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Environmental Management Designed to Build Climate Change Resistance in a Squatter Settlement in Nepal

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Abstract
Climate change has become one of humankind's most challenging global environmental issues. Urban centers, with their industries and infrastructure, produce greenhouse gases and therefore play a crucial role in climate change. In developing countries such as Nepal, the expansion of cities produces parallel growth of large slum areas, threatening all aspects of the quality of life there. This study focuses on one squatter settlement's adaptation to climate change and proposes strategies for managing the enclave's infrastructure to make it better prepared and more responsive to climate change. Specifically, it addresses biodegradable solid waste management to generate bio-gas, carbon sequestration to reduce total carbon in the atmosphere and a control system for its frequent flooding.
Keywords: Climate change, squatter, pollution, green house gases

Introduction

The term "climate change" refers to all forms of climatic inconstancy or any variation in climate over time, whether due to natural phenomena or as a result of human activity. Whether a direct or indirect result of human activity, if it alters the composition of the global atmosphere and is not attributable to natural climate variability over comparable time periods, then it can be called climate change. Considered one of the major global threats of this millennium, a large number of countries, particularly developing countries, face serious challenges to their humanitarian and economic development as a result of climate change. Nepal is one such country. Building resilience to climate change involves the adjustment of practices, processes and structures to reduce its negative effects and take advantage of any opportunities that result as a by-product of climate change. This is considered one of the most serious threats to sustainable development, having an adverse impact on the environment, human health, food security, economic activity, natural resources and physical infrastructure of both individual countries and the global community.

In particular, change in weather conditions creates significant negative impact. There is change in the hydrological cycle with drought, landslide, flooding, and crop diseases reducing agricultural productivity and producing health problems for human beings and animals alike. People migrate to urban areas in countless numbers to pursue better lives. Thus, cities and towns all over the world are facing the effects of climate change and resource depletion. As a result of climate change, we have explosive physical growth of urban areas with its concomitant rapid and uncontrolled urbanization. The number of homeless people and squatters is also growing, bringing urban poverty and a myriad of environmental problems. People living in squatter settlements lack even the most basic infrastructure, such as sources of clean drinking water and healthy food, proper sanitation, waste management facilities, energy resources, public transport, etc. There is growing food insecurity, uncontrolled population increase, and economic instability. Urban sprawl and squatter settlements, with their many environmental problems, are among the most visible reflections of these problems, making the lives of poor and vulnerable people all the more difficult.

So-called "squatter settlements" are illegal, unauthorized collections of dwellings that accommodate low-income and impoverished people with no land titles. The basic characteristics of such settlements are decaying and infirm housing structures, poor ventilation, acute over-crowding, faulty alignment of streets, inadequate lighting, lack of safe drinking water, food insecurity, flooding during rains, absence of toilet facilities and non-availability of basic physical and social services. Living conditions have a direct impact on public health. People living in squatter communities both contribute to and are victims of urban pollution.

In fact, it can be said that slums and the squatters who live there are the worst manifestation of urban poverty, deprivation, and exclusion in the modern world and both are rapidly multiplying. In such areas, urban crime is rampant, transport efficiency is on the decline with increasing road accidents, energy costs are rising and health problems are prevalent. Therefore, it is imperative that attention be focused on how to address these problems. As a preliminary step, this study considers ways to rectify at least a few of them, with the ultimate goal of increasing climate change resistance and providing more sustainable development.

Methods

The study was conducted in a densely populated squatter settlement of about 600 households in Kathmandu, Nepal, called Manohara Bhaktapur. Physical observations, focus group discussions, key informant interviews and a case study were carried out. Targeted households, members of adolescent groups, a squatter leader, a

community leader, and various men, women and children were the informants. The methods applied were a pre-field study, i.e. getting a map and locating the study area, a preliminary study, a literature review, problem identification, and selection of the specific topic. After completion of the pre-field study, a field study was carried out which included primary and secondary data collection. Primary data were collected through observation (site visit, field survey and investigation), questionnaires and interviews with squatter and community leaders, men, women and children. Similarly secondary data were collected from government reports, newspapers, journals, Internet websites and academic papers. After completion of the field study, the information was compiled and the resultant data was analyzed using Microsoft Excel.

Results and discussion

Five different environmental issues for managing the environment in the squatter settlement were selected, and these were prioritized based on a number of criteria and a scoring system which included scores both on **qualitative** and **quantitative scales**. Respondents were asked questions on five different criteria and their answers were tabulated and calculated. These criteria received scores from 1 (lowest) to 3 (highest) and weights from 3 (least important) to 5 (most important) as shown in Tables 1 to 5 below.

Table 1: Scores and Weights for Criteria 1, 2 and 3

Criterion	Qualitative Scale Rating	Quantitative Scale	
		Score	Weight
Criterion 1: Degree of influence on human health	Large Medium Small	3 2 1	5
Criterion 2: Degree of influence on environment quality	Large Medium Small	3 2 1	4
Criterion 3: Degree of non-conformity with legal requirements	Large Medium Small	3 2 1	3

Source-Urban Environmental Management Plan (UEMP) for Bistrita Municipality and UEMP for Cape Town

Criteria 4 and 5 are related to a qualitative scale (Large, Medium, and Reduced). These criteria were given only scores and no weights.

Table 2: Scores for Criteria 4 and 5

Criterion	Qualitative Scale Rating	Quantitative Scale Score
Criterion 4: What are the costs related to solving the problem?	Large Medium Small	1 2 3
Criterion 5: To what extent does the approach benefit public health/environment?	Large Medium Small	1 2 3

Table 3: Answers from Respondents for Criteria 1, 2 and 3

Air Pollution Lg/Med/Sm			Water Pollution Lg/Med/Sm			Waste Management Lg/Med/Sm			Flood Management Lg/Med/Sm			Transport Lg/Med/Sm		
C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3	C1	C2	C3
Med	Med	Sm	Lg	Sm	Lg	Lg	Lg	Med	Lg	Lg	Lg	Med	Med	Med

C1 = Criterion 1, C2 = Criterion 2, C3 = Criterion 3 Lg = Large, Med = Medium, Sm = Small

Table 4: Answers from Respondents for Criteria 4 and 5

Air pollution Large/Medium/ Small		Water pollution Large/Medium/ Small		Waste management Large/Medium/ Small		Flood Management Large/Medium/ Small		Transport Large/Medium/ Small	
C4	**C5**	**C4**	**C5**	**C4**	**C5**	**C4**	**C5**	**C4**	**C5**
Large	Medium	Medium	Medium	Medium	Small	Large	Small	Large	Small

Calculation- Calculation was done for Criteria 1, 2 and 3 by multiplying scores by weights allotted to each criterion regarding each individual problem and then by summing them up to obtain a partial total value. Secondly, only scores have been allotted to the characteristics of action (Criteria 4 and 5). The final calculation involved multiplication of actions scores (Criteria 4 and 5) with the partial total value obtained for Criteria 1, 2 and 3. The resulting general total was used to prioritize the problems, with the first priority being the parameter with the highest value obtained by calculation, and the last priority being the one with the smallest value.

Table 5: Scores, Weights and Calculations

Environmental problems	Criteria for problem importance and severity			Partial total for problem importance and severity (Score A=1+2+3)	Criteria for establishing priorities for action		Total (Score B= Crit.4+Crit.5 × Score A)
	CRIT.1 x WEIGHT(5) -1-	CRIT.2 x WEIGHT(4) - 2-	CRIT.3 x WEIGHT(3) -3-		CRIT.4	CRIT.5	
Air pollution	2×5	2×4	1×3	21	1	2	63
Water pollution	3×5	3×4	3×3	36	2	2	144
Waste management	3×5	3×4	2×3	33	2	2	132
Flood management	3×5	3×4	1×3	30	1	3	120
Transport	2×5	2×4	2×3	24	1	3	96

The calculation shows that water pollution is the most important problem in the squatter settlement. Ranked from highest to lowest priority, the scores indicated that the perceived ranking of the urgency of the problems was water pollution, waste management, flood management, transport, and air pollution.

Environmental infrastucture To assess environmental infrastructure, house type (Table 6), roof type (Table 7), kitchen type (Table 8) and construction materials used by the people in the settlement (Table 9) were recorded.

Table 6: House type

No. of respondents	House type		Percentage	
	Pakki	Kachhi	Pakki	Kachhi
65	22	43	34%	66%

Note: *Kachhi* means a very simple house made of bamboo and tin and *pakki* means a house made of brick and tin.

Table 7: Roof type

No. of respondents	Roof type			Percentage		
	Tin	Tile	Thatched	Tin	Tile	Thatched
65	62	2	1	95%	3 %	2%

Table 8: Kitchen type

No. of respondents	Kitchen type					
	LPG	Firewood	Kerosene	LPG and kerosene	Firewood and kerosene	LPG, firewood and kerosene
65	47	25	8	2	6	1

Table 9 House construction material

No. of respondents	Construction material				Percentage			
	Bamboo	Block	Tin	Brick	Bamboo	Block	Tin	Brick
65	16	24	6	19	25%	37%	9%	29%

The results show that the majority of the houses in the settlement are very simple, constructed mainly of block, bamboo and brick, all of which are weak, with 95% of roofs made of tin. The majority of the people use LPG and firewood and there is no separate kitchen in the house. There is no electricity supply with a meter, nor a direct line in the settlement. However, people living there sometimes get electricity from a line from the other side of the road opposite the settlement with those using the electricity sharing the bill, although some cannot afford to pay even that, and live without electricity.

Solid waste generation- There are about 600 households in the settlement, and the waste produced from these houses is generally thrown into the river, the road or an open area. This biodegradable waste could be used for generating biogas, with the energy thus produced being used by the people and the waste being effectively utilized and managed. Above all, this could result in a reduction in the emission of CO_2 into the atmosphere, thereby helping the community do less to contribute to climate change.

Table 10: Total biodegradable solid waste generated per day

No. of households	Total waste produced per day			
	Bio-degradable (kg)			Total (kg)
	3kg	2kg	1kg	
65	6	34	25	111

Based on the data obtained from 65 households (Table 10), it was revealed that the 600 houses seem to generate about 1025 kg of biodegradable solid waste per day. This could be a huge resource for the generation of community biogas. Sanitation in the settlement (Table 11) is very poor, with many using a nearby pit, field or open area. This creates the very great risk of transmission of diseases in the settlement population, which is about 3000 (600 houses x 5 people per family).

Total excreta produced by the 3000 people living in the settlement per day will be about 1200 kg (400 gm produced by one person per day). This is enough raw material to fuel about 15 plants of 10 m^3, each of which could theoretically generate 15 x 10 x 2400 = 360000 liters of biogas daily. Those 36000 liters of gas obtained from excreta could be used to fuel a stove for some 90 hours. The gas thus generated could be used in school canteens or given to those who cannot afford to buy LPG, those who are currently using firewood. This could be a great advancement that would save time and labor for housewives.

Table 11: Types of toilets used in the settlement

Sample households	Toilet type					
	Private			Public		
	Simple	Pit	Modern	Field	River	Open area
65	10	21	4	8	5	17

When the people were surveyed regarding flooding, the majority of them said that water from a nearby river comes inside the house whenever it rains heavily. Anti-flooding measures are very necessary but there are none being carried out at the present time. They were also asked about their awareness of climate change. Their answers are shown in the table below (Table 12).

Table 12: Settlers' awareness of climate change

No. of respondents	Temperature increase	Mosquito increase	Long term drought	Food price increase	Flood occurrence
65	Yes	Yes	Yes	Yes	Yes

The settlers feel that there is increase in mosquitoes with concomitant increase in illnesses such as malaria. Furthermore, there is long-term drought, which has resulted in rises in food prices and flooding, both direct and indirect results of climate change. The unexpected drought has forced many people to leave the country. For example, Lumakanta Puri, one inhabitant of the settlement, has gone to Qatar to work. There are many other people who have been forced to leave their homes.

Transportation in this settler's colony is very poor, and the majority of the people agree that road conditions are terrible. They say it is quite difficult to walk there during the rainy season as the road is very slippery and muddy. Transport within Kathmandu Valley is a fundamental necessity for people and for the economy, one which has a direct impact on air quality, especially in terms of greenhouse gas emissions and noise pollution.

All the people living in the settlement feel that they suffer from major problems, ranging from lack of water supply to living in a flood zone without title to the land they occupy. They feel the acute lack of security, schools and a health center. The residents are also concerned because their drinking water comes from a stone tap and is not treated. Therefore, the elderly and babies in particular, often fall victim to illnesses caused by drinking contaminated water.

To rectify these and other problems, those living in the settlement say that they are willing to cooperate and participate. They are ready to provide labor support in terms of solid waste management, construction of flood control walls, road repair and maintenance, planting of trees and making open public spaces. What they lack is proper guidance, government support and money, but still they are working to stop river water coming inside the house when it rains, such as raising the front portion of the house using stones and bricks. Practicing flood prevention by raising the wall is something the government could have done to help them. In other sectors there are some donor agencies such as DAIL (a Korean support that helps children). But there is no support for - flood prevention from any sector. Money and government support would be very instrumental in helping them to solve some of their problems.

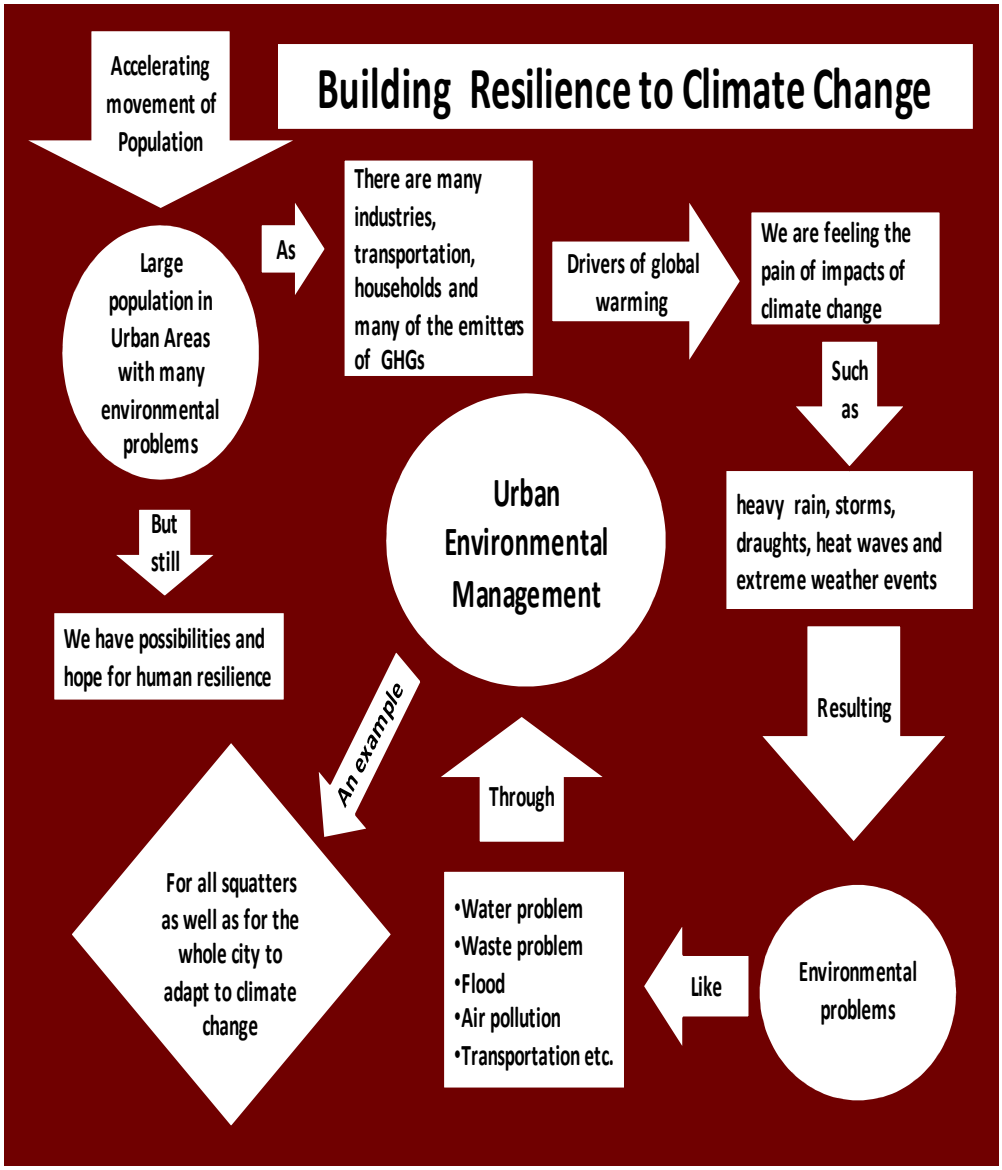
A case of a schoolgirl suffering from climate change

"Drinking water and it's shortages stop me going to school"

"My name is Sumitra Tamang and I am 12 years old. I study in grade 6 at a local school in Lokanthali. It's me who has to collect water for the house. There are only two taps in the area and only one is functioning during winter , there is very little water coming. All the people in the slum depend on that tap, besides people living in Kausaltar and Lokanthali area also come . Many times in winter I wait more than 2 hours before my turn comes . I remember it used to be two taps working in winter also, but now low rainfall and less water , we only have one tap working. It's late for me to go to the school and I do not like attending school late, it makes me hard to concentrate in class. I wish we had drinking water supply in the slum, I could go to the school. "
(Translated into English)

Sumitra Tamang, Nayabasti, Manohara, Nepal.

There are many girls like Sumitra who are not able to go to school. Fetching water is the job of children in this squatter colony. Since there is only one stone tap in the settlement that functions during winter, people have to wait for a long time for their turn to draw water. Children like Sumitra have to go and collect water daily for their families' survival. This prevents her and other girls like her from attending school.



An example of urban environmental management through squatter settlement to adapt to climate change

Recommendations and Strategies

Cities can be designed to store more carbon by means such as planting more trees and domestic gardening. "Recycling of plant litter and especially grass clippings in cities should be encouraged. This recycling would return nutrients from litter to ecosystem and reduce fertilizer use and associated emissions of greenhouse gases" (Churkina, 2008). In this section, we will propose a series of recommendations and strategies that could lead to solutions to some of the environmental problems that exist in this squatter community and, no doubt, many others like it worldwide.

First, we will consider children's right to basic education. Working with children on climate change adaptation is one way of protecting their rights. The changing climate has an impact on families' livelihoods and can make it difficult or impossible for them to send their children to school. Governments need to ensure, through scholarships, stipends or fee waivers, that children get the education they need to improve their own and their families' prospects for the future. They should be encouraged to participate and get involved in order to adapt to a changing climate.

Next, we will address the pressing issue of securing an adequate supply of potable water. The people of this colony are working hard to identify and secure a source of water near the settlement. If they succeed, and if that water can be used, a significant problem of the people living there will be solved. For this work, either government itself or NGOS/INGOS can take action to ensure that there is a proper water supply. If they manage to do this, students like Sumitra would not need to go and fetch water and wait for long hours. Students like her will be able to go to school and get their education, which will in turn benefit both their lives and those of their

families. Furthermore, rainwater harvesting can be done in the settlement to help settlers to meet their water needs.

Thirdly, we can reduce carbon dioxide emissions through carbon sequestration of biomass, which is the most natural medium for storing carbon. Hence, an increase in forested areas by means of actions such as planting trees along the bank of the river would help to store carbon produced in the city. Planting trees can be one of the most important long-term solutions. Planting bamboo near riverbanks provides additional income to families, as bamboo is easily sold locally.

Furthermore, we will consider food reserves**.** We know floods and droughts are annual occurrences in Nepal, but their frequency and magnitude are increasing. In order to cope, we can encourage families to prepare food and dried vegetables for the monsoon and dry seasons. The practice of storing dry foods like rice, maize, dried vegetables, dried radish and carrots, cauliflower, and so forth would be a good practice for adapting to climate change.

Finally, we will take solid waste management into an account. Bio-degradable solid waste along with human excreta can be used to generate bio-gas in the settlement. The generation of bio-gas can help poor people to meet their energy demand which they can use for cooking. This practice will not only help generate energy but also help to reduce emissions of carbon dioxide into the atmosphere, thus helping to generate money through Clean Development Mechanism. For example a total of about 15 plants of 10 m^3 size biogas can be constructed which can generate – 15 x 10 x 2400 = 360000 liters of gas daily. These 36000 liters of gas can be used to fuel a stove for 90 hours. Biogas plants so constructed can work for about 30 years, i.e. in 30 years about 483.574 tones of CO_2e will be stopped from being emitting into the atmosphere. Again we can generate money through CDM, about Rs 906,701.25.

The solutions proposed in this study are many and varied. Some are easier to accomplish than others. Some, like planting bamboo and locating a water source, are already underway. Others, such as storing carbon or generating biogas, must be tackled as large-scale projects with support from outside. Some of these solutions seem almost impossible to achieve in the immediate future. However, we can start some of the practices mentioned above and see the outcome. We would definitely achieve something and help the dwellers in settlers' colonies such as the one investigated in this study to adapt to climate change.

Conclusion

Our examination of the facts and opinions of these squatter colony dwellers regarding global climate change reveals interesting points. These people have many problems and they desperately need solutions. They are willing to work to solve their most immediate problems, such as flood control and sanitation issues. However, they can only provide sweat equity; planning and financial support will have to come from external sources, such as the Nepali government and NGOs.To summarize, the water problem is felt by all people living in the settlement. Solid waste can be managed through generation of biogas helping to reduce CO_2 emission into the atmosphere. A total of about 15 plants of 10 m^3 size biogas can be constructed which can generate – 15 x 10 x 2400 = **360000 liters of gas** daily which can be used to fuel a stove for 90 hours. Biogas plants so constructed can work for about 30 years, i.e. in 30 years about **483.574 tones of CO_2e** will be stopped emitting into the atmosphere. Again through CDM **Rs 906,701.25** can be recovered. Similarly from the excreta of human 15 plants of 10 m^3 size biogas can be constructed.

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