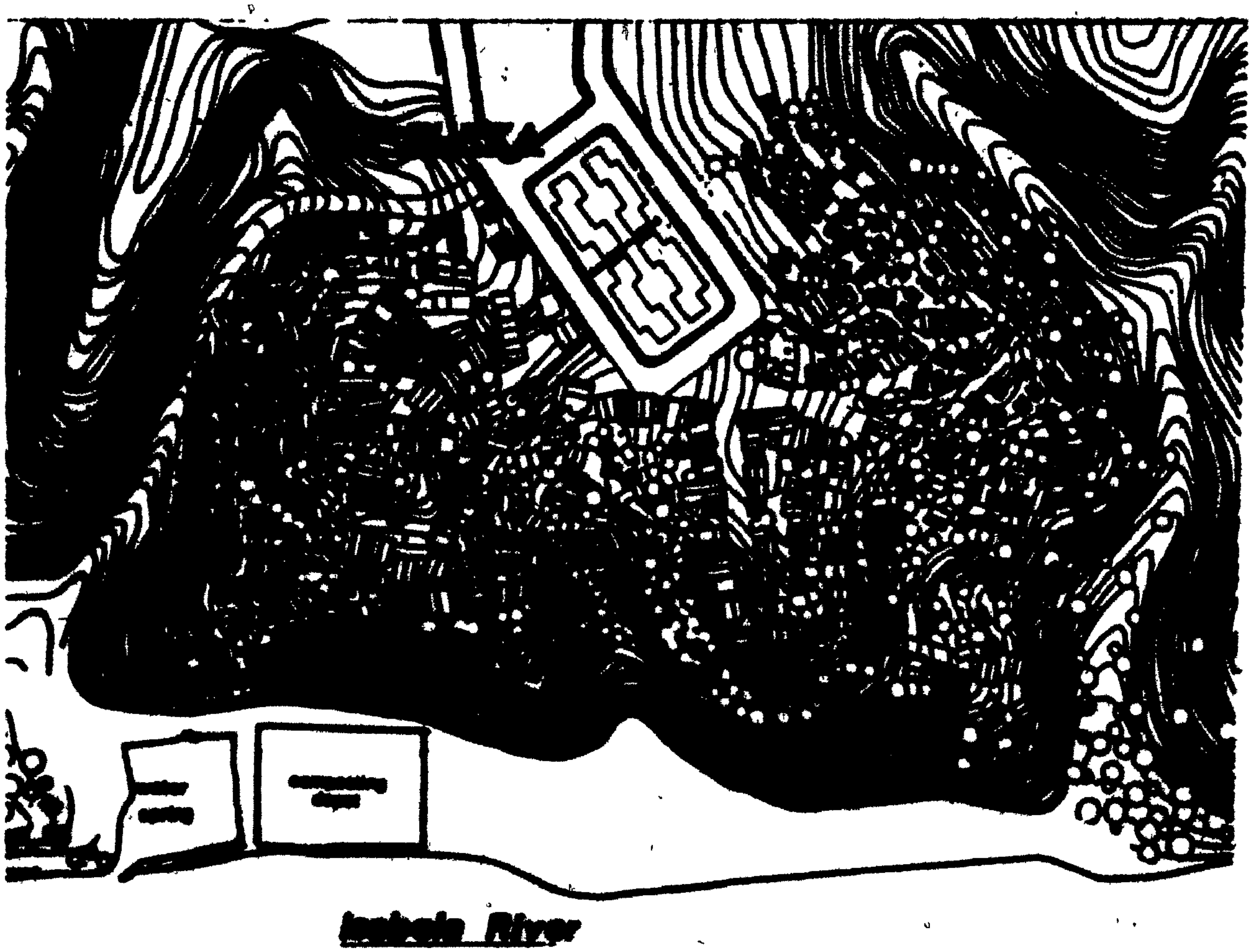
Diagram 16

Layout of Compost Unit in Depot using Stacks

Source: Gotaas, Harold B., Composting. World Health Organization, Switzerland - 1956.

Diagram 17

Typical Thatch Roof Supported on Tree Poles



Scale 1:2500

Map 12

Composting Depot

space for vehicular circulation to allow for the compost to be removed.

3.3 SERVICE ROAD

The composting depot needs road access to dispose of the compost, whether it is to be re-used or just removed. For this purpose, a small service road should be constructed near the foot of the hill (Map 13). This road will also improve the existing road network and the situation of the settlers on the lower part of the hill, by giving them easier access to transportation in and out of the settlement. This road will be built by the City.

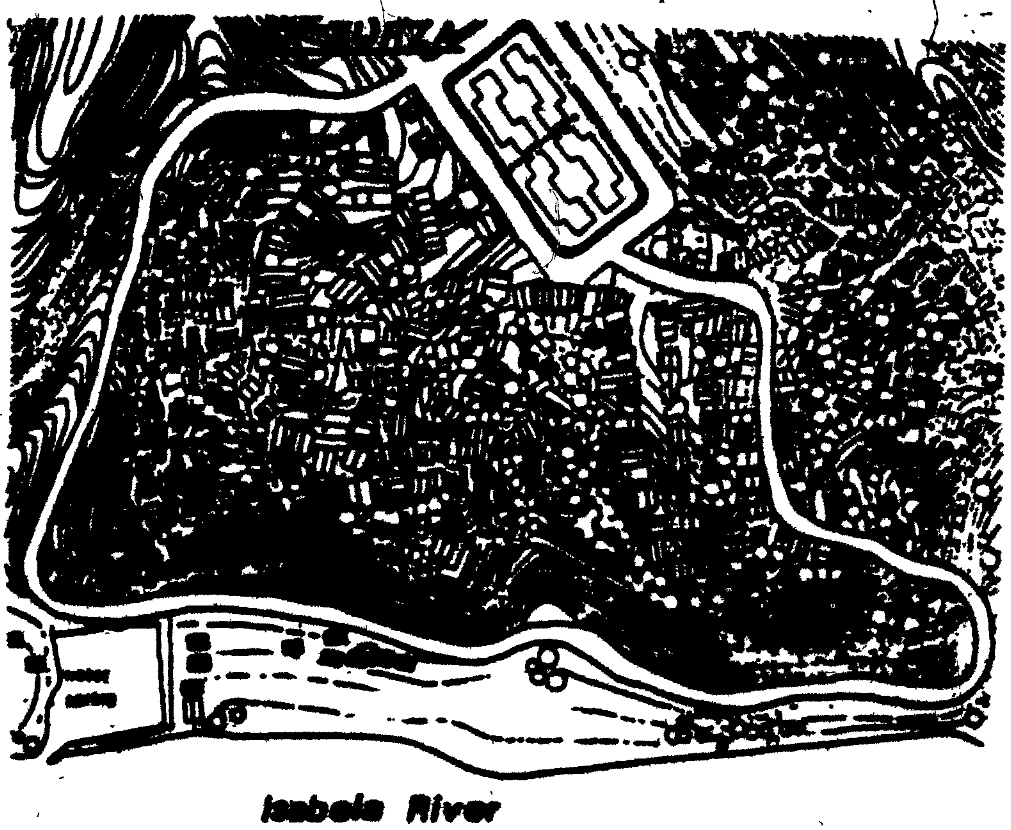
3.4 STAGING

3.4.1 Stage One

During Stage One, sectors A and B will be upgraded, ravines will be paved, and waste collectors A-I, A-II and B-I (Map 11) will be built, along with their corresponding drain channels. The reason for selecting sectors A and B to be upgraded first, is because of their location in relation to the composting depot, which is directly below them (Map 12), making the necessary moving around of the material much easier. Only half of the depot will be built at this stage, as its full capacity is not needed.

3.4.2 Stage Two

Sectors C and D will now be upgraded, together with the second half of the composting depot, and collectors B-II, C-I and C-II (Map 11) will be installed.



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Map 12

Service Road

Chapter 4

WATER SUPPLY

When trying to improve the sanitary aspects of a community, water is the most necessary element to be considered[34]. When water is scarce personal as well as environmental hygiene is neglected, increasing the risk of the inhabitants to contract diseases and also the risk of epidemic spread. The system selected to solve or ameliorate the problems should be carefully studied, for if not well planned, considering the amount of water related diseases that exist in the tropics, it could turn into a threat instead of a benefit to the users.

4.1 STAGING

4.1.1 Stage One

The proposed upgrading consists of a small piped water system whose objective is to redistribute the existing water supply making it more accessible to the settlers. At present there is only one reliable source of water supply - the reservoir - which at the end of the first stage will be closed to the public and will be left just as what is supposed to be an emergency water storage facility. This water storage facility is very necessary since the water supply is infrequent and erratic, and without it most people would be left without water since they have no way of finding out when the water supply is in operation.

As shown on Map 14, 320 meters of P.V.C. pipes, 500mm in diameter will be laid to have one hydrant in each of the four sectors into which La Zurza has been divided (Map 9). Each hydrant will have two water taps. With this, a major improvement will be achieved for the hygiene and health of the inhabitants, since by redistributing the existing water supply the distance and the time spent to get water are shortened. The number of people using each hydrant will be reduced to one fourth of the total population (Diag. 18), that is from the current 4,256 persons to 1,064 persons per hydrant. Installing one water hydrant in each sector not only reduces the number of people served per hydrant; it also reduces the number of settlers that use contaminated water because it brings potable water within walking distance of their homes. Presently most of the inhabitants of the lower part of the settlement use the water from the river or the water spring, which is contaminated (see page 17) because the distance to be walked to the reservoir is too long and steep.

4.1.2 Stage Two

During this stage three improvements will be made: the extension of the water supply system, an increment in the

Isabela River

Scale 1:2500

Map 14

Water Supply - (Stage One)

No. of Users	Current	Stage 1	Stage 2
Per hydrant	4,256	1,064	355
Per water tap	2,128	532	178

Diagram 18

Number of Users per Hydrant

amount of water supplied, and the collection of rainwater. The objective is to make water more accessible to the entire community in quantities large enough to prevent the settlers from using the contaminated waters of the spring and the river.

To start with, 440 meters of P.V.C. pipes 250mm in diameter, will be laid, continuing from hydrants A-1, B-1, C-1 and D-1 (Map 15), providing each sector with three water hydrants instead of one. In this way, the time and distance to get water are again shortened, because instead of 1,064 persons per hydrant (Diag. 18), there will now be only 355 persons. The distance from their homes to the taps is shorter - the maximum distance being 40 meters - and more comfortable than the distance to the water spring or the river, discouraging in this way the use of these sources.

During this stage, a small increment in the quantity of water supplied will take place, based on a more continuous service from the city aqueduct which presently functions only two hours or less per day. This improvement in the services of the city aqueduct is not a theoretical assumption, since the work for its enlargement has already been started. This increase in the water supply, was not taken into consideration for the first stage of this project, because squatter settlements are usually the last communities to get the benefits of any improvement made by the city authorities.

Isabela River Scale 1:2500

Map 15

Water Supply - (Stage Two)

Diagram 19

Rain Collection

Rainwater collection is intended as a complement to any irregularities or faults in the city aqueduct service.

To collect the water bamboo pipes cut in half lengthwise are placed at the edge of the roof (Diag. 19), and at one end of it an oil drum collects and stores the water. This drum should be first treated with an appropriate anti-rust paint or coating and provided with a well fitted lid.

Assuming an average rainfall of 150mm/month (5mm/day) and assuming an average roof area of 30 sq.m. and a collection efficiency of 75%, each house can collect approximately 100 litres of water per day. An oil drum holds 208 litres, so one drum is enough per household.

Rain water collection was not proposed for the previous stage, because of its costs and also because this project is not primarily concerned with the betterment of the houses. A response from the settlers is expected as they start to understand the principles behind the technical innovations proposed, and realize that it will lead them to a self-promoted continuous evolution. The improvement of the roofs is expected to happen during the first half of the second stage.

DIAGRAM 20 - HYDRANT

Chapter 5

ECONOMICS

This chapter deals with the implementation costs of the technologies selected in the preceeding chapters. The unit costs of various items are listed in Annexe 2. All prices are 1983 Dominican prices, and given in US dollars. Labor costs are not considered as it has been assumed that the necessary labor will be provided by squatters.

5.1 SANITATION

5.1.1 Number of Components - Stage One

During this first stage twenty-eight of the existing latrines will be upgraded and a total of forty-eight communal latrines, that is twelve units per sector. First the components for the upgraded latrines will be shown (see Chapter 2). Pits will be lined one meter deep from the top with concrete blocks. Five rows of blocks are needed, which amounts to 105 units. A reinforced concrete slab is needed to cover the pit's hole. The dimensions of the pit are 1.5m by 1.7m by 10 cm. thick which gives a total of about 0.26 cu. m. of concrete per slab. A seat and a lid will be made of wood. The total length of wood needed is equal to 17m per seat. Ventilation pipes will be placed on each pit. They will be made of 5 cm diameter PVC pipe of a unit length of 6m. Considering the unit length of each pipe unit and the needed length of each ventilation pipe which is 3m, one 5 cm diameter PVC pipe is needed per upgraded latrines.

The cost of one upgraded latrine will include:

a) Concrete blocks for lining pits..........105 units

b) Reinforced concrete for slab.............$0.26m^3$

c) Wood for seat and lid....................17m

d) Ventilation pipe........................6m

For the communal units the number of components are as follows. Pits will be also lined as before with concrete blocks. To line both pits 590 units of concrete blocks are needed. Two reinforced concrete slabs are needed to cover the alternative pits. The dimensions of each slab are 2.3m by 2m by 10 cm. thick, which gives a total of about 0.46 cu. m. per pit. Therefore the concrete needed per latrine to make two slabs equals 0.92 cu. m. A seat and lid will be provided. The seat is exactly the same as the one described for the upgraded latrines. Therefore a total length of 17m of wood will be needed per latrine. Ventilation pipes are also the same as for upgraded latrines. Therefore one 5 cm diameter PVC pipe is needed per communal latrine.

Differently from semi-private latrines, outhouses for communal latrines will be provided. The structure to support the roof will be made of wood. Eleven meters of wood posts will be needed per latrine. The roof will be made out of galvanized metal sheets (1.2m X 2.4m). Considering that the outhouse is 1.8m by 1.8m, one and a half sheets of galvanized metal 1.2m by 2.4m are needed per latrine. Walls will also be made of galvanized metal, an average of three metal sheets will be needed per latrine. Considering roofing and walls, a total of 4.5 galvanized metal sheets 1.2m by 2.4m will be used per latrine.

The costs of a communal latrine will include:

a) Concrete blocks for lining pits.........490 units

b) Reinforced concrete for slabs...........0.92m^3

c) Wood for seat and lid....................17m

d) Ventilation pipe.........................6m

e) Wood for roofing structure...............11m

f) Galvanized metal sheets..................4.5 units

5.1.2 Cost Breakdown - Stage One

The following table shows the breakdown of the costs for upgraded latrines. Unit costs of components as well as total costs are shown.

		Units	Total Cost
a)	Total number of concrete block units		
	needed to line one pit per latrine	105	
	Cost of concrete block per unit	($0.14	$15.
	<u>Total cost of concrete blocks per</u>	each)	
	<u>latrine</u> = 105 units X $0.14		
b)	Total quantity of reinforced concrete		
	needed for slab per latrine	$0.26m^3$	
	Cost of one cu. meter of reinforced		
	concrete	($35.00	$ 9.
	<u>Total cost of reinforced concrete per</u>	/m)	
	<u>latrine</u> = $0.26m^3$ X $35.00		
c)	Total amount of wood needed for seat		
	and lid per latrine	17m	
	Cost of wood per meter	($1.20	$20.
	<u>Total cost of wood for seats and lids</u>	/m)	
	<u>per latrine</u> = 17m X $1.20/m		
d)	Total length of 5 cm diameter PVC		
	pipes for ventilation pipes needed per		
	latrine	1	
	Cost of one PVC pipe of a unit length		
	of 6m	($4.00	$ 4.
	<u>Total cost of ventilation pipes per</u>	each)	
	<u>latrine</u> = 1 unit X $4.00		
	<u>Total Cost of one Upgraded</u>		
	<u>Latrine</u> (Stage 1)		$48.

Breakdown of costs for communal latrines.

	Units	Total Cost
a) Total number of concrete block units to line two pits per latrine	490	
Cost of concrete blocks per unit	($0.14 each)	$ 69.
<u>Total cost of concrete blocks per latrine</u> = 490 X $0.14		
b) Quantity of reinforced concrete needed for slabs per latrine	$0.92m^3$	
Cost of one cu. meter of reinforced concrete	$35.00 /m	$ 32.
<u>Total cost of reinforced concrete per latrine</u> = $0.92m^3$ X $35.00		
c) Total amount of wood needed for seat and lid per latrine	17m	
Cost of wood per meter	$1.20 /m	$ 20.
<u>Total cost of wood for seats per latrine</u> = 17m X $1.20		
d) Total length of 5 cm diameter PVC pipes for ventilation pipes needed per latrine	1	
Cost of one PVC pipe of a unit length of 6m	($4.00 each)	$ 4.
<u>Total cost of ventilation pipes per latrine</u> = 1 unit X $4.00		
Sub-total		$125.

	Units	Total Cost
Carried over		$125.
e) Total amount of wood needed for roofing		
structure per latrine	11m	
Cost of wood per meter	($1.20	$ 13.
<u>Total cost of wood for roofing structure</u>	/m)	
<u>per latrine</u> = 11m X $1.20		
f) Total number of galvanized metal units		
needed for walls and roofs per latrine	4.5	
Cost of one unit of galvanized metal	($2.00	$ 9.
<u>Total cost of galvanized metal sheets</u>	each)	
<u>per latrine</u> = 4.5 X $2.00		
<u>Total Cost of one Communal Latrine</u> (outhouse included) Stage 1		$147.

5.1.3 Number of Components - Stage Two

During the second stage the 28 existing latrines that were not upgraded during stage one will be upgraded. Also, 113 new double-pit latrines will be built for semi-private use.

To upgrade the 28 existing latrine exactly the same process followed during stage one will be applied. Therefore the description made for stage one fully applies to this second stage.

For the construction of the new 113 semi-private latrine units the same procedure described for the upgrading of the existing latrines will be followed. The ony difference that exists is that two pits will be lined and two slabs will be needed. As in the case of the upgraded latrines, one pit was already built. Therefore considering this it is not necessary to repeat the whole description.

The cost of building one new double-pit semi-private latrine will include:

a) Concrete blocks for lining two pits.......210 units

b) Reinforced concrete for slabs............$0.52m^3$

c) Wood for seat and lid....................17m

d) Ventilation pipe.........................6m

5.1.4 Cost Breakdown - Stage Two

The following table shows the breakdown of the costs to construct one new double-pit latrine. The cost breakdown for the upgrading of existing latrines is not repeated as it corresponds to the table shown for the first stage.

	Units	Total Cost
a) Total amount of concrete block units needed to line two pits per latrine Cost of concrete blocks per unit **Total cost of concrete blocks per latrine** = 210 unit X $0.14	210 ($0.14 each)	$ 29.
Sub-total		$ 29.

	Units	Total Cost
Carried over		\$ 29.
b) Total quantity of reinforced concrete needed for two slabs per latrine	$0.52m^3$	
Cost of reinforced concrete per cu. m.	(\$35.00 $/m^3$)	\$ 18.
<u>Total cost of reinforced concrete per latrine</u> = $0.52m^3$ X \$35.00		
c) Total amount of wood needed for seat and lid per latrine	17m	
Cost of wood per meter	(\$1.20 /m)	\$ 20.
<u>Total cost of wood for seat per latrine</u> = 17m X \$1.20		
d) Total length of 5 cm diameter PVC pipes for ventilation pipes needed per latrine	1	
Cost of one PVC pipe of a unit length of 6m	(\$4.00 each)	\$ 4.
<u>Total cost of ventilation pipes per latrine</u> = 1 unit X \$4.00		
<u>Total cost of one new Double-pit Latrine</u> (Stage 2)		\$ 71.

5.1.5 Cost per Stage

The following table summarizes the costs of each stage of implementation of the sanitation system.

	Units	TOTAL COST Stage 1	Stage 2
a) Total number of existing latrines upgraded in stage 1	28		
Cost of one upgraded latrine	$48.00 /unit	$1,344.	
Total cost of upgraded latrines - Stage 1 = 28 units X $48.00			
b) Total number of communal latrines built in stage 1	48		
Cost of one communal latrine	$147.00 /unit	$7,056.	
Total cost of communal latrines - Stage 1 = 48 units X $147.00			
c) Total number of existing latrines upgraded in stage 2	28		
Cost of one upgraded latrine	$48.00 /unit		$1,344.
Total cost of upgraded latrines - Stage 2 = 28 units X $48.00			
d) Total number of new latrines built in stage 2	113		
Cost of one new latrine	$71.00 /unit		$8,023.
Total cost of new latrines built in Stage 2 = 113 units X $71.00			
Total Cost per Stage		$8,400.	$9,367.
Cost per Family		$12.63	$14.08

5.2 SOLID WASTE AND DRAINAGE

5.2.1 Number of Components - Stage One

Of the total number of 6 waste collectors to be built by this project, 3 (A-I, A-II and B-I) will be constructed during this stage. To collect the garbage about 750m of ravines and gullies will be paved with sisal-cement. An average of 250m per waste collector. Considering that the average width of the chutes will be 1.75m, and that their thickness will be about 5 cm., a total of 22 cu.m. of sisal-cement will be needed per waste collector (Diag. 15).

To support the weight of the chutes, a header will be placed every 10m. That is a total of 25 headers per waste collector. The quantity of concrete required for each header is 0.18 cu.m. (Diag. 15). As 25 headers are needed the total amount of concrete per waste collector is equal to 4.5 cu.m. Each header will also need 6m of 10mm reinforcing bars. The total amount required for 25 headers is 150m. One meter of 10mm bar weighs 0.52 kg., therefore, 150m weigh about 78 kg., total weight of reinforcing bars needed per waste collector.

The waste collector itself will need (Diag. 15) a fence made of wood poles. 18m of these wood poles are needed per waste collector. A metal grill to prevent garbage from faling into the filter is also needed. This metal grill will be made of 6mm bars. Each grill will need 16 kg. of 6mm bars. Each grill will need 16 kg. of 6mm bars. A very simple filter will be built, to prevent small pieces from the refuse from getting into the drainage channels. Each filter will need 4.2 cu.m. of gravel. A drainage channel will take residual water from the collector to the river. These drainage channels will be built of 53 cm diameter concrete tubes. An average length of 45m of drainage channel will be needed per collector. Considering the unit length of the concrete tube, 1.2m, 38 units are needed per waste collector.

The cost of one waste collector will include:

a) Paving of ravines....................22cu.m.

b) Headers...............................25 units

c) Wood fence............................1 unit

d) Iron grill............................1 unit

e) Gravel................................4.2 cu.m.

f) Drainage tubes........................38 units

Also during stage one 4 of the 9 stacking bases needed for the composting depot will be constructed. Only half of the depot capacity is needed until the 6 waste collectors are built during Stage Two. Stacking bases will be made of "rejon" (page 83). Each base is 10m by 10m, that is $100m^2$. Around the base a drain channel paved with sisal-cement will be provided. This channel will have a total length of 40m per stacking base, a width of 0.1m, and a thickness of 3 cm. for the paving material. Therefore, 0.18 cu.m. of sisal-cement to pave drains are needed per base. These drains will be connected to the main draining channels using 5 cm diameter PVC unpressurized pipes, of a unit length of 6m. The total length of connection pipes needed per base is about 15m.

To protect the composting material from the rain, a roof will be built over each base. Thatch has been chosen as the roofing material because of costs. $100m^2$ of thatch roofing will be needed per base. To support the roof a simple wood structure will be made using tree poles. 100m of wood will be used per base.

The costs of one stacking base will include:

a) "Rejon"..................................100 sq. m.

b) Drain channel (sisal-cement)............0.18 cu.m.

c) Connection to main drainage.............15m

d) Roof (thatch)...........................100 sq. m.

e) Supporting structure for roof
   (tree poles)............................100m

5.2.2 Cost Breakdown - Stage One

The following table shows the breakdown of the costs. Unit costs of components as well as total costs are shown.

		Units	Total Costs
a)	Total quantity of sisal-cement needed		
	to pave ravines	$22m^3$	
	Each cu.m. of sisal-cement	$12.00	$264.
	Total cost of paving ravines per waste	/m	
	collector = $22m^3$ X $12.00		
b)	Total number of headers per waste		
	collector	25	
	Each header costs	($5.20	$130.
	Total cost of headers per waste	each)	
	collector = 25 X $5.20		
c)	Total quantity of tree poles needed		
	for fence	18m	
	Each tree pole costs per meter	$0.75	$ 14.
	Total cost of tree poles per waste	/m	
	collector = 18m X $0.75/m		
d)	Total quantity of 6mm bars needed		
	for iron grill per collector	16kg.	$ 6.
	Cost of 6mm bars per pound	$0.37	
	Total cost of 6mm bars needed for iron	/kg.	
	grill per waste collector		
	= 16kg X $0.37		
	Sub-total		$408.

	Units	Total Cost
Carried over		$408.
e) Total amount of gravel needed for filter per waste collector	4.2m^3	
Cost of gravel per cu. meter	($6.00 /m^3)	$ 25.
Total cost of gravel needed for filter per waste collector = 4.2m^3 X $6		
f) Total length of 53 cm diameter concrete tubes	45m	
Each tube of a unit length of 1.2m costs	($12.00 /m)	$456.
Total cost of drainage tubes per waste collector = 38 units X $12.00		
Total Cost per Waste Collector (Stage 1)		$895.
Cost breakdown for Composting Depot.		
a) Total quantity of "rejon" needed per base	100m^2	
At a cost per sq. meter of	($1.50 /m^2)	$150.
Total cost of building one stacking base = 100m^2 X $1.50		
Sub-total		$150.

	Units	Total Cost
Carried over		$150.
b) Total amount of sisal-cement for drain		
channel per base	$0.18m^3$	
At a cost per cu. meter of	($12.00	$ 2.
Total cost of drain channel per base =	$/m^3$)	
$= 0.18m^3 \times \$12.00/m^3$		
c) Total length of 5 cm diameter		
unpressurized PVC pipes	2.5	
Each pipe of a unit length of 6m costs	($4.00	$ 10.
Total cost of pipes per stacking base	/each)	
= 2.5 units X $4.00		
d) Total amount of thatch roofing needed		
per base	$100m^2$	
At a cost per sq. meter of	($0.80	$ 80.
Total cost of thatch roofing per base	$/m^2$)	
$= 100m^2 \times \$0.8$		
e) Total length of tree poles needed for		
supporting roof structure per base	100m	
At a cost per meter of	($0.90	$ 90.
Total cost of wood for structure per	/m)	
base = 100m X $0.90		
Total Cost per Stacking Base (Stage 1)		$332.

5.2.3 Number of Components - Stage Two

During Stage Two the same process described in Stage One will take place. This time for waste collectors B-II, C-I and C-II. Therefore the description made in Stage One applies totally to this second stage.

Concerning the composting depot, the process will also be exactly as in Stage One. The only difference is that instead of 4 stacking bases, 5 will be constructed during this second stage. As the number of components are found per stacking base, no description is necessary apart from the one given in Stage One (see Section 5.2.1).

5.2.4 Cost Breakdown - Stage Two

The table showing cost breakdowns for waste collectors in Stage One, applies to this stage. The same applies for the table showing cost breakdowns for stacking bases (see Section 5.2.2).

5.2.5 Costs per Stage

The following table summarizes the costs of each stage of implementation of the solid waste and drainage system.

		Units	Stage 1	Stage 2
a)	Total number of waste collectors stages 1 & 2	3		
	Cost per waste collector - stages 1 & 2	($895. each)		
	<u>Total cost of waste collectors - Stage 1</u> = 3 X $895.		$2,685.	
b)	<u>Total cost of waste collectors - Stage 2</u> = 3 X $895.			$2,685.
c)	Total number of stacking bases - Stage 1	4		
	Cost per stacking base	($332. each)		
	<u>Total cost of stacking bases - Stage 1</u> = 4 X $332.		$1,328.	
d)	Total number of stacking bases - Stage 2	5		
	Cost per stacking base	($332. each)		
	<u>Total cost of stacking bases - Stage 2</u> = 5 X $332.			$1,660.
	<u>Total Cost per Stage</u>		$4,013.	$4,345.
	<u>Cost per Family</u>		$6.03	$6.53

5.3 WATER SUPPLY

This section deals with the first stage of installing a water supply system. It establishes the various components required for its implementation. The cost of the first stage of the water supply system is then calculated on the basis of the number of components used.

5.3.1 Number of Components - Stage One

During the first stage 4 hydrants will be installed, one on each sector (Map 14). To distribute water to hydrants A-I, B-I, C-I and D-I, 320 meters of 5 cm diameter, PVC pressurized pipes will be laid. An average of 80m of piping will be used for each hydrant.

The unit length of each pipe unit is 6m and fourteen units are needed per hydrant. Two water taps will be installed on each hydrant. Underneath each water tap a catch basin will be built to prevent water spillage and the formation of standing water pools. These basins will drain into the nearest ravine or gully. The quantity of concrete required for each catch basin is $0.6m^3$ (see Diag. 19). For the drainage, 5 cm diameter unpressurized PVC pipes are used. Each hydrant needs about 10m of drainage pipes. Each pipe unit is 6m long and two units are needed per hydrant.

The cost of one hydrant during stage one will include:

a) Distribution pipes................80 meters

b) Water taps........................2 units

c) Concrete catch basins.............$0.6m^3$

d) Drainage pipes....................10 meters

5.3.2 <u>Cost Breakdown - Stage One</u>

The following table shows the breakdown of the costs. Unit costs of components as well as total costs are shown.

		Units	Total Cost
a)	Total length of 5 cm diameter PVC pressurized water distribution pipes	14	
	Each pipe of a unit length of 6m costs	($9.00 each)	$126.
	<u>Total cost of pipes per hydrant</u> = 14 units X $9.00/unit		
b)	Quantity of concrete needed for the catch basin per hydrant	$0.6m^3$	
	Each cu. m. of concrete costs	($22.00 /m)	$ 13.
	<u>Total cost of concrete/hydrant</u> = $0.6m^3$ = $0.6m^3$ X $22.00		
c)	Number of water taps required per hydrant	2	
	Cost of one water tap	($3.00 each)	$ 6.
	<u>Cost of two water taps per hydrant</u> = 2 X $3.00		
	Sub-total		$145.

	Units	Total Cost
Carried over		$145.
d) Total length of 5 cm diameter PVC unpressurized drainage pipes	10m	
Each pipe of a unit length of 6m costs	($4.00 /m)	$ 8.
Total cost of pipes per hydrant = 2 units X $4.00/unit		
Total Cost per Hydrant (Stage 1)		$153.

5.3.3 Number of Components - Stage Two

During the second stage, eight hydrants will be installed, two in each sector (Map 15). To distribute water to hydrants A-2, A-3, B-2, B-3, C-2 and C-3, 440 meters of 4 cm diameter PVC pressurized pipes will be laid. An average of 55m of piping will be used for each hydrant.

Considering that the unit length of each pipe unit is 6m, 9 units are needed per hydrant. Two water taps will be installed on each hydrant. Underneath each water tap a catch basin will be installed for the same purpose as in Stage One. These basins will also drain into the nearest ravine or gully. The quantity of concrete required for each catch basin in $0.6m^3$, as they are the same size as those built during Stage One. For the drainage 4 cm diameter, unpressurized PVC pipes are used. Each hydrant needs about 10m of drainage pipes. Since each pipe unit is 6m long, 2 units are needed per hydrant.

The cost of one hydrant during Stage Two will include:

a) Distribution pipes..................55 meters

b) Water taps.........................2 units

c) Concrete catch basins...............$0.6m^3$

d) Drainage pipes......................10 meters

Also during Stage Two rain water collection will be introduced. To collect the water from the roofs, bamboo pipes will be used. About 6m of tree pipes will be needed per house. Also one 114 liters oil drum per house will be used to store the collected water.

The cost of the rain collection per house will include:

a) Bamboo pipes........................6 meters

b) 114 liters oil drum.................1 unit

5.3.4 Cost Breakdown - Stage Two

The following table shows the breakdown of the costs. Unit costs of components as well as total costs are shown.

		Unit	Total Cost
a)	Total length of 4 cm diameter PVC pressurized water distribution pipes	9	
	Each pipe of a unit length of 6m costs	($7.00 each)	$ 63.
	<u>Total cost of pipes per hydrant</u> = 9 units X $7.00/unit		
b)	Quantity of concrete needed for the catch basin per hydrant	$0.6m^3$	
	Each cu. m. of concrete costs	($22.00 $/m^3$)	$ 13.
	<u>Total cost of concrete per hydrant</u> = $0.6m^3$ X $22.00		
c)	Number of water taps required per hydrant	2	
	Cost of one water tap	($3.00 each)	$ 6.
	<u>Cost of two water taps per hydrant</u> = 2 X $3.00		
d)	Total length of 4 cm diameter PVC unpressurized drainage pipes	2	
	Each pipe of a unit length of 6m costs	($3.00 each)	$ 6.
	<u>Total cost of pipes per hydrant</u> = 2 units X $3.00/unit		
	<u>Total Cost per Hydrant</u> (Stage 2)		$ 87.

Cost breakdown for rain collection.

		Units	Total Cost
a)	Total length of bamboo pipes	1	
	Each pipe of a unit length of 6m	($2.00	$2.
	<u>Total cost of bamboo pipe per house</u>	each)	
	= 1 X $2.00		
b)	Number of 114 liters oil drums per		
	house	1	
	Each oil drum costs	($7.50	$7.50
	<u>Total cost of water storage drum per</u>	each)	
	<u>house</u> = 1 X $7.50		
	<u>Total Cost of Rain Water</u>		
	<u>Collection Per House</u>		$9.50
	(Stage 2)		

5.3.5 <u>Cost per Stage</u>

The following table summarizes the costs of each stage of implementation of the water supply system.

		Units	Stage 1	Stage 2
a)	Total number of hydrant to be			
	installed - Stage 1	4		
	Each hydrant costs	($153.00		
	<u>Total cost of hydrant</u>	each)	$612.	
	<u>Stage 1</u> = 4 hyd. X $153.00			
	Sub-total		$612.	

	Units	Stage 1	Stage 2
Carried over		$612.	
b) Total number of hydrants to be installed - Stage 2	8		
Each hydrant costs	($87.00		$ 696.
Total cost of hydrants-Stage 2	each)		
= 8 hyd. X $87.00			
c) Total number of rain collection units - Stage 2	665		$6,318.
Cost of each unit	($9.50		
Total cost of rain collection	each)		
units = 665 units X $9.50			
Total Cost Per Stage		$612.	$7,014.
Cost per Family		$0.92	$10.55

5.4 AFFORDABILITY

The following table shows the costs per stages of the different aspects covered by this project - sanitation, solid waste and drainage and water supply. It also shows the costs per family of each aspect as well as the total cost of the project.

	Sanitation		Solid Waste & Drain.		Water Supply		Totals	
Costs	Total	per fam	Total	per fam	Total	per fam	Total	per fam
Stage1	$8,400.	$12.63	$4,013.	$6.03	$ 612.	$0.92	$13,025.	$19.58
Stage2	$9,367.	$14.08	$4,345.	$6.53	$7,014.	$10.55	$20,726.	$31.16
Proj.	$17,767.	$26.71	$8358.	$12.56	$7,626.	$11.47	$33,751.	$50.74

Diagram 21

Costs per Stage Total, and per Family

The uniform annual cost (UAC) per family is calculated based on the formula UAC = P X UCR. Where P represents the present worth per family and UCR represents the uniform capital recovery. The formula used and the UCR values are taken from Life Cycle Cost Analysis[15].

The following table shows the total costs per stage and per family related to the UAC per family.

Interest Rate		Costs		Avg. income = $30	
5%	Yrs	Total	Per Fam	UAC/Fam	% of income
Stage 1	10	$13025.	$19.58	$2.53	8.5%
Stage 2	10	$20726.	$31.16	$4.03	13.5%

Diagram 22

U.A.C. per Family Compared to Average Income

It is estimated that people should spend 25% of their income to pay for housing. As this is a services project, it is considered that 10% of people's income should be used to pay for it. Diagrams 21 & 22 show the amount needed to be paid by squatters to implement the systems selected. Stage one is totally affordable by the community as the income percentage needed per family, 8.5%, falls below the set margin of 10%. Stage two requires some subsidy for its implementation as the percentage needed per family to cover its implementation costs, 13.5%, is above 10% margin. Therefore the amount of subsidy needed for stage two is 3.5% per family.

To reduce this amount during stage one settlers will be required to pay the set margin of 10% of their income per family. The overpayment of 1.5% per family for stage one will be used to create a fund for the settlers which will allow them to subsidize themselves part of the second stage. With this arrangement settlers reduced the net subsidy needed from 3.5% per family to 2% per family.

This project's concern in keeping the necessary subsidy to a bare minimum is mainly due to the following reasons:

a) The scarcity of funds available in the country for the improvement of the life standards of very low-income communities.

b) The fact that no project dealing with squatter settlements have yet been implemented in the Dominican Republic.

c) The belief that improvements of living standards should be a result of a self-supported plan, desired, accepted and affordable by the community in question.

Annexe I

THE DOMINICAN REPUBLIC

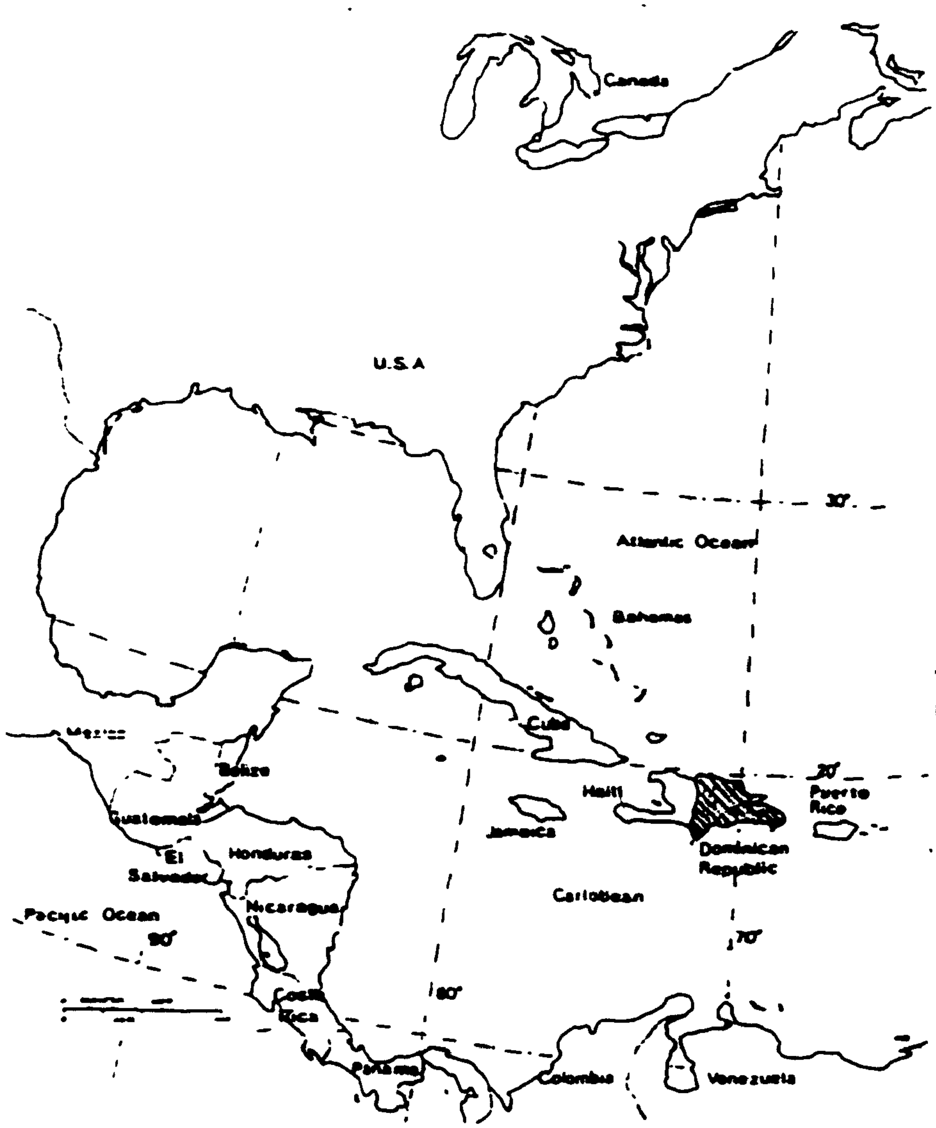
A1.1 INTRODUCTION

The Dominican Republic is located on the island of Santo Domingo, or Hispaniola, which is the second largest of the Greater Antilles Islands, found in the Caribbean Sea (Map 16) between parallels 17° 36' 40" and 190° 58' 28" latitude north and longitudes 68° 20' and 74° 30' west of Greenwich[5]. It covers two thirds of the island while Haiti occupies one third; the two countries are divided by a 388 Km. border. The territorial area of the Dominican Republic is 48,422 sq. Km. in which three regions are clearly defined (Map 17), North, South-east and South-west[33].

A1.2 POLITICAL SITUATION

The Dominican Republic was under the dictatorship of Rafael L. Trujillo for thirty-one years (1930-61). During this period the country slowly started the process of modernization. The armed forces and public services were expanded and new social sectors - labour and middle class - began to appear. Of course, many of these improvements,

THE DOMINICAN REPUBLIC



Map 16

Geographic Situation of the Dominican Republic

Source: National Geographic Magazine.

specifically the improvements of the communication system and of the armed forces, were designed to strengthen the dictatorial regime with very little interest for economic growth. The Trujillo era was characterized by a limited inflow of foreign investment, and the repayment of the public external debt to the American and British governments[17].

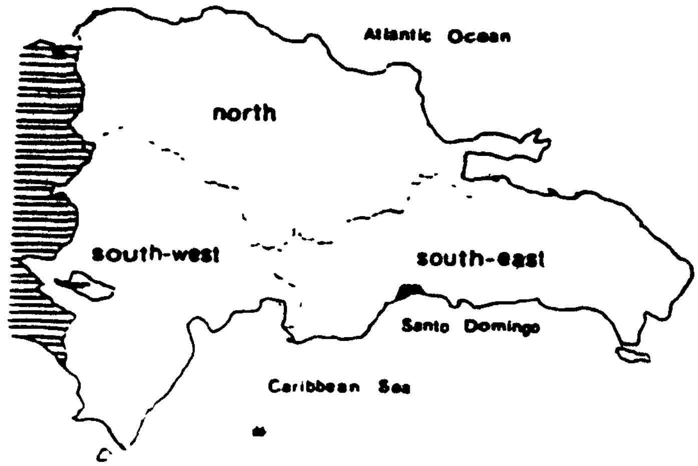
Trujillo's death in 1961 marked the beginning of a chaotic period of political activity. The political vacuum left after his death was filled by a series of short-lived governments.

In 1962 Juan Bosch was elected to the presidency but nine months later his government was overthrown.

Between then and 1965, the conservatives were always in power, until the civil revolution which started in April 1965 and ended with a military occupation by American Marines.

After the revolt elections were held in May 1966 and President Joaquin Balaguer was elected. The major economic goal of the newly elected president was to open the Dominican Economy to the rest of the world in order to promote growth and development and to create a domestic industrial sector.

In the Dominican Republic, elections are held every four years and President Balaguer was elected for three consecutive periods ending in 1978, when Antonio Guzman defeated him. During Guzman's government the country's economic situation became very bad and unemployment rates increased.



Map 17

Dominican Republic Main Regions

Source: Union Panamericana - O.E.A.[32]

ANNUAL	SUMMER	WINTER
25.1°C	27.1°C	24.0°C
	August	January

Diagram 23

Average Temperatures

Source: Union Panamericana - O.E.A.[32]

In May 1982 a new president, Salvador Jorge Blanco, from the same political party as ex-president Guzman was elected and is still in power.

A1.3 ECONOMIC ACTIVITY

The Dominican economy depends mostly on the exportation of agricultural products and minerals[33]. Sugar revenues have accounted for about 50% of agricultural foreign exchange revenues, on the average, followed by coffee, cocoa and tobacco[17]. Mineral (nickel and bauxite) sales accounted for 15% of total revenues.

A1.4 CLIMATE

The climate in the area is sub-tropical without extreme temperatures, due to the sea breeze and to the four mountain ranges which run East and West and modify the climate. These ranges are: Central, Septentrional, Neiba and Bahoruco[5]. Diagram 23 shows the average temperatures in summer, winter and annually, and, as can be noticed, seasonal variation is minimal.

Generally, for the areas near the coast, the seasonal variation of cloudiness shows a maximum doubling during the months of May and June and another during September and October. The average of daily cloudiness changes considerably, being usually greater between 4:00 P.M. and 6:00 P.M.[33].

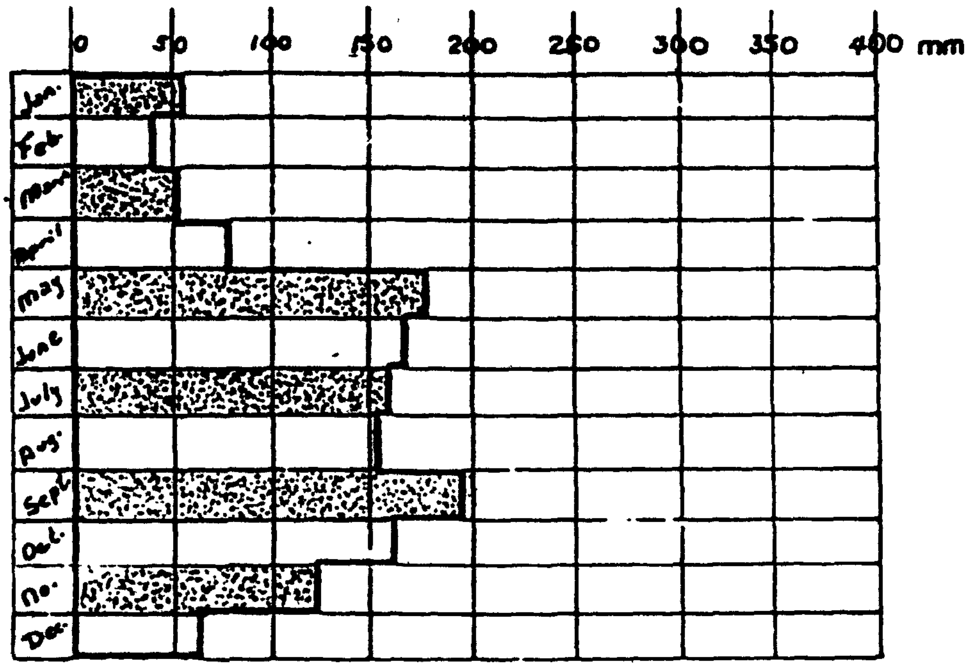
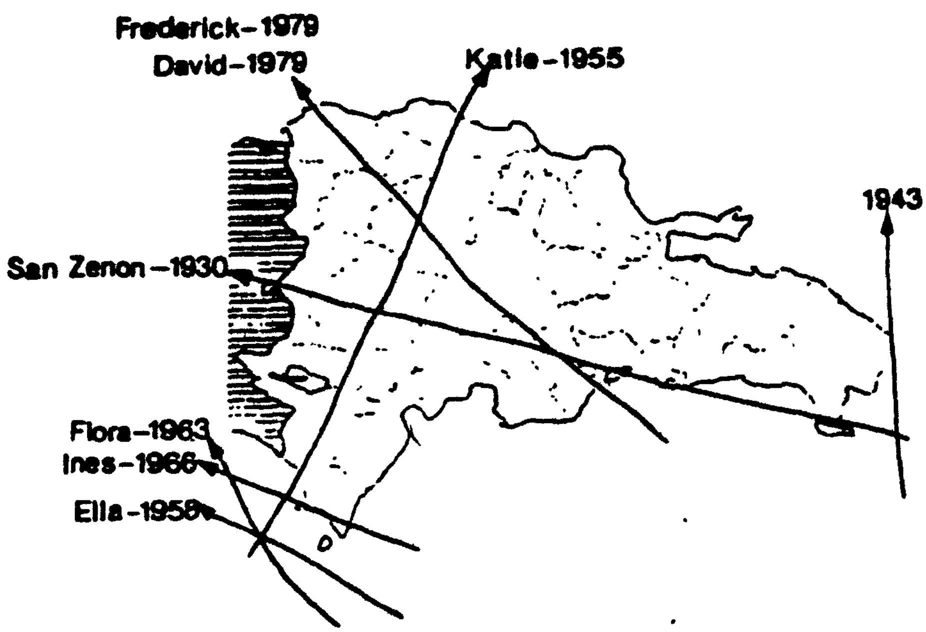


Diagram 24

Monthly Distribution of the Rain in Santo Domingo

Source: Union Panamericana - O.E.A.[32]



Map 18

Hurricanes

Source: Meteorologia

The southern parts of the island are subject to the onslaught of tropical hurricanes with great frequency and power. In extreme cases, hurricane winds may reach an intensity greater than 250 kilometers per hour, provoking intense rainfalls that can total as much as 750 millimeters in twenty-four hours[33]. The hurricane season starts in the month of June and lasts until September. However, the most disturbing climatic conditions do not usually start until the month of August. Hurricanes deserve special attention, because of the danger that they represent to human life, wildlife, forestry, to construction in general and to agriculture (Map 18).

A1.5 POPULATION

The population of the country is about five million inhabitants (1978) of which one million two hundred and thirty-two thousand live in the capital city Santo Domingo, which is the center of all commercial, administrative, governmental, cultural, social and industrial activities[20]. This is the reason why many people from the rural areas emigrate to Santo Domingo. The second largest city is Santiago, in the Northern region, with a great agricultural potential.

Diagram 25 and 26 give an idea of the rural-urban evolution of the population, in numbers and in graphics, from 1950 to 1978[20]. In 1950, 23.8% of the population was urban

	1950	1960	1970	1976	1977	1978
Urban	508,401	922,090	1,593,235	2,243,632	2,362,717	2,487,243
Rural	1,627,471	2,124,980	2,416,223	2,591,575	2,614,984	2,637,151
Total	2,135,872	3,047,070	4,009,458	4,835,207	4,977,701	5,124,394

Diagram 25

Evolution of the Rural and Urban Population (Numbers)

Source: Indicadores Basicos - ONAPLAN[20]

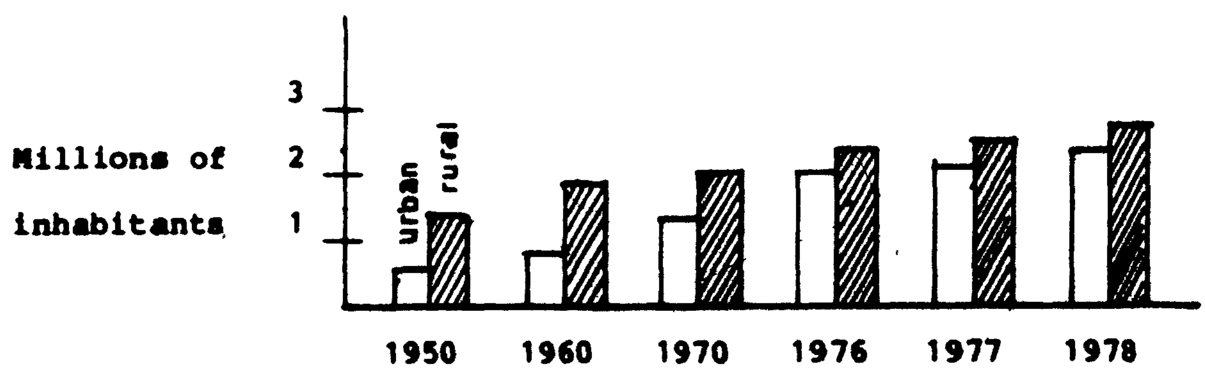


Diagram 26

Evolution of the Rural Urban Population (Graphics)

Source: Indicadores Basicos - ONAPLAN[20]

and 76.2 rural, but in 1978 both percentages have almost balanced with an increase of the urban population to 48.54% and a drop in the rural population to 51.46%. As shown in Diagram 27 the majority of the population are mulattos (72.93%) followed by a small percentage of whites (16.07%) and blacks (10.9%)[20]. The country is predominantly Catholic (98.17%), as Diagram 28 shows.

Whites	16.07%
Blacks	10.89%
Mulatos	72.93%
Asians	0.11%

Diagram 27

Ethnic Composition

Source: Estructura del Entorno[10]

Catholics	98.17%
Presbysterians	0.97%
Adventists	0.18%
Other	0.60%
None	0.08%

Diagram 28

Religious Composition

Source: Estructura del Entorno[10]

Annexe 2

LIST OF PRICES

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*All prices Dominican Republic's values in 1983 US Dollars.

A2.1 Steel Reinforcing Bars

.6cm $0.08/m

1.0mm $0.18/m

1.2cm $0.32/m

A2.2 Polyvinylchloride (PVC) Pressurized Pipes

D=3.8cm @ $2.00 (L=6m)

1.9cm @ $3.00 (6m)

2.5cm @ $4.50 (6m)

3.8cm @ $7.00 (6m)

5cm @ $9.00 (6m)

A2.3 Polyvinylchloride (PVC) Unpressurized Pipes

D=3.8cm @ $3.00 L=6m

5cm @ $4.00 6m

7.5cm @ $8.00 6m

10cm @ $13.00 6m

15cm @ $30.00 6m

A2.4 Water Taps

1 complete unit @ $6.00

Installation cost $6.00

A2.5 Concrete Tubes - not reinforced

L=1.2m W=6.4m @ $12.00

A2.6 Nipples

W=1.3cm	@ $0.25
1.9cm	@ $0.38
2.5cm	@ $0.65
Y=3.8cm	@ $0.90

A2.7 Concrete and Related Materials

Simple concrete (1:3:5)	@ $22.00/$m^3$
Reinforced concrete (.10m thick)	@ $35.00/$m^3$
"Rejon"	@ $15.00/$m^3$
Sisal cement	@ $12.00/$m^3$

A2.8 Labor Costs

Minimum salary in the D.R. $2.50/day

Labor Cost for pouring concrete $1.00/$m^3$

A2.9 <u>Hand Digging Rates</u>

Soil	1.50m^3/day
Clay	1.30m^3/day
Soft Rock	1.05m^3/day
Hard Rock	0.50m^3/day

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2. Baez Lopez-Penha, Ing. Ramon - Dean of the Engineering Faculty of the Universidad Nacional Pedro Henriquez Urena - Santo Domingo, Dom. Rep.

3. De Sanctis, Vicente Md - Director of the Social Security Hospital Laboratories - Santo Domingo, Dom. Rep.

4. La Zurza Settlers - Groups of settlers chosen at random were interviewed concerning various aspects of this project.

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