german cooperation
DEUTSCHE ZUSAMMENARBEIT

বাংলাদেশের সুবর্ণজয়ন্তী Bangladesh 50

INTERNATIONAL CONFERENCE ON URBAN AND REGIONAL PLANNING (ICURP) 2021

| 30TH OCTOBER 2021
BANGABANDHU INTERNATIONAL CONFERENCE CENTER (BICC), DHAKA, BANGLADESH
| 31 OCT – 06 NOV 2021
VIRTUAL SESSION, BANGLADESH INSTITUTE OF PLANNERS (BIP), DHAKA, BANGLADESH

PLANNING FOR INCLUSIVENESS AND SUSTAINABILITY IN POST PANDEMIC ERA

Implemented by:
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

বাংলাদেশ ইনস্টিটিউট অব প্ল্যানার্স (বি.আই.পি.)

IN ASSOCIATION WITH

Save the Children ISOCARP

Published by:
Bangladesh Institute of Planners (BIP
Dhaka, Bangladesh

Implemented by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Address for Correspondence

Editor
Planners' Tower (Level-7)
13/A, Bir Uttam C.R. Datta (Sonargaon) Road
Bangla Motor, Dhaka-1000, Bangladesh.
Telephone: +880-222-33-67653, +880-222-33-65223
Fax: +880-222-33-65223
Email: bipinfo@bip.org.bd

Programme/Project Description
International Conference on Urban and Regional Planning (ICURP) 2021

Design
Bangladesh Institute of Planners (BIP)

The editorial board assumes no responsibility for opinions and statements so presented by the contributors in their respective write-ups.

© Bangladesh Institute of Planners (BIP)

ISBN: 978-984-35-2613-7

The International Conference on Urban and Regional Planning
ICURP-2021

Dhaka, October 30 - November 6, 2021

Editors: Dr. Akter Mahmud, Dr. Adil Mohammed Khan

Produced and Published by Bangladesh Institute of Planners (BIP)

ICURP-2021 Organizing Committee	
Dr. Adil Mohammed Khan **Convener, ICURP-2021**	Md. Rejaur Rahman **Member Secretary, ICURP-2021** Board Member, BIP
Dr. Akter Mahmud President, BIP, ICURP-2021	Muhammad Ariful Islam Vice president, BIP
Dr. Chowdhury Md. Zaber Sadeque Vice president, BIP	

Paper Review Committee		
Dr. Adil Mohammed Khan	Dr. Ahsanul Kabir	Dr. Akter Mahmud
Md. Esraz Ul Zannat	Muhammad Ariful Islam	Mohammad Swapan
Dr. Chowdhury Md. Zaber Sadeque	Dr.Shammi Akter Shatu	Mohammed Rasel Kabir

ICURP-2021 Research Associates/Assistant	
Planner Hosneara Alo	Yeasir Mohammad Amin

ICURP-2021 Associates		
Lisun Asib Khan	Md Fahim Abedin	Shanjida Akbar Nishat
Al Fahim Ibn Ashraf	Sadia Nowrin Sushmee	Md.Yeasin Khandokar
Shormila Islam Peu	Shafiqul Islam Shawon	

International Conference on Urban and Regional Planning 2021
Theme
'Planning for Inclusiveness and Sustainability in Post Pandemic Era'

Major thematic areas for the ICURP conference are:

Session -1	Urban Planning and Management for Sustainable Development
Session- 2	Redeveloping Urban Areas for attaining Sustainability
Session -3	Regional Development and Rural Planning for Balanced Development
Session -4	Environmental Planning, Disaster Management and Climate Resiliency for Sustainable Development
Session- 5	Regenerating Public Space and Recreational Facilities
Session -6	Sustainable Planning of Cities and Regions for Integrated Development
Session -7	Planning for Sustainable Utilities and Services
Session -8	Planning for Sustainable Transport and Infrastructures
Session -9	Sustainable Cities and Settlements for Inclusive Development and Child Sensitive Urban Planning
Session -10	Housing, Community and Settlement Planning for Sustainability

MESSAGE

Dr. Adil Mohammed Khan
Convener, ICURP 2021
General Secretary, BIP

It's really pleasure that The International Conference on Urban and Regional Planning (ICURP) 2021 is organized by Bangladesh Institute of Planners (BIP) with the theme 'Planning for Inclusiveness and Sustainability in Post Pandemic Era' This conference highlights the issues that current pandemic has forced to rethink traditional planning practices and move ahead for attaining the goal of inclusiveness and sustainability in the post Pandemic era.

Due to the current extraordinary situation around the globe, this year ICURP 2021 held in combination of physical events and virtual sessions, which certainly widen the scope for planners and the professionals from home and abroad to participate in this International Conference. BIP believes that ICURP 2021 conference brings together the planners, professionals, academics, practitioners, scientists, researchers, scholars and decision-makers relating to various fields of Urban, Regional and Rural Planning around the world to exchange diverse ideas, share knowledge and explore recent developments in the field of Planning during this extraordinary time

This year is really a remarkable year for the Bangladesh because Bangladesh celebrates 50 years of its independence *and we are celebrating the* Birth Centenary of the Father of the Nation, Bangabandhu Sheikh *Mujibur* Rahman. And we have the honor to give homage to our great father of the Nation and valiant freedom fighters of the nation on this great occasion of ICURP.

As we all know, Bangladesh Government has given utmost importance to the physical and economic development of the country with due importance to planning, sustainability and environmental considerations to attain the goal of 'Sonar Bangla (Golden Bangla)' dreamt by our Father of the Nation Bangabandhu Sheikh Mujibur Rahman and valiant Freedom Fighters of our great Liberation War of independence. Moreover, Sustainable Development Goals of the United Nations have greatly emphasized inclusiveness as well as

sustainability and the advent of Covid pandemic has even more highlighted the indispensability of making our cities and settlements inclusive and sustainable for all. In addition, the current pandemic has posed some challenges to traditional planning practices and therefore planning norms and ideas might have some major shifts in pursuit of attaining the goal of inclusiveness and sustainability in the post Pandemic era.

BIP expresses its sincere gratitude to different Government, Non-Government and International Organizations, namely GED of Planning Commission, Rural Development and Co-operatives Division, Urban Development Directorate, Local Government Engineering Department (LGED), RAJUK, DNCC, DSCC, DWASA, DTCA, NHA, Municipal Association of Bangladesh (MAB), City Development Journalist Forum Bangladesh (CDJFB). The international organizations are Save the Children, UN Habitat, Food and Agriculture Organization, and World Bank each of these organizations for their wholehearted support for ICURP 2021.

TABLE OF CONTENT		
PAPER	**AUTHOR**	**PAGE**
THE FUTURE OF SPATIAL PLANNING OF BANGLADESH	SUJAUL ISLAM KHAN A K M RIAZ UDDIN	1-13
SOCIO-SPATIAL ASPECTS OF ORGANIC AND PLANNED DHAKA: SENSE OF COMMUNITY AND COMMUNAL RESILIENCE EMBEDDED ON INDIGENOUS SETTLEMENT MORPHOLOGY	KARESHMA – E-SHAMS	14-31
HOUSING SETTLEMENT PROPOSAL FOR LOW-INCOME PEOPLE THROUGH URBAN UPGRADING A STUDY OF NARAYANGANJ CITY COOPERATION, CHANMARI SLUM	ADDRI ATTOZA, RAFIA ANJUM RIMI, TASNUVA RAHMAN, SHAD HOSSAIN	32-44
MEASURING THE SUSTAINABILITY OF SANITATION SERVICE FACILITIES IN THE MAJOR URBAN SLUMS OF KHULNA CITY USING AHP TOOL	MAHBUB HASAN MEDUL, AZMERI FERDOUS, MD. ABDUL FATTAH, SYED RIAD MORSHED, MD SABBIR HOSSAIN, MD LUTFOR ROHMAN	45-77
PROBLEMS AND CONTRIBUTIONS OF ROOFTOP GARDENING: A CASE STUDY OF KHULNA CITY	NAILA FERDOUS NITOL,TUSAR KANTI ROY,MD SABBIR HOSSAIN	78-92
LIVELIHOODS AND CYCLIC MOVEMENT OF PEOPLE DURING THE MONSOON PERIOD AT PADMA RIVER CHAR: A CASE STUDY IN RAJSHAHI CITY	MD. ABU SADATH,	93-109
APPLICATION OF ELECTRICITY GENERATING PAVING SLABS IN DHAKA CITY: A SUSTAINABLE PATHWAY TO SMART CITY	UMME NABILA SAMANTA	110-120
PEOPLE-CENTRIC PUBLIC SPACE THROUGH DOCUMENTING PUBLIC LIFE: A CASE OF SHEIKH KAMAL SORONI.	MARJUKA SALEH,	121-134

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF A PROJECT OF SREEMANGAL PAURASHAVA: AN ANALYTICAL STUDY MOVING TOWARDS ENVIRONMENTAL SUSTAINABILITY	MOHAMMED SAIFUL ISLAM	135-150
IMPACT OF COVID-19 PANDEMIC ON MEDICAL PURPOSED TRAVEL BEHAVIOURS	MS DILRUBA AFROZE,MS NAWSHIN BASHIR, MS NAWSHIN TABASSUM	151-166
E-WASTE MANAGEMENT IN BANGLADESH: AN OVERVIEW	UMME LAIBA RAHA	167-176
3R APPROACH FOR A SUSTAINABLE MUNICIPAL SOLID WASTE MANAGEMENT SYSTEM A STUDY OF WARD NO.1 OF DNCC	MEHJABEEN HAQUE MOHONA., MOHAMMAD MIZANUR RAHMAN,	167-190
RURAL-URBAN LINKAGE'S EFFECT ON RURAL POVERTY IN BANGLADESH'S SOUTH-WEST REGION	MD.BE-NOZIR SHAH SHOVON., MITHILA ISLAM SENJUTI., S.M. FIROZ HOSSAIN., HOWLADER NAZMUL HUDA	191-205
AN INTEGRATED RURAL PLANNING OF CLIMATE RESILIENT INFRASTRUCTURES FOR SUSTAINABLE LIVELIHOOD AT TEESTA-BRAHMAPUTRA BASIN OF BANGLADESH	1. MD. ANISUL WAHAB KHAN., MOHAMMED MAKSUDUR RAHMAN	206-215
BUILDING COMMUNITY RESILIENCE TO FIRE HAZARD: A CASE STUDY OF WARD 33 IN OLD DHAKA	ZAKIA AKTER., DR. ADIL MOHAMMED KHAN	216-229
ASSESSING SPATIAL FLOOD VULNERABILITY OF GREATER RANGPUR REGION IN BANGLADESH USING GIS: A TOOL FOR RESILIENCE PLANNING AT REGIONAL SCALE	TASIN ISLAM HIMEL1, RIFAT HOSSAIN TALUKDER1, MD. ZAKIR HOSSAIN1, SUMYA NAZ1, SUMAYA ARFIN1, JANNATUN NAHAR FARIHA1	230-246

ASSESSMENT OF VULNERABILITY TO FIRE HAZARD OF RDA MARKET IN RAJSHAHI CITY	MD. ABU SADATH., FARHANA AFROZ., FAHIM SHAHRIAR SAKIB	247-256
DELINEATION OF FLOODED AREAS USING REMOTE SENSING TECHNOLOGY A CASE STUDY ON SUBARNAREKHA RIVER BASIN, ODISHA, INDIA	ZAKARIA SALIM	257-264
ANALYZING THE CAUSES OF FREQUENT WATERLOGGING AND THE SUBSEQUENT SOCIO-ECONOMIC IMPACTS IN DEVELOPING COUNTRIES: A CASE STUDY OF TELIGATI, KHULNA	MD. SABBIR HOSSAIN., MD. LUTFOR ROHMAN., MAHBUB HASAN MEDUL	265-282

THE FUTURE OF SPATIAL PLANNING OF BANGLADESH

Sujaul Islam Khan
A K M Riaz Uddin

Abstract

Scarcity of land on the water disaster-ridden deltaic land prone to climate change, competing requirements of agriculture and manufacturing call for the expediting of spatial planning as a key priority of national policy of Bangladesh. Yet despite its obvious necessity, spatial planning is still in its infancy in our country. This paper examines the colonial legacies, concurrent political-economic forces of the neoliberal era, and ground conditions which are shaping the current scenario of spatial planning. This may benefit spatial planning practitioners of Bangladesh.

Keywords
Spatial planning, Neoliberalism, colonial rule.

---

1. Introduction: Planning in the age of Neoliberalism

Under the spell of neoliberal politics spanning about the last four decades, the populist view that planning is a form of control, which is not often beneficial for business, has challenged modernist planning in the developed world. (Campbell, 2013).

However, in our country, a developing one, planners are still trained with modernist theories and skills. As the popular phrase goes -- if all you have is a hammer everything looks like a nail. Thus, for most planners, everything looks like an object to be planned from above with a bias towards an end-state, which is often idealistic. The current dominance of neoliberalism which prioritizes the machinations of the open market greets the planners with new challenges. Leaving matters to the market solved some problems but created others, which warranted interventions. The planner's hammer faced a challenge to reimagine its role and character. For countries of the global south with a colonial legacy, like Bangladesh this re-imagination has a long way to go.

This paper examines the colonial legacies and political-economic forces and ground realities which are shaping current spatial planning practices.

Spatial planning, according to the European Regional/ Spatial Planning Charter "gives geographical expression to the economic, social, cultural and ecological policies of society" (Europe, 1983). It is at the same time "a scientific discipline, an administrative technique, and a policy developed as an interdisciplinary and comprehensive approach directed towards a balanced regional development and

the physical organization of space according to an overall strategy." The paper also refers to the Dutch planning system, which applies the principles of spatial planning at local, municipal, provincial and national levels both for strategic and project planning as described by Faludi (2000).

2. Understanding current ground conditions:

The dynamics of the neoliberal economy of Bangladesh: News from Nowhere: Nimsar Bazaar, Cumilla 2021

The authors had heard of a wholesale market located on the middle point on the Dhaka Chittagong highway shown in Figure 1, and made a field trip in May 2021, to understand the potential of a government-led infrastructure project in the area. The ground conditions were not quite, what one would expect: this small local bazar (kitchen market) had become a giant wholesale operation within the last ten years, with almost no intervention from the state regarding infrastructure, except the upgrading of the highway. Currently it operates as a regional node of the agricultural supply chain network of the nation with fresh produce from the North Bengal, the Haor Basin and many other parts of Bangladesh. The authors did not expect such produce to bypass wholesale buyers from Dhaka, the mammoth primate capital city and its suburbs, and bought by buyers from Cumilla and Chittagong. A fairly well structured system of spaces for such activities had sprung out based on the primary road network only within a span of a few years entirely on private initiative. The sheds in the market are all set up by private investment and the places are privately managed. These private investments are replacing a need for public investment yet making significant contributions in the agricultural value chain. A public investment in creating such facilities as "public goods" would go a much longer way; revenue collected from such a market would help to strengthen the local government authority and consequently benefit the local community through the creation of more 'public goods'.

Nimshar Bazaar is not an isolated phenomenon. The supply chain of fast moving consumer items and essentials almost all over the nation has changed over the last decade, fuelled by the cellular phone network and improvement of surface roads. Private initiative was the prime driver even in provision of services that are meant to be provided by the public sector. While a significant segment of intellectual discourse constitutes a discord on the perils of neoliberalism and often correctly, they rarely offer alternate courses of action. In the constantly changing landscape the role of the public sector and private initiative remains unclear . This ambiguity often leads to a lack of agency for both and thus for a country like Bangladesh, the response is mostly unprepared. From a planner's point of view, Nimsar Bazar and similar markets would probably be classified as "organic", "unplanned", "informal", or all of these. The authors wonder whether such semantics aim to cover the inadequacy of understanding the dynamics of

the neoliberal economy of Bangladesh. An alternative way forward is to understand the dynamics of change and respond accordingly.

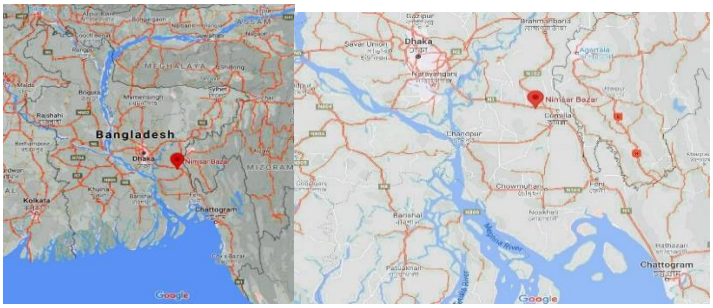
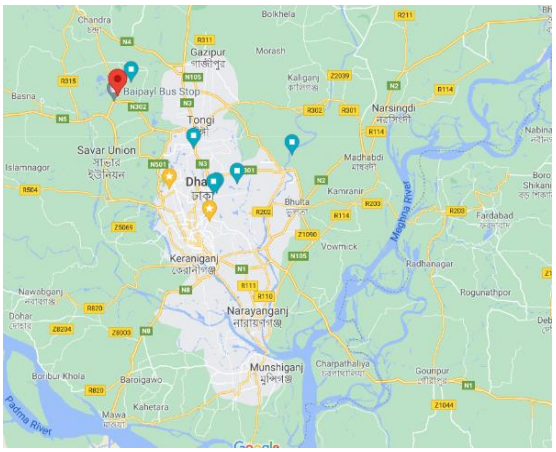


Figure 1: (From Top to bottom) Maps showing location of Nimsar Bazar, and aerial photos showing the growth from a local retail kitchen market to a regional wholesale hub in 2003, 2011, 2014, 2018 and 2021. Source Google Earth. Retrieved 15082021

Contemporary urbanization in Bangladesh features rapid growth coupled with ineffective urban planning and development controls. A case in point is the growth of state sponsored industrial zones known as Export Processing Zones (EPZ). In Figure 2, the Dhaka EPZ, located on a peri-urban site situated on the Dhaka Tangail Highway is seen in the top left and upper left corner. These zones do not provide any designed housing for workers. The aerial photographs taken in 2004 and 2018 show how the parcels of land, mostly privately owned, situated around the industrial zones have transformed into residential areas housing the

workers built with private initiative, with scant public urban amenities and facilities.



Savar EPZ, shown with the red dot.

Figure 2: (From Top to bottom) Aerial views of Dhaka Export Processing Zone DEPZ , Savar Dhaka in 2004 and 2018. Source Google Earth. Retrieved 1508202

3. Spatial Planning in Bangladesh: Exigencies, legacies and praxis

Spatial planning is shaped primarily by the political economy. If one traces the trajectory of planning practices since the colonial period, the dominance of certain forces and factors become apparent.

i. Exigencies

Khan et al (2015) describe the importance of spatial planning on a nationwide scale for sustainable development in Bangladesh, an extremely densely packed water-disaster-prone delta territory with agriculture as the primary means for sustenance. Though there is a National Land Use Policy and zoning regulations, it is hardly implemented, resulting in unplanned urbanization, environmental degradation, reduced disaster resilience and overcrowding in the key cities. Some recent planning initiatives, such as the Delta Plan 2100 communicates the intent to step into long range and country wide planning that considers the ecological and hydrological peculiarities of Bangladesh. The "My Village My Town" initiative of the government is also another example of extending the horizon of the settlement planning in Bangladesh both spatially and thematically.

On an urban scale, the trajectory of urbanization and spatial planning in the post-independence era follow a similar path. By the late 1980's neoliberal structural adjustment policies resulted in the thrust for deregulation of state control and emphasis on privatization (Nuruzzaman 2004). The economy began to shift from an agricultural base towards manufacturing and services. This fueled a growth in urbanization hitherto unseen, barring the distress migration in the post liberation era. New job opportunities meant that the population of Dhaka began to swell at a staggering rate. Dhaka is now categorized as one of the fastest growing megacities in the world, belonging to a special category of megacities, alongwith Kolkata, Delhi, Mumbai and Karachi, all characterised by high growth, unplanned settlements and corruption according to Laquan. (Hutchinson & Ray, 2011)

ii. Legacies :

A. Spatial practices of the British Raj

The British Raj (referred to as the Raj) ruled over India with state policies which Tirthankor Roy (2015) terms as fiscal-military. Through the Permanent Settlement Act of 1793, the colonial rulers imposed their extractive mechanism of revenue collection on the local landlords, known as the Zamindars in the then Bengal region. On behalf of the East India Company, revenue collectors would assess the land taxes after categorizing the territory owned by the Zamindars as crop land and wastelands. The Raj formulated systems to apply land taxation systems on a territory which Iqbal (2010) and Spodek (2013) describe as fluid terrain, where the boundaries of land and water are shaped by the whims of the

rivers, silt and in coastal belts the Bay of Bengal. The impact of the classification and taxation system of the Raj is still quite prevalent even today. Tirthankar (ibid) further notes that the lasting legacy of the Raj is the elaborate bureaucracy designed to ensure extraction and maintain the huge military which was aimed to check armed uprisings.

In the mid 18th century, the railways transformed the delta-ecology of the then Bengal and severely interrupted the terrain shaped by the natural river system flowing from the north south direction was severely interrupted by the railway lines traversing the land in the opposite direction. The railways were built on huge embankments with inadequate allowance for the rivers and wetlands to drain. Due to the lack of flow, invasive species of water hyacinth bloomed to the magnitude that the water crucial for irrigation fell short of supply and consequently crop production fell to the point where famine became recurrent in the early 20th century. This set the stage for the subsequent practice of building embankments, dams, roads at the expense of the delta ecology and adverse impact to local communities under different agro-ecosystems.

B. City Planning during the British Raj

Spodek (2015) narrates the growth of urban settlements during the British Raj, focusing on Bombay and Calcutta. The larger urban settlements are characterized by strategic military garrisons to quell riots, especially after the uprising of 1857, segregation of living quarters for the expatriates, enforcement of laws enabling land acquisition and creation of separate town improvement trusts bypassing elected local government bodies. The latter resulted in the disconnect between the communities and the planning process.

In the midst of town planning led by the techno- bureaucratic regime, Spodek (2015) mentions the work of Sir Patrick Geddes in many cities of the Raj including Bombay and Dhaka. Geddes advocated for a mode of holistic planning responsive to the socio- spatial characteristics of older cities with extremely well-knit communities and based his visions for cities on the nature of their landscape; hence Dhaka was to be a canal city, like Venice. The fact that Geddes' plans were not executed speaks of the indifference of the planning process to the social and physical characteristics of settlements.

C. Spatial planning in the post colonial era

In 1953, shortly after independence from the colonists in 1947, the feudal landlord system was abolished in India and erstwhile East Pakistan. While the movement against colonial rule had certainly galvanized political activity towards self-determination, the first decades of the post-independence era of the entire Indian subcontinent is marked with the dominance of the civil-military bureaucracy in state affairs partly due to the absence of local landlords. Bangladesh emerged in 1971 as a result of a struggle for self-determination.

During the Pakistan era, the spatial planning practices of the British Raj, with a bias for techno-bureaucratic solutions favouring the urban elite were applied with renewed rigour in the absence of the landlords, who used to act as local interlocutors implementing spatial planning to ensure agricultural sustenance.

iii. Praxis:

A. Contemporary spatial planning with Dhaka as an illustrative case

In 1953, the Dacca Improvement Trust (DIT), the state agency for development control and urban planning in Dhaka was formed bypassing the elected autonomous body, the then Dacca Municipality, thus drastically reducing the scope of public participation in the processes of spatial planning . In 1959 it prepared the first Masterplan for Dhaka. It allocated huge swathes of land for the cantonment and airport, provided serviced land for the new urban elite and improved the surface road network to favor northbound growth. Not surprisingly, the planning at that period was essentially physical and inclined to an end-state, and the change in Dhaka's prominence due to independence was not anticipated in that plan. Parallels can be drawn between the urban planning practices of the Raj mentioned by Spodek (2013).

DIT consisted of representatives from the members of the public until 1988, when the military ruler in power General Ershad dissolved the Trust and formed the Rajdhani Unnayan Kartripakkha (Capital Development Authority), an almost solely bureaucratic public organization with very little accountability to the citizens. In 1990, the same military dictator was deposed in a popular uprising and an era of democratically elected government ushered in. The nation entered a new phase of massive economic growth fuelled by growth in the manufacturing sector, growth of microcredit, contributions from the expatriate workers, population dividend and improvement in healthcare and education. The massive swell in urban population primarily due to new opportunities for employment in the manufacturing sector resulted in the haphazard growth of Chittagong, Dhaka and its peripheral areas and townships as shown in Figure 2.

Urban planning practices could not simply keep up with the pace and scale of urbanization as is documented by consequent planning documents, namingly the Dhaka Metropolitan Development plan 1995-2015, The Detail Area Plan (2008), Dhaka Structure Plan (2016-35) and the Bishod Anchal Porikolpona (2015-35). The latter aims to close the chasm between the elected urban governance agency, The Dhaka North City Corporation and Dhaka South City Corporation and the key agency for urban planning and development, the Rajdhani Unnayan Kartripakkha through the formation of a metropolitan government. While this, among other commendations are noteworthy, the document adopts an overly idealistic view regarding execution and falls short of placing Dhaka within a regional planning framework.

Though plans are meant to be preemptive, urban planning for Dhaka plan is mostly a reaction to the massive decline in liveability and capacity overload. The decline of liveability in the key cities is an outcome of massive migration from the rest of Bangladesh. If we accept that people migrate from one place to another to get better livelihoods, this fate of Dhaka is indicative of far worse quality of life in the rest of the country.

The inadequacy in spatial planning partly can be attributed to a lack of public agency inherited from the legacy of the colonial practices and partly to being unprepared to deal with the neoliberal transformation of the state. Over the last three decades the impact of the rising economic capacity coupled with the politics which has systematically ensured the growth of the elite class enabled through the progressive disenfranchisement of the general citizens has fuelled the growth of cities which have curtailed the people's rights to the city, and has promoted the rise of land speculation, all of which have contributed to the dysfunctional nature of the capital city, Dhaka, benefitting the elite-driven economy (Hossain, 2009).

B. Contemporary Spatial Planning on a Nationwide Scale

On a regional scale, dispossession of lands and livelihoods of the marginalized continue unabated by both state and non-state actors in the name of economic zones, new townships and industrial areas as an almost inherent consequence of the 'capital accumulation through dispossession phase' theorized by David Harvey. Lack of implementation of environmental laws combined with unplanned urbanization and industrialization contribute to territorial scale environmental degradation. Parallels of the current scenario may also be drawn to the last five decades of the Raj, where the interconnection with the global commerce and finance intertwined with the aspirations and expanded capacities of the local business elite ensured economic growth at the expense of social equity between agro-ecology based rural and industry based urban areas. (Tirthankar, ibid)

Over the last three decades, improvements primarily in surface transport and cellular phone technology has integrated markets and ensured flow of labour and goods on an unprecedented scale fostering a new urban rural continuum. On another note, the dynamics of regional geopolitics has led to the demand for improved connectivity with neighbouring nations. Stemming from such aspirations, new infrastructure projects such as the Padma Bridge Project and Padma Bridge Rail Link project are designed to enhance connectivity between parts of India and China. (17) These projects have the potential to trigger spatial planning on a regional scale involving new cities and settlements in the corresponding corridors, yet the current spatial planning practices make such possibilities seem gratuitous.

4. Contemporary trends in politics

Spatial planning, primarily involved in how land and infrastructure is allocated is a form of regulatory control and the critical issue becomes "Who is deciding what for whom? Since politics is concerned with 'who gets what?', planning by nature has a political content which must be duly acknowledged.

Renowned scholars Lewis and Schendel (2020) have focused on the shortcomings of the understanding of the relationship between society, nationhood and state of Bangladesh. It is noteworthy that they mention the connection between community leadership and the intricacies of spatial planning in the delta, which depends on agroecology for sustenance. A lack of understanding of the dynamics of social norms is an issue which needs to be reconciled for effective spatial planning. They also mention the recent shift from multi-party democracy to single party rule with its inevitable consequences of consolidation of state power to the civil military bureaucracy and even further marginalization of the general people by the state machinery.

Ruud (2020) further elaborates on the nature of contemporary politics of Bangladesh as a complex web of informal power relations within the ruling party which dictates the interactions between the state and the elite. Such relationships shape the dynamics of power between the local level and central level actors, more than often involving spatial development on public land and especially protected areas such as forest reserves and wetlands.

5. Epilogue: The future of spatial planning of Bangladesh

It is evident that the tools and practices currently used for spatial planning are mostly inherited from the colonial rule. These are inadequate to face the current trend rapid urban development; the absence of institutional capacities has rendered the future of open-ended top- down planning approaches uncertain; bottom-up community driven approaches may have the potential to ensure better social equity, but again these measures become uncertain due to the power relationship between center and periphery shaped by what Ruud (ibid) mentions as the 'Mohol'.

The current situation faced by spatial planners and policymakers alike is portrayed by the example of Nimsar Bazar. If we accept that the benefits of the growth of the economy should reach the society in an equitable manner, we need to define the boundaries of the private and public sector in the related policy structure with due foresight. As the private sector becomes increasingly dominant, the public sector must assume a role to set the institutions and rules to ensure that the public goods, the boundaries of public and private domain, and nature of the markets are defined with a vision towards social justice and sustainability. The inequality caused by unregulated markets may be balanced by rules that make upward mobility easier and extreme wealth difficult.

Future spatial planning must be a product of active collective participation and a redefinition of the role of the state for the outcome to be sustainable, which can be ensured by conducive political processes at local and central level.

The exigencies of environmental degradation, impact of climate change, recent surge in public health concerns in the pandemic and failure of current paradigm of economic development to ensure general wellbeing of the people has brought a new relevance to spatial planning, despite the circumstances which one may view as contrary.

The history of Bangladesh as an independent country is not much old and under the purview of the constantly changing landscape of neoliberal triumph, it takes a lot of reflexive learning as to how to plan to ensure social, economic and intergenerational justice through planning. The domain of spatial planning has now expanded to include social, economic and environmental concerns. To make collective action possible a society has to work on a vision formed by a narrative. The potential of neoliberalism to undermine ecological and social justice has now become a self-fulling prophecy that can be effectively undone by creating such a narrative based upon a belief to the contrary.

6. References

Bhattacharyya, Debjani. (2018). Fluid Histories: Swamps, Law and the Company-State in Colonial Bengal. Journal of the Economic and Social History of the Orient Volume 61: Issue 5-6 https://doi.org/10.1163/15685209-12341466 Retrieved 15072021

Campbell, HJ, Tait, MA and Watkins, CA (2013) Is there space for better planning in a neoliberal world? Implications for planning practice and theory. Journal of Planning Education and Research. December 2013. DOI: 10.1177/0739456X13514614

Doshi, Sapana. (2018). The Redevelopmental State: Governing Surplus Life and Land in the 'Urban Age. Development and Change 00(0): 1–28. 2018 International Institute of Social Studies. DOI: 10.1111/dech.12410. retrieved 20072021

European Conference of Ministers; Responsible for Regional Planning. Spain: European Regional/spatial planning Strasbourg. 1983

Faludi, A. (2000). The performance of spatial planning. Planning practice and Research, 15, 299-318.

Gottdiener, Mark & Hutchison, Ray Ed. (2011). The New Urban Sociology Fourth Ed. Westview Press.

Guha, Swapna Banerjee ed. (2010). Accumulation by dispossession: transformative cities in the new global order. SAGE Publications

Hossain, Taufiq Khurshid Zabin. (2020). 'Interfacing of urban planning, urban economics and ecology: a new paradigm for sustainable urban development of Mega city Dhaka, Bangladesh.' unpublished PhD thesis paper. Bauhaus- Universitat, Weimar

Iqbal, I. (2010). The Bengal Delta: Ecology, State and Social Change, 1840–1943 Palgrave MacMillan

Khan, Sujaul, Ayasha Siddiqua. (2015). An analysis of prevailing urban planning practices and alternate planning strategies for Greater Dhaka region. International Journal of Civil Engineering Volume 4 Issue 3 April May 2015.

Khan, Sujaul Islam, Islam, Monirul Syed & Saha, Dibbendu. (2015) Spatial Planning: A Prerequisite for Sustainable Development of Bangladesh. Journal of Bangladesh Studies Volume 17, Number 1, 2015 , Retrieved 16072021

Lewis, David and van Schendel, Willem. (2020). Rethinking the Bangladesh state. Contributions to Indian Sociology, 54 (2). 2020 https://doi.org/10.1177/0069966720911733 retrieved 16072021

Lee, Alexander. (2018). Land, State Capacity, and Colonialism: Evidence From India.

Comparative Political Studies Volume: 52 issue: 3, page(s): 412-444: https://doi.org/10.1177/0010414018758759 Retrieved 15072021

Levien, Michael. (2012). The land question: special economic zones and the political economy of dispossession in India . The Journal of Peasant Studies Volume 39, 2012 - Issue 3-4 https://doi.org/10.1080/03066150.2012.656268. Retrieved 15072021

Nuruzzaman, Mohammed (2004) Neoliberal economic reforms, the rich and the poor in Bangladesh, Journal of Contemporary Asia, 34:1, 33-54, DOI: 10.1080/00472330480000291

Powell, Baden. (1892). The Land Systems of India. Oxford.

Roy, Tirthankar. (2015).The Economic Legacies of Colonial Rule in India: Another Look. Economic and Political Weekly Vol. 50, No. 15 (APRIL 11, 2015), pp. 51-59 (9 pages)

https://www.jstor.org/stable/24481887 Retrieved 15072021

Ruud, Arild Engelsen. (2020). The mohol: The hidden power structure of Bangladesh local politics. Contributions to Indian Sociology 2020 https://doi.org/10.1177/0069966720914055 retrieved 20072021

Spodek, Howard. (2013). City Planning in India under British Rule. Economic and Political Weekly Vol. 48, No. 4 (JANUARY 26, 2013), pp. 53-61 https://www.jstor.org/stable/23391350 Retrieved 15072021

https://dailyasianage.com/news/250849/padma-bridge--regional-connectivity-and-economic-progression. retrieved 20072021

Sujaul Islam Khan is a practising architect and Assistant Professor of the Dept. Of Architecture, North South University. He obtained his B. Arch degree from Bangladesh University of Engineering and Technology (BUET) in 1999. He attended Design & Visual Arts Washington University in St. Louis, USA where he received Master of Architecture (M. Arch). He was the Member Secretary Environment and Urbanization, 20th Executive Council, Institute Architects Bangladesh 2013-14.

A K M Riaz Uddin is a senior specialist at My Village My Town project of Local Government Engineering Department (LGED). He has studied Urban and Regional Planning in Bangladesh University of Engineering and Technology (BUET) and University of Illinois at Urbana Champaign (UIUC). He has also studied Water Resource Development at Institute of Water and Flood Management (IWFM), BUET.

SOCIO-SPATIAL ASPECTS OF ORGANIC AND PLANNED DHAKA: SENSE OF COMMUNITY AND COMMUNAL RESILIENCE EMBEDDED ON INDIGENOUS SETTLEMENT MORPHOLOGY

Kareshma – E- Shams, Architect, Bangladesh

Abstract

The culture and the lifestyle of the people of any city are critically developed over time to meet basic human needs, such as shelter, security, social bonding, and wellbeing. However, from the observation of morphological growth and the living history of rapidly growing cities, a shift in urban texture can be highlighted. This change in city fabric has a direct impact, resulting in a) image crisis of the city, b) loss of cultural lifestyle and community coherence, and c) psychological disorder [intensive, criminal, tendency, paranoid, heavy stress, anger, impatient]. This paper discusses the morphological transformation and its impact on the capital of Bangladesh, Dhaka city, which has witnessed the submerged imprints of different socio-cultural, geo-climatic, political, and economic influences. This paper focuses on the interplay of social and spatial elements of the urban space of Dhaka. To recreate the sense of belonging, which brings out the communal bond and communal resilience, how the factors of settlement (i.e. space flow, functional distribution, unit of the community, etc.) from the original culture of the Dhaka city can guide the current pattern of city planning, is the aimed outcome of this paper.

Keywords

Indigenous morphology, Sense of community, Spatial elements

1. Introduction

The aim of this chapter is to shed some light on the issue of how over time the city fabric of Dhaka evolved and how that caused a shift of impact on the resident's lifestyle.

1.1 Correlation between socio-cultural construct and space morphology

To develop the idea of identity and comfortable state, psychologically human beings often rely on social and territorial status (Siregar, L., 2002). Theoretically, Babaei (2012) explained that culture relates with ideas, concepts, and assumptions that emerges from the urgency of communication needs, social justification, and member behaviors (Daim, 2012). Human behaviour is a result of lifelong experiences within the spectrum of mass and space. With appropriate socio-cultural characteristics in a community, mass and space can be defined as place. A place is a relationship between actions, conceptions, and physical attributes, which is meaningful to the people. Yet, in every place, in order to be acknowledged by others, humans need to have a defined territory not as a resting place, but also to start a living (Smith 2007). According to this fact, socio-cultural constructs become the territory of a meaningful place. Socio-cultural aspects contribute to developing the unique characters of any settlement. The uniqueness is profound and becomes an undeniable part of the identity of both people and city (Kubat 1999). The characters of settlement appear in concrete objects (shape, orientation, appearance, texture, and colour) and also in an abstract form like the practice of socio-cultural situations of the people in a specific place. Aldo van Eyck developed "space-time-conception", explaining that human behavior is involved in the process of creating a concept of the place he/she lives in (Luchsinger A 1981). Neuman (2005) scrutinized the unique character of place with its static elements and function in a city sphere. He classified the special features that can be related to different kinds of functions depending on the context, for instance a space for trading, settlement, socialization, traffic, parking, and others. For example, a street or an alley can have dynamic typology of shape and functions according to the socio-cultural aspects of the community and vice versa. Morphology of a place or settlement is identified by socio-cultural values it reflects. Although a variety of culture can arise in a city, in a global and local context. They are: a strong potential identity as a living area for a large number of people, a stage for city activities, and a space for working and trading (Chad G and Félix A 2002). By discussing the above, we can now say that, spatial environment or a settlement influences the physical, social and

mental dimension of the people. Culture with its material and immaterial component, stands in the ecosystem in place of settlements.

1.2 Dhaka, the city of culture

Dhaka, the capital of Bangladesh is 400 years of cultural life style built through the link between social values (intangible) and build-environment (tangible) artifacts. Apparently, the age-old chaotic urban morphology, which provides unique socio-spatial dimensions, shows clues to a hidden order that gives a distinctive texture and characteristics to the traditional settlement morphology. The lifestyle of Dhaka people has been typically expressed as " leisure and work", as evident in the saying '12 month 13 festivals' that has manifested and transcended to festivities like 'boi mela', 'Amor Ekoishe', 'Vijoy Utshav', Phalgun or 'Baishakhi Utsav' or even Eid-e-Miladun Nabi, Muharram or Vijaya Dashami Carnival. These festivals are celebrated by the people of each community, religion, social and financial status. Along with this fairly long history of festivals, Dhaka is also culturally well known for its fine muslin, mosques and rickshaws, street foods and street markets. This crowded city represents through its people.

1.3 Indigenous spatial pattern

The historic core of Dhaka city, typically known as 'Old Dhaka', reflects the organic structure of the indigenous city. It was founded as an important trading town along the River Buriganga several centuries before being a capital. During 1608 A.D., Dhaka turned to a Mughal citadel and the center of administration, cultural and social life, which has directly influenced the socio-cultural and socio-spatial elements of the settlement. Although, pre- Mughal core of the city developed spatial foci with the static elements like Kella (fort), Chowk (market square) and Ghat (river port). The Fort severed as the backbone of the city, the Chowk with the mosque was the main market place like other Muslim cities and the river front was transformed into the main commercial area (Nilufer 1997). The traditional spatial pattern of Dhaka grew with the axis of 'chowk' or 'square'. Besides the commercial service line 'chowk', straight roads acted as a main commercial and administrative zone with irregular roads feeding to the residential areas beyond. The traditional neighborhoods or mohollas were integral units of the social system of indigenous Dhaka (vastu-shipla foundation, 1990). The basic physical module for settlement, the moholla was formed during this period. It comprised a homogeneous community having self-contained facilities derived from the indigenous village pattern. Later, with the invasion of colonial rulers, the indigenous pattern of the old city went through rapid

alteration along with the economic and political changes. After the independence of Bangladesh, the social composition, family structure and pattern of settlement have been changed due to population growth and rapid urbanization. However, in comparison to Dhaka city as a whole, this changing morphology influences a little in the physical pattern of the historic core and the spatial structure remains almost homogenous over the period of four hundred years.

1.4 Morphological transformation

Urban morphology is the physical appearance of social reality, expressed by Pesaresi & Bianchin, 2001. Dhaka, with the passage of time, reveals different faces of history. Currently, Dhaka is one of the most densely populated and rapidly growing megacities in the global south of the world. The physical growth and development of Dhaka can be divided into six periods, e.g. the pre-Mughal period (1205-1610), the Mughal period (1620-1757), the East India Company period (1758-1858), the British colonial period (1858-1947), the Pakistan period (1947-1971) and the Bangladesh period (from 1971). Dhaka has seen development as the main city of the region 'since its inception as Mughal capital in 1608 AD. The British gave Dhaka the foundation concept of a modem city. Between 1947 and 1971, Dhaka went through political and economic power dynamics. However, after liberation in 1971, successive governments did not give due attention to the need of proper urban planning and resulted to misguided urban growth. Indeed above the level of technology and economic condition of the population, the pattern of aerial expansion and the form of Dhaka has been dominated largely by the physical configuration of the landscape in and around the city, particularly the river system and the height of the land in relation to flood level (Islam 1996). Throughout the development of the planned residential areas in Dhaka city, they had taken place without any rigid planning regulation. The earliest example of residential development within the framework of city planning could be observed in 1876, after the establishment of Dhaka Municipality. There was some evidence of effort in implementing planned residential development before 1947, but the actual development started in 1948 under a planning division created by the East Bengal Government in which a physical plan was prepared for Dhaka city for its future growth. Dhanmondi was planned as an important development project in 1950. In the later period Gulshan I was developed in 1960, Banani and Uttara was planned as middle class residential area in 1965 and in 1972 Baridhara as high class residential area of Dhaka city (Khan N, 2008). In the more recent period, to meet the demand of the growing population of Dhaka City, some new residential projects were developed by RAJUK like Nikunja, Purbachal, Jhilmil and Uttora Third Phase.

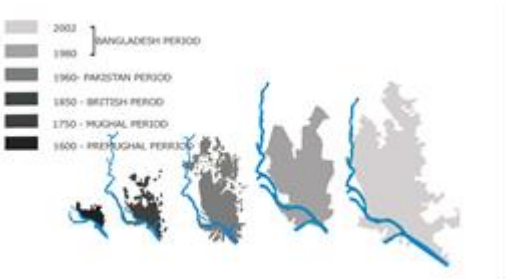


Figure 1: Physical growth of Dhaka over time and political periods

The original development of those planned areas had not been properly guided with planning principles. They are designed as residential areas, their development were not based on the principles of Neighbourhood planning. Not only that, due to the weakness of planning rules and zoning policy, non-residential functions invaded into the planned residential area to meet the demand of the growing population. Authority sometimes amended the rules to accommodate such changes but these could not retain the character of the planned residential neighbourhood. In the end, these planned housing society residential areas have turned into an unplanned mixed land use pattern of layout. Such as, the morphology of Dhanmondi Residential area (1950), Wari Residential area (1880), and Wahab Colony (1956) have transformed over time from a purely residential area to variety of commercial, educational, cultural - and administrative institution to satisfy the functional needs of the inhabitants and other users (Khan N, 2008). At present the Gulshan, Banani, Baridhara indicate that those areas are in the process of the above trend. If this trend of transformation remains, it can be assumed that, the newly planned residential area like Nikunja (South) Residential Housing Estate, Uttara Model Town (Third phase), Purbachal (Yusufganj), and Jhilmil Housing Project (Keraniganj) will also be transformed in due course of time (Kabir A, 2012). Therefore, it is crucial to understand the morphological transformation through the indicators and the variables.

1.5 Aftermath of the morphological transformation

Change in social-economic condition affects the status of that location, its usability and adaptability, its physical growth and density and as a whole its relation to the overall structure of the city. Dhaka mega city is growing in an uncontrolled, unanticipated and incoherent manner. The evidence suggests that if there are no major decisions in terms of its pattern of development, creating imageability, could reach intolerable levels of messy urbanization in the near

future (Kabir and Parolin, 2011). In ripple effect, the socio-cultural contract of the residents is affecting. Social equity in form of neighbourhood or Moholla is changing into housing society. The common ground of belonging to a community is dewindling from the people of the city as a result of rubber stamp architecture, grid iron settlement planning.

2. Literature Review

The purpose of this chapter is to understand theoretical background of settlement morphology over time with the filter of sense of community.

2.1 Indigenous socio-spatial structure of Dhaka within organic urban structure

N.K Bhattashali (1936) had interpreted the historical core of Dhaka as the extension of pre-Mughal trade centre and the new Dhaka as Islam khan's city. Both the old and new Dhaka has witnessed a series of political turn over, development phases. Thus, among the spatial structure within two distinctive phases; one is the historical core, now known as 'indigenous' and other is after liberation developed improvisatory settlement, now labelled as 'informal development' (Siddiqui.K, 1991). The indigenous socio-spatial structure of Dhaka started developing its character during Mughal rule. By the establishment of Lalbagh Fort in 1679, Chandnighat and the Chawk [the market place beside the old fort at present Central Jail] city morphology started growing under the Mughal leaders (Dani, 1956) [Figure 2]. Mughal Dhaka is rooted in the indigenous attitude towards space making in urban spatiality of layers. The result is a great deal of informality – the axis always shifts, space moves diagonally, the route shifts. Each movement has its own law, but the total amounts to coming together of diverse parts within an indigenous unity (Mowla 2011).

2.1.1 'Moholla' as a unit of socio-spatial morphology

Historical core of Dhaka features its organic morphology of creating settlement through neighbourhood or locally known 'moholla' as the unit of social construction. 'Moholla's developed as the communal unit on the basis or caste or craft groups, religion, social status (Nilufar, 2004). Hollander suggested that these organically developed neighbourhood or 'moholla' historically created not only the social distinctive axis but also the harmony where the Hindu and Muslim lived in compact groups (Karim, 1964). In another argument, Porteous put forward the idea of traditional neighbourhoods morphology encouraged, exchange of mutual socio-cultural values, help and information. These

neighbourhood system set up organic boundaries within different associations (occupation, ethnic, racial) (Porteous, 1977). In pre Mughal era, the 'moholla's formed as Hindu traders settlements and named after the specializations, such as Tanti Bazaar, Shakhari Bazaar, Bangla Bazaar, Lakhsmi Bazaar, Kamar Nagar, Sutar Nagar, Goala Nagar etc (Nilufar, 1997). These artisan community flourished during Mughal rule and developed the prominent city settlement, inspired from Islam inspired urban morphology (Mowla 2011) [Figure 2, 3]. 'Moholla' as each unit formed out of few houses from similar community. Hollander expressed in his writing, though from the main roads, lanes like a labyrinth connected each 'mohollas', but also there was invisible social boundaries between houses of different 'mohollas' (Hollander 1990). Khan contradicted with his argument that, the 'mohollas' were not featuring psychological social boundaries, rather the sequence of space from the central part. The central access, locally known as 'bazar road', the 'moholla' morphology developed in singular row of housing. Though in existing settlement evidence has found that bazar or 'chowks' were in sequence with the cluster of different 'mohollas' (Mowla, 1997) [Figure: 3].

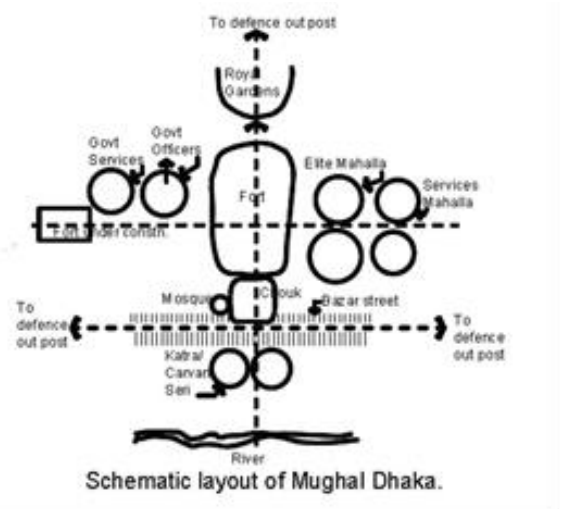


Figure 2: Settlement morphology of the core of Dhaka
Source: Mowla, 2011

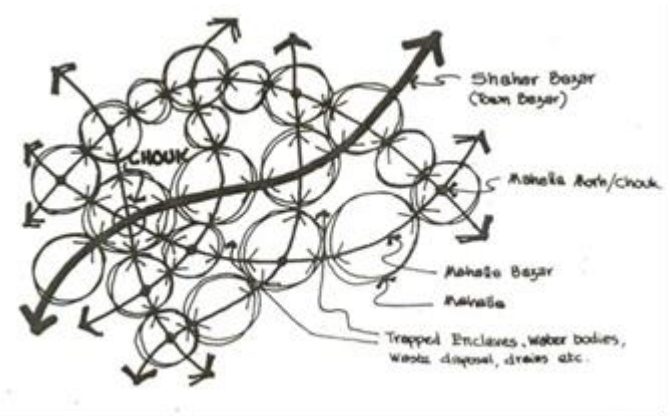


Figure 3: Fundamental order of 'moholla'
Source: Mowla 1997

2.1.2 'Moholla' morphology of indigenous core of Dhaka endorsing 'sense of community'

In contrast, of any urban space, two sorts of people are evident, i.e. one group is aware of their physical and human surroundings and another group most likely to be unaware, which impacts to shape their social-psychological developments (Tankel, 1963). First group of people found in setting of such space, which can be used, viewed, felt and also gave active and passive recreation activities, circulation and privacy, insulation, a sense of spaciousness and scale. Indigenous 'moholla' or neighbourhood's physical and spatial characteristics are the unintentionally grown example of this category space, which bring the sense of community among the residents (Mowla, 1997). A sense of community is associated with the symbolic interaction, which taken place through the use of physical environment (Brower, 1980). In another argument, provision of civic amenities within public space in close proximities and user friendly scale, can boost a great sense of community (Fisher, 1993). Mowla described in his study of the morphology of 'moholla' that, the spatial qualities and unique architectural details build up through the socio-cultural identity of the people and sometimes vice versa, which allows them to have the most face to face social interaction opportunities [Figure 4]. He pointed out that the static elements of 'moholla', such as the narrow, human-scaled road or the 'goli', inward-facing houses, roundabout or 'morh' as embryo of activities and public square or 'chowk' as foci, meeting place, magnet of the community. Typically, the flow of these spatial elements are the extended form of interaction which start from the semi-

private family meeting place, 'uthan' of the households/homesteads. The intimate and human scaled public interaction adds the special value to the 'moholla' morphology [Figure 4]. Through the socialization and experience of the community, the perception and image of the 'moholla' or neighbourhood settlement build up (Rapoport, 2002).

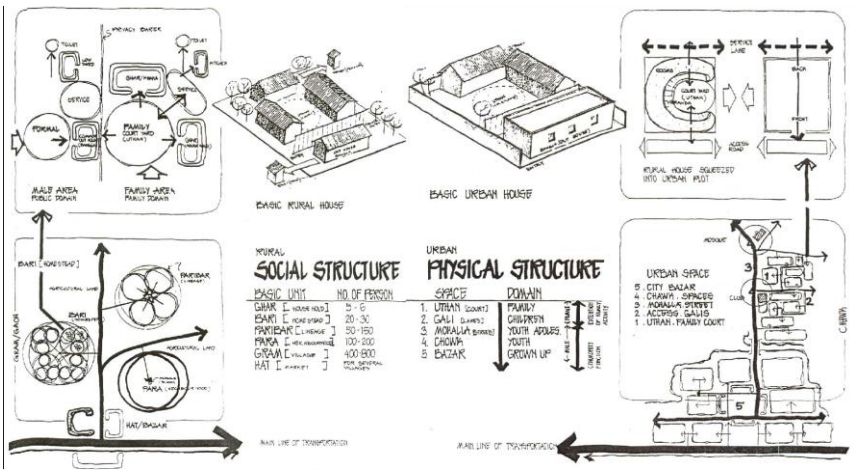


Figure 4: Social Structure manifested spatially in the traditional morphology of Dhaka (Mowla,1997)

2.2 Socio- spatial aspects of Dhaka within planned urban grid

In the traditional settlement of Dhaka, the hierarchy of roads are the distinctive feature, whereas in the modern planned settlement, wide straight roads and setbacks become highlights. Christopher Alexander, differentiate between naturally grown settlement and planned settlement with the concept of tree or semi lattice. In an organic city when intentionally planned elements get introduced, the human mind cannot encompass the complexity of semi lattice (multiple overlaps of socio-cultural aspects) (Nilufar, 1997). In the evolution of Dhaka city, due to rapid fast rate of growth, some urban space elements left behind, and the land use structure made adjustments in developing residential areas (Nabi, 2007). Subsequently, post-independence (end of 70's) Dhaka experience, a curious mixture of planned and naturally grown space morphology, especially in residential zones (Nilufar, 2001). During this period, the generation was expanding, joint families were dissolving into nuclear families, inherited lands were dividing, and walk-up rentable (up to 4 stories) apartments were building up, which led to a different dwelling typology than the indigenous

settlement (Ahmed, 2009). There was no prominent evidence of unique characteristics of planned residential fabric, comparing to the indigenous core of Dhaka. Though these intended planned areas (such as Dhanmondi, Gulshan, Banani) follow the main arterial road of the city and occupancy started from the periphery. The integration core of planned overlapped the global integration core of the city through dynamic development of over time (Khan N, 2008). The massive migration, population explosion and centralized development of Bangladesh lead the capital towards the real estate developers build high rise apartments trend. This box living faded away the ties between neighbours, socio-cultural bonding and intimate use of public space (Ahmed, 2009). Nilufar described this transformation of socio-spatial quality as 'named to anonymous'. Change and adaptability in settlement morphology are gospel truth. Yet out of context or too fast change is damaging the community structure, imageability and perception (Mowla, 1997).

3. Context Analysis

This part of the research will focus on one particular 'moholla' – Tanti Bazar, which is located at the global integration core of pre Mughal indigenous core [Figure 4], to decipher the settlement characters and spatial elements. This study is collective outcome of ethnographic and secondary (studies have been done on the morphology of Tanti Bazar socio-spatial structure) data analysis. The settlement of Tanti Bazar exhibits compact and linear buildings with a narrow frontage along the spinal axis. Its strong morphological identity is distinct from the loosely spaced buildings and open plots in surrounding areas except the settlement at Shakharibazar (Tabassum, 2010). The dynamic street network is unique example of urban morphology.

Figure 4: GI core of pre Mughal era

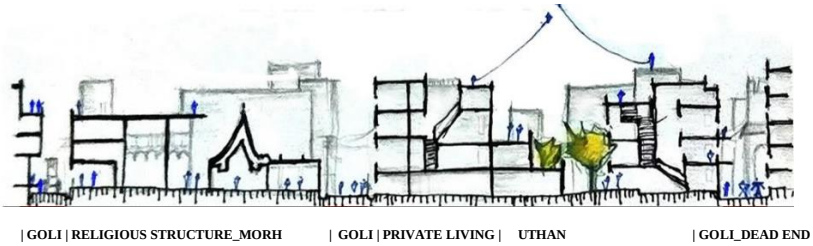


Figure 5: The flow of spatial elements through the social interaction at Tanti Bazar. Source: Kabir, Meher 2014 (adopted)

Figure 5 and Figure 6 are expressing the observation of spatial domain and how it influence the behaviour pattern of the residents of Tanti Bazar. The order of interpersonal interaction flows beyond the age, gender and even among other 'mohollas' through the organic setting as well as intimate distribution of public services (Kabir, Meher, 2014).Simple daily needed interactions among the community joint like honeycomb with the manifestation of spatial elements in sequence of 'Uthan' to 'Goli' to 'Morh' to 'Chowk'. In the context of Tanti Bazar as well as indigenous 'moholla' setting, the important properties of these 4 spatial elements, are intimate-human scale and the role of transitional space.

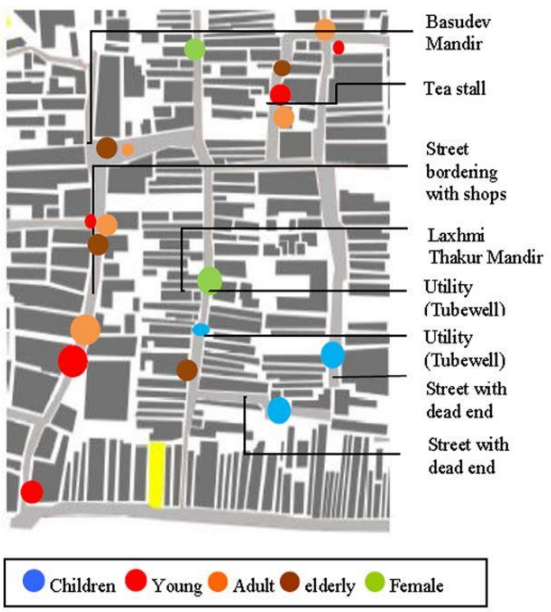


Figure 6: Social behavioural map of Tanti Bazar, Source: Kabir, Meher, 2014

3.1 Uthan

In a typical Tanti Bazar house, 'uthan' or court yard is mostly L/U/O shaped, vibrant, geo climatic breathing space for dwellers. It is also the place for religious activities. Building interior facade towards the 'uthan' creates different levels of interaction (Tabassum, 2010). The placement of 'uthan' inside the typical house, behaves like a buffer space, which connects the private part of the house to the public space (goli) and transition the entrance, service area of the house.

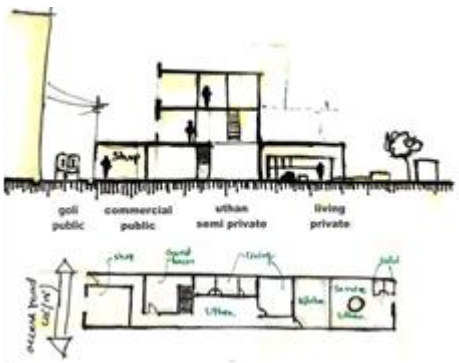


Figure 7: Typical Tanti Bazar house layout, Source: Tabassum 2010 (adopted)

3.2 Gol

The most crucial element in the organic urban Dhaka is 'goli' or adjacent, connecting lane. The 'goli' of Tanti Bazar is mostly 12 to 15 feet wide, which allows visual as well as face to face social relationship. The dynamic and effortless interaction happened on the periphery of 'goli' via the shops at the ground floor of houses, balconies /windows of the houses, roof tops and sometimes the dead ends (where mostly 5 to 10 aged children play under the surveillance of parents from viewing proximity). Indiscriminately every one of the community use the 'goli' for recreation or service or daily need, as if it's the extension of their living room.

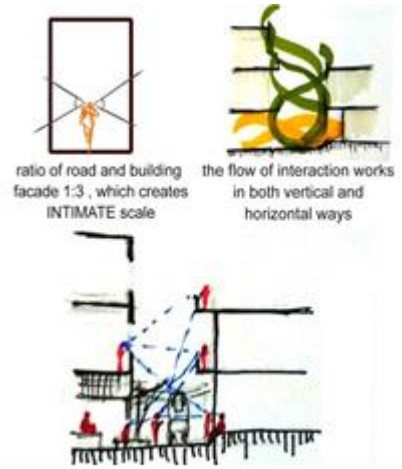


Figure 8: interaction diagram of typical ‘goli’, source: Author

3.3 Morh

The ‘morh’ or node is the serendipity of lanes/roads connection or cross section. A simple connection of streets gets the place of attraction with tea stalls, sweet shops, school or religious building like Mandir at Tanti Bazar. Different ‘morh’ brings out different provision of public, communal or commercial services. The mixed land use concept gets lively at the ‘morh’ of the indeginous settlement in most organic and socio-culturally inspired ways.

Figure 9: Activities at ‘morh’,

Source : Author

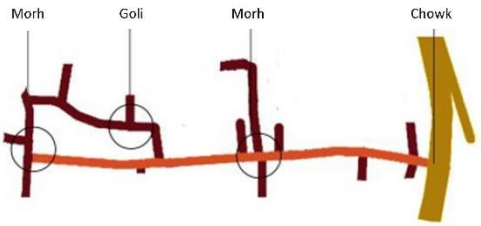


Figure 10: Schematic design of public spaces in 'Tanti Bazar'

Source: Author

3.4 Chowk

Among the closely knit urban fabric of indigenous 'mohollas', semi open bazar space in pedestrian scale is 'chowk' (Khan N, 2008). Tanti Bazar and adjacent 'moholla' Shakari Bazar are connected via the activity space 'chowk' or a singular linear bazar space. The social structure balance with the spontaneous and sequential location of 'chowk' connection 'mohollas' and create socio-spatial settlement fabric. Hierarchy of spaces from the public domain to private domain creates a sequence of socialization pockets along with sense of belonging and safety (Tabassum, 2010).

4. Discussion and Conclusion

Typically perceived cognitive image of the inhabitant of Dhaka city lies in 3 elements: locality, 'moholla' or neighbourhood, local bazar (Nilufar, 2009). The reasons behind planned residential areas are transforming into unplanned, uncontrolled, messy mixed land use zone, are blindly following the grid iron settlement plan, which is more of a western system, and out of context for this region. To pace up in the race of globalization, change in living cost, living style, family size, influence of technology are inevitable. However, ignoring the socio-cultural identity as well as needs of residents in planning giving them a roof but also coming with an adversary of alination from neighbors. Which can be a trigger for several psychological issues.

4.1 Sense of community in the time of 'social distance'

Recent pandemic, the outbreak of COVID-19 brought not only piled up dead bodies, health hazards, above and beyond mental health risk. Living stuck at

home during the pandemic caused anxiety and panic, obsessive-compulsive symptoms, insomnia, digestive problems, as well as depressive symptoms and post-traumatic stress (Roger, 2020). The norms of new normal post pandemic will also carry out the concept of social distance. In this case, the intimate human scaled, visually connect spatial elements traditional 'moholla' morphology can ease out the 'social-animal' inside the residents. In the transition of daily routine rather than going to an enclosed, designated community space of apartment build, stand 4to6 feel away open 'uthan' of the cluster can ensure social and psychological well-being of the residents. To create such places its crucial to learn the properties of spatial element from indigenous settlement, where after series of transformation communal resilience exists.

4.2 Adopt the properties of socio-spatial interactions

It's time that planners and architects create interaction through their design. By creating hierarchy of spaces in public, semi-public domain and social relationship through 'moholla', 'uthan', 'goli', 'morh', 'chowk' all together the manifestation of sense of community is possible. The feel of 'moholla' can be recreate by clustering apartment building, holding common 'uthan'. Rather than creating setbacks to the periphery of the building, which encourages only negative, polluted spaces between buildings, houses can be flushed to the adjacent lanes and other facade will bring out the harmonious relationship with street via terrace and windows. Reintroduce the shop house culture again in the urbanization to support can be proven milestone for creating pop up interaction-attract points as well as small business. During pandemic e-commerce or small business become passion for a lot of people. Moving forward it's only make sense that the number of entrepreneur will increased along with the need of shops. The mixed land use zoning should incorporate in organic style to the planned residential morphology. The aim of conceptualizing 'moholla' in planned morphology is to bring back the sense of belonging to the residents. The ripple effect of belonging to a neighbourhood is so important and empowering in several areas of psychology including clinical psychology, environmental psychology, social psychology and community psychology (Rapoport, 2002).

The territory of Dhaka city is expanding. Purbachol, Ashulia, Bashundhara Residential area, and by the bank of Turag khal many housing settlements are developing. It's absolutely crucial to plan the adaptation now, for future settlement morphology. The intangible aspects of indigenous spatial elements are the physical manifestation of a rich-cultural background of Dhaka and the stories of its people. As design theorist Christopher Alexander stated, "A City,

is most beautiful when it comes from your life – the thing you care for, the things that tells your story".

5. Reference

Ahmed, D. Z. (2009, January). Tracing Globalization: reflection of changes in lifestyle in domestic architecture. Protibesh , 17-28

Babaei, H., Ahmad, N. and Gill, S.S., 2012. Bonding, bridging, and linking social capital and psychological empowerment among squatter settlements in Tehran, Iran. Journal of Basic and Applied Scientific Research, 2(3), pp.2639-2645.

Bhattacharya, SN (1935) Dhaka University Studies, Vol:1 No.1

Chad G and Félix A 2002 Space, Place and Inka Domination in Northwest Argentina in Experimental Archaeology Replicating Past Objects, Behaviors, and Processes vol S1035,ed James R and Mathieu, British Archaeological Reports, International Series (Oxford: Archaeopress) pp

Daim, M.S., Bakri, A.F., Kamarudin, H. and Zakaria, S.A., 2012. Being neighbor to a national park: Are we ready for community participation?. Procedia-Social and Behavioral Sciences, 36, pp.211-220.

Dani, A. Hasan [1956],Dacca: A Record of it's Changing Fortune. Dhaka: Asiatic Press.

Fisher, R.J., 1993. Social desirability bias and the validity of indirect questioning. J. Consumer Res. 20 (2), 303–315

Hollander, A. N. J. den. And Azam, Khwaja Mahomed (1990),The Panchayet System of Dhaka Muntasir Mamun (ed.) Dhaka Study Series :3, Centre for Dhaka Studies, Dhaka.

Islam, N., 1996. Dhaka: from city to megacity: perspectives on people, places, planning, and development issues (No. 1). Urban Studies Programme, Department of Geography, University of Dhaka.

Kabir, A. and Parolin, B., 2012, July. Planning and development of Dhaka–a story of 400 years. In 15th international planning history society conference (pp. 1-20).

Kabir, S. and Khan, F.M., 2014. Traditional urbanity and social equity: Learning from Old Dhaka. The AIUB Journal of Science and Engineering (AJSE), 13(1), pp.65-72.

Karim, A. [1964], Dacca: the Mughal Capital . Dhaka: Asiatic Society of Pakistan

Khan, N., 2008. Study of morphological transformation in planned residential areas of Dhaka city.

Khan, Nayma and Nilufar. Farida (2009).Spatial Logic of Morphological Transformation: A Paradigm of Planned - Unplanned Areas in Dhaka city, Proceedings of the 7th International Space Syntax Symposium (Eds) Daniel Koch, Lars Marcus and Jesper Steen, Stockholm: KTH, Sweden

Kubat, A.S., 1999. The morphological history of Istanbul. Urban Morphology, 3, pp.28-40.

Luchsinger A 1981 Structualism in Architecture and Urban Planning (Stuttgart)

Mowla, Q.A. 1997. 'Settlement Texture: Study of a Mahalla in Dhaka', Journal of Urban Design, Vol.2(3),1997.pp.259-275

Mowla, Q.A. 2011: 'Urban Aesthetics: A Study on Dhaka' in 'The History Heritage and Urban Issues of Capital Dhaka', Vol.III, published by the Asiatic Society of Bangladesh, to celebrate the 400 years of Capital Dhaka.

Nabi,AS.M. Mahbubun & Hashem, Maqsud (2007), " Trends of Development on Dhanmondi" in Sarwar jahan& KM.Maniruzzaman(ed) "Urbanization in Dhaka:Pattern issue and approach to planning" Dhaka: Bangladesh institute of Planners

Neuman M 2005 The Compact City Fallacy Journal of Planning Education and Research25 11- 26

Nilufar, F., 1997. The spatial and social structuring of local areas in Dhaka City-a morphological study of the urban grid with reference to neighbourhood character within naturally-grown areas. University of London, University College London (United Kingdom).

Nilufar, Farida,2004 Hidden Morphological Order in an Organic City, Protibesh, Journal of the Dept. of Architecture, BUET, Dhaka, pp.34-41,.

Pesaresi, M. and Bianchin, A., 2003. Recognizing settlement structure using mathematical morphology and image texture. Remote sensing and urban analysis: GISDATA, 9, pp.46-60.

Pesaresi, M. and Bianchin, A., 2003. Recognizing settlement structure using mathematical morphology and image texture. Remote sensing and urban analysis: GISDATA, 9, pp.46-60.

Rappaport, J., 2002. In praise of paradox: A social policy of empowerment over prevention. In A quarter century of community psychology (pp. 121-145). Springer, Boston, MA

Rogers, J.P., Chesney, E., Oliver, D., Pollak, T.A., McGuire, P., Fusar-Poli, P., Zandi, M.S., Lewis, G. and David, A.S., 2020. Psychiatric and neuropsychiatric presentations associated with severe coronavirus infections: a systematic review and meta-analysis with comparison to the COVID-19 pandemic. The Lancet Psychiatry, 7(7), pp.611-627

Smith, M.E., 2007. Form and meaning in the earliest cities: a new approach to ancient urban planning. Journal of planning history, 6(1), pp.3-47.

Siddique, K., 1991. Social formation of Dhaka City-A study in third world urban society.

Siregar, L., 2002. Antropologi dan Konsep Kebudayaan. Jurnal Antropologi Papua, 1(1), pp.1-12.

Tabassum, Tanima (2010). Analyzing a Traditional Neighbourhood Pattern of Old Dhaka: A Case of Tantibazaar, Journal of Sustainable Architecture and Urban Development, pp. 215-229

Tankel, S.B. (1963) The importance of open space in the urban pattern, in: I. Wingo (Ed.) Cities and Space, (M Baltimore, MD, Johns Hopkins University Press)

VASTU-SHILPA FOUNDATION. 1990, Aranya: An Approach to Settlement Design: Planning and Design of Low-cost Housing Project at Indor, Housing & Urban Development Corporation, Vastu-Shilpa Foundation for Studies and Research in Environmental Design, Ahmedabad, India

Research Paper

HOUSING SETTLEMENT PROPOSAL FOR LOW-INCOME PEOPLE THROUGH URBAN UPGRADING

A Study of Narayanganj City Cooperation, Chanmari Slum

Addri Attoza, Undergraduate Student, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh

Rafia Anjum Rimi, Undergraduate Student, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh

Tasnuva Rahman, Undergraduate Student, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh

Shad Hossain, Undergraduate Student, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh

Abstract

Bangladesh, having more than 1100 people live in every square kilometre, is one of the most populous countries in the world. Moreover, according to the World Bank`s data in 2010, One-third of the 160 million people are living below the poverty line. Since the liberation war of 1971, the urban population are rapidly growing and continues to do so at over 3.5 % annually. Migration (rural to urban) is the primary reason for the rapid growth in urban areas. Due to high-rent houses, the poor migrants' basically live-in slum and squatter settlements for shelter. Slums are generally located on the government land, semi- governmental units, where minimum 25 members live in maximum 3 households with poor water, sanitation and hygiene condition. The socio-economic status of the community is below standard income level because most of the people work as labour in informal sector such as rickshaw pullers, hawkers, domestic workers, etc. or very low-paying formal sector positions such as garments. Considering this fact, the aim of the study was to analyse the existing situation and find out the proper low-income community scheme for the slum people of the Chanmari Area. Simple random sampling method has been used for collecting data about the existing condition of the low-income people of the Chanmari area where haphazard housing patterns are situated with no water source for drinking and daily activities, poor sanitation, as well as lack of other community facilities. Later on, a housing plan was prepared according to the affordability of the people of that area. The plan will enable to improve their living condition which is done under Urban Upgrading techniques where proper planning methods have been maintained.

Keywords

Slum People, Low-income Housing, Urban Upgrading, Affordability

1. Introduction

Bangladesh having a country of about 146.10 million people containing nearly 5.3 million slums people (Hossain, 2020). The slum is primarily a name that reflects the griefs of deprived people who have to struggle with poverty to earn their livelihood (Lilford et al., 2017) Because of the work opportunity the poor people migrate from rural to urban areas and stay in the slum due to lack of affordability in substandard living condition.

Bangladesh contains the lowest land-person ratios with high land prices. Low-income people try to find cheaper alternatives for living. For this reason, Proper drinking water and sanitation facilities, utility facilities, and accessible community services are not noticeable in slum areas. (Kim et al., 2016). The Government of Bangladesh (GoB) has taken several housing programs throughout the country, generally in government Khas lands, in order to rehabilitate the local low-income families, but in most cases, it has unfortunately ended in failure. (Ramanauskas and Dringelis, 2011)

Urban Upgrading is a technique that is mostly used for low-income urban neighbourhoods, sometimes referred to as Slum Improvement. The technique is a package of essential services to improve the community's well-being such as clean water supply and proper sewage disposal. Upgrading usually comes with a bundle of improvements to the roadways, sidewalks, and drainage. Furthermore, it promotes solid waste collection, which has a positive impact on health, as well as street lighting for security and night-time activities.

Research conducted by World Bank in 1990 in the Latin American Region (LCR) emphasized that the cost recovery strategy should be up-front; economic analysis can be the best tool for project planning. In addition, institutional appearances and community participation should be ensured. Also, Land tenure regularization is the most challenging process. (Cira, 2002) In practice, Colombo Municipal Council (CMC) has been executing innovative shelter-upgrading programs associated with central government and external support agencies since 1978. These programs ensure the provision of basic services for the improvement of environmental health, housing for the poor, innovative laws and procedures are also introduced to plan and construct affordable infrastructure and support-based housing policies to improve the quality of housing stock through self-help, in addition to the promotion of participatory approaches to develop community organizations (Jayaratne and Sohail, 2005). The quality of life also secures a low

crime rate as well as high urban safety. ('Sustainable Urban Development and Crime Prevention through Environmental Design for the British City. Towards an Effective Urban Environmentalism for the 21st Century', 2002) ('Safety and dwelling in Singapore', 2004).

The goal of the research was to call attention to the urban upgrading technique for the low-income slum dwellers of Chanmari, Narayanganj. So, the study investigates & analyses the housing condition and proposes an affordable housing design as well as possible execution procedure and cost recovery of the project.

Despite the fact that the study will cover the most important aspects of slum life, due to a lack of time, information, and manpower, as well as the pandemic scenario, it may not be possible to cover all components required for accurate information about the people. Despite the fact that the houses were planned to be affordable for all, it is possible that only a few of them would be able to afford the minimal cost with difficulty.

2. Study Area Profile

Narayanganj, one of the most important cities of Bangladesh, lays on23° 37' 24" North, 90° 30' 4" East geographic coordinates (Maplandia.com Team, no date). Narayanganj became City Corporation on 5 May 2011 unifying three former municipalities: Narayanganj Municipality, Siddhirganj Municipality, and Kadam Rasul Municipality (Narayanganj, no date). It plays a major role in the development of the economy as having a good number of Garments, industries and commercial places. Here, most of the people are day labour and Industry workers and their socio-economic status is low. But it does not housing facilities for low-income people. For this reason, the number of slums in Narayanganj is gradually rising. "Chanmari Slum" is one of them that are about 1KM from CBD, 5KM from Bus Stand. Chanmari Slum area is a place having 80 acres with 3500 people along with 500-750 families. Basically, this area is a government property having a lack of proper sanitation, drinking facilities, and haphazard housing is developed here.

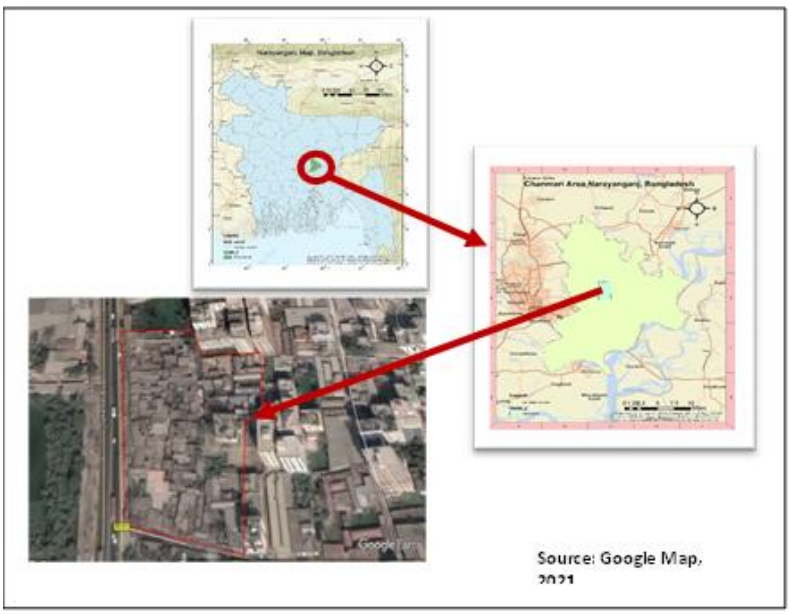


Figure 1 Study Area

3. Methodology

3.1. Data Collection Process:

After a primary observation of the study area being done, the methods for data collection were prepared and brought into actions. Mainly two types of data (primary and secondary data) are collected from the study area.

Sampling Methods: Simple random sampling method was used for collecting data about the present condition of Chanmari Slum Area. Since the study is about the assessment of the housing condition of the people of Chanmari Slum, the data was collected in a way which will include the random Slum families which will result in the overall condition of the people living there.

Sample Size Calculation: Population- 750 Families (approximately), Confidence level- 95%, Confidence interval- 10%, Sample size- 68 Families (approximately)

3.2. Data Analysis and Interpretation:

After the collection of data from different sources, the collected data is accumulated together and analysed consequently with graph and chart. Through

the analysed data, the present condition of the people in Chanmari was assessed and necessary preparations were taken for designing the housing of the study area according to the affordability and demands of the people of the study area.

4. Result and Discussion

4.1. Data Analysis and Interpretation

4.1.1. Demographic Analysis

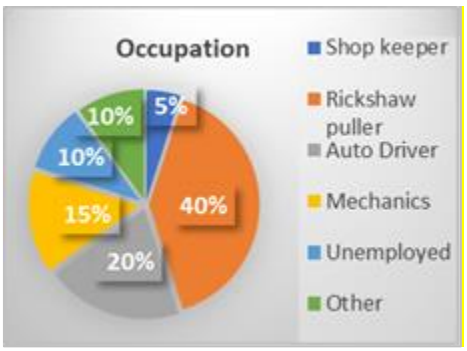


Figure 2 Demographic Information

4.1.2. Housing Condition:

Generally, the existing condition of any housing can be evaluated based on few elements like housing materials, housing pattern, types and facilities. The detailed analysis on the variables is observed. Maximum house structure of the

slum is semi pacca and, 74% house is made of break, wood, tin and 26% is made of brick, and cement.

4.1.3. Lack of facility and consumer's priority

The basic facilities like sanitation, drinking water, sewage etc. are missing in the area. The percentage represents their preferences. The graph (Figure: 3) shows the facilities which are absent in the slum according to the priorities considered by the slum dwellers.

4.1.4. Sludge Management:

The Sludge Management condition is very bad. Only 25% people said Sludge Management condition is Moderate.

4.1.5. Source of Water:

A graphical distribution of the source of water is given at Chanmari Slum (Figure:4). Most of it is in Water Tanker Truck (54%).

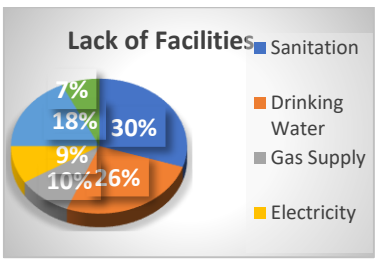


Figure 3 Lack of Facilities

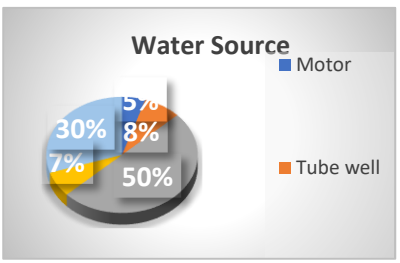


Figure 4 Water Source

4.1.6. Water quality and quantity:

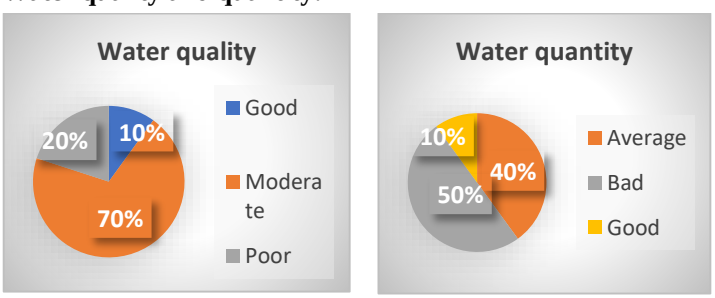


Figure 5 Water quality and quantity

4.1.7. Sanitation:

In Chanmari Slum, the quality of the sanitation system is not adequate to human use. About 65% people claims that sanitation facilities is not enough for them ad 75% people thinks the facilities are below average.

4.1.8. Sanitation type

The most common type of sanitation facility was a pit latrine with slab is about 60%. Only 25% are pacca and 15% are kacha that says that it moderately average but not good.

4.1.9. Sanitation hygiene maintenance:

Only 10% people of the household have a hand-washing facilities after sanitation and nearly 65% people are used separate sandals for sanitation. Rest of the people have no facilities of hand washing system and they don't use separate Sandals.

4.1.10. Dispose System:

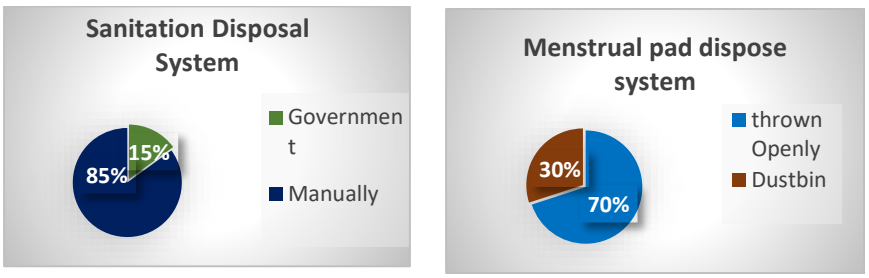


Figure 7 Sanitation Disposal System

4.1.11. Household waste management:

About 90% household wastes are managed by government and only 10% is managed by public.

4.2. Detailed Design Proposal of Housing

The design proposal of the low-cost housing design project for the slum dwellers with detail information of land use distribution, layout map, and house-type are given below:

Features	Percentage (%)	Area (Square ft.)
Residential Area	68	41616
Road and Drainage	10	6120
Community Facility	18	1116

Commercial Facility	6	3672
Total Area	100	61200

Table 1 Land-use Percentage

4.2.1. Calculated area distribution for Land use:

Name of the use	Area (Square ft.)	Numbers (Minimum)
450 square ft. plot	29700	66
550 square ft. plot	14850	27
360 square ft. plot	33480	93
Commercial house	7920	4
Sanitary Latrine	3780	2
Water facilities (Tube well)	6500	21
Pharmacy	720	2
Open space	2518	7
Community purpose	1300	2
Central area	850	1
Mosque	920	2
School	500	1
Play field	408	1
Clinic	300	1
Community	350	1
Nursery	350	1
Waste disposal area	350	1

Table 2 Land-use Distribution

4.2.2. Detailed Design of the area:

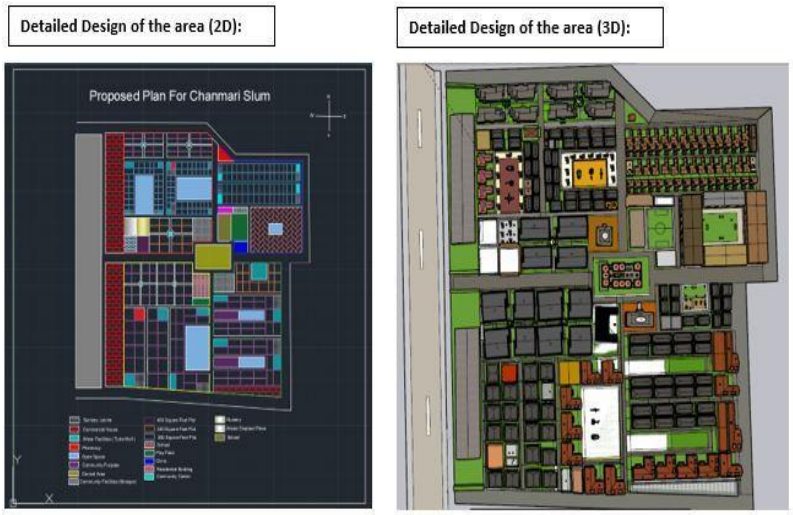


Figure 11 Detailed design of the area

4.3. Cost Estimation and Recovery:

○ 4.3.1 Detailed Cost estimation:

The rate of the items was reviewed from the "Schedule of Item Rates for the years 2019-2020" of Bangladesh Water Development Board which included all types of costs for housing also the labour costs. Taking all those rates from the schedule, cost estimation of a typical 450 square feet dwelling was done.

	Type:1	Type: 2	Type:3	Type:4	Type :5	Type :6	Type :7
Story	1	1	1	1	1	2	1
Area per family	450	360	360	550	450	330(7920)	550
Cost/ sq ft	550	450	400	450	400	555	400
Family	4	1	1	4	1	24	1
House type	Pacca	Pacca	Semi-pacca	Pacca	Pacca	Pacca	Pacca
Material	Brick, Cement	Brick, Cement	Brick, Tin	Brick, Cement	Brick,Tin	Brick, cement	Brick,Tin
Room	8	2	2	8	2	2	2
Washroom	Attached	Not attached	Not attached	Not attached	Attached	Common	Attached
Total Cost	2,47,500	1,62,000	1,44,000	2,47,500	1,80,000	43,95,600	2,20,000

Table 4 Types wise House Cost

4.3.2 Cost Recovery process and Predicted Time for Cost Recovery:

Construction expenditures are primarily those should be recouped in accordance with the planning procedure. According to the many case studies, cost recovery by rent can be used as a more convenient and flexible approach for people to pay for their homes.

Each house has been divided into 7 types according to the pattern and structure of the house. Where for each type of house, cost recovery has been calculated according to the number of houses, family of the all types of houses.

	Type: 1	Type: 2	Type: 3	Type: 4	Type: 5	Type: 6	Type: 7
Cost per house	2,47,500	1,62,000	1,44,000	2,47,500	1,80,000	10,98,900	2,20,000
Number of house	8	4	89	12	58	4	15
Family	4	1	1	4	1	24	1
Rent per family	2000	1900	1100	1600	1500	1200	1800
Total cost	19,80,000	6,48,000	1,28,16,000	29,70,000	1,04,40,000	43,95,600	33,00,000
Month	31	85	130	38	120	43	122
Year	3	7	10	3	10	3.5	10

Table 5 Cost recovery and required time

In this way, the whole planning process along with its expenses and recovery, the project will accomplish its objective to provide housing for the low-income people.

4.4. Land tenure Regularization:

In general upgrading programs face challenges from slow bureaucratic procedures and inadequate and fragmentary regulatory frameworks, with urban standards that were inappropriate to the social reality of low-income households. For this reason, Land Tenure Regularization is essential to long-term sustainability of project. Beneficiaries will pay an amount of money in every month according to their housing materials facilities. This process is regularized by the corresponding authority. Proper Land tenure regularization will help to recovery project cost in time and accessing credit.

4.5. Additional Requirements:

Organizing Authority: In Bangladesh, organisations like (BRAC, Municipality, UN-Habitat, Government, NGO, Donors and grassroots-organization) mainly work on urban upgrading related project. In foreign country, World Bank, UN-Habitat, UNDP, Lincoln Institutions wok on urban upgrading project.

Community participation: If the public is more involved in the planning and decision-making processes of urban upgrading, it is more probable that they will work within established procedures to solve their basic facilities (water, sanitation) and others problems. Through Public engagement urban upgrading plan, decision, environment quality of the slum area is improved quickly.

5. Conclusion

The study mainly focused on assessment of the housing and living condition along with all other facilities specially water, sanitary facilities provided to the Chanmari slum area people and propose an affordable housing plan for them. The study highlighted the present living condition and the extent of affordability to avail the upgrading of their living condition. Most of the occupations of Chanmari slum area are having low capacity of earning money, this degraded condition of occupation has an adverse impact on the existing housing and other facilities condition of the study area. There is no proper sanitation system, pure drinking water facility and particular waste management system in the study area and most of the people throw their waste in the wrong places. The road in this area is too much narrow to even move any vehicle easily and quite impossible to provide the drainage facilities. So, water logging becomes a great issue during the rainy season. Important services like educational institute, health centre, local market and recreational places like parks or playgrounds are not in relative distance to the study area. The study tried to contribute to help the low-income people who are still neglected from all facilities in our society. The study will provide the design of a planned residential area for low-income people with all necessary facilities. The design will provide low-cost housing facility with all other amenities which can be afforded much easily by the people of Chanmari slum area. Since the study could obtain much information about their occupation, the design could make some arrangements which will provide more employment opportunity for both men and women. All these steps might be responsible for a successful accomplishment of better living of the people of a greater portion of the urban area of Narayangonj.

6. References

Cira, D. A. (2002) 'Urban Upgrading in Latin America and the Caribbean'. Available at: http://documents.worldbank.org/curated/en/2002/06/1977232/urban-upgrading-latin-america-caribbean (Accessed: 12 October 2021).

Hossain, B. (2020) 'Slum of Bangladesh: An overview'. Unpublished. doi: 10.13140/RG.2.2.28678.52800.

Jayaratne, K. A. and Sohail, M. (2005) 'Regulating urban upgrading in developing countries', Proceedings of the Institution of Civil Engineers - Municipal Engineer, pp. 53–62. doi: 10.1680/muen.2005.158.1.53.

Kim, S. et al. (2016) 'Analysis of the implication of accessibility to community facilities for land price in rural areas using a hedonic land price model', Journal of Korean Society of Rural Planning, 22(1), pp. 93–100.

Lilford, R. J. et al. (2017) 'Improving the health and welfare of people who live in slums', The Lancet, 389(10068), pp. 559–570.

Maplandia.com Team (no date) Narayanganj Map. Available at: http://www.maplandia.com/bangladesh/dhaka-div/narayanganj-zl/narayanganj/ (Accessed: 12 October 2021).

Narayanganj (no date). Available at: https://en.wikipedia.org/wiki/Narayanganj (Accessed: 12 October 2021).

Ramanauskas, E. and Dringelis, L. (2011) 'ŽEMĖS SKLYPŲ PERTVARKYMO PATYRIMAS PLANUOJANT MIESTŲ TERITORIJAS', Journal of architecture and urbanism, 35(4), pp. 285–294.

'Safety and dwelling in Singapore' (2004) Cities , 21(1), pp. 19–28.

'Sustainable Urban Development and Crime Prevention Through Environmental Design for the British City. Towards an Effective Urban Environmentalism for the 21st Century' (2002) Cities , 19(2), pp. 129–137.

Cira, D. A. (2002) 'Urban Upgrading in Latin America and the Caribbean'. Available at: http://documents.worldbank.org/curated/en/2002/06/1977232/urban-upgrading-latin-america-caribbean (Accessed: 12 October 2021).

Hossain, B. (2020) 'Slum of Bangladesh: An overview'. Unpublished. doi: 10.13140/RG.2.2.28678.52800.

Jayaratne, K. A. and Sohail, M. (2005) 'Regulating urban upgrading in developing countries', Proceedings of the Institution of Civil Engineers - Municipal Engineer, pp. 53–62. doi: 10.1680/muen.2005.158.1.53.

Kim, S. et al. (2016) 'Analysis of the implication of accessibility to community facilities for land price in rural areas using a hedonic land price model', Journal of Korean Society of Rural Planning, 22(1), pp. 93–100.

Lilford, R. J. et al. (2017) 'Improving the health and welfare of people who live in slums', The Lancet, 389(10068), pp. 559–570.

Ramanauskas, E. and Dringelis, L. (2011) 'ŽEMĖS SKLYPŲ PERTVARKYMO PATYRIMAS PLANUOJANT MIESTŲ TERITORIJAS', Journal of architecture and urbanism, 35(4), pp. 285–294.

'Sustainable Urban Development and Crime Prevention Through Environmental Design for the British City. Towards an Effective Urban Environmentalism for the 21st Century' (2002) Cities , 19(2), pp. 129–137.

Case Study Paper

MEASURING THE SUSTAINABILITY OF SANITATION SERVICE FACILITIES IN THE MAJOR URBAN SLUMS OF KHULNA CITY USING AHP TOOL

Mahbub Hasan Medul, Azmeri Ferdous, Md. Abdul Fattah, Syed Riad Morshed,

Md Sabbir Hossain, Md Lutfor Rohman

Khulna University of Engineering & Technology, Khulna; Bangladesh

Abstract

Sanitation, a basic human need and influential sector of development which contributes to a healthy life and economic progression is in miserable condition in the urban slum of Bangladesh. This poor condition of the slums would be the impediments to achieve Sustainable Development Goals. The study aims to assess the current sanitation system and measure the sustainability of sanitation services by using the Analytic Hierarchy Process (AHP) in the major slums in Khulna city. Rupsha slum, Montu Colony slum and Railway colony slums of Khulna city is chosen to fulfil the objectives of the study. Several field surveys have been conducted based on five specific criteria (Social, economic, environment, governance, Health and hygienic) and 20 sub-criteria. Analysis shows the poor sanitation system at the study area where 83.67% households share the same latrine, 62.8% unsatisfied people and 8% people wash hands with soap before eating. The AHP process which was judgement by three experts shows that the social (58%), health and hygiene (15.6%) and economy (10.7%) criteria had more priority than others environmental and governance. The final score of sustainability 4.361, 4.0161 and 3.955 for respectively Rupsha, Montu Colony and Railway Colony slum indicates the poor sustainability achieved in these slums. The outcome of the study will be helpful to the responsible authorities and NGOs in the management and planning municipal service facilities appropriately in the slum area.

Keywords

AHP Process, Sustainable Sanitation, Sanitation Service Condition

1. Introduction

About 860 million people or one third of urban population of developing countries live in slums. Global slum population is expected to rise from 924

million to 2 billion in the next three decades [1]. Slums of Bangladesh can be defined as the settlement of people of homogeneous socio- economic condition that developed. The slum population in Bangladesh has increased significantly over the last three decades, along with the growth and expansion of towns and cities [2]. Urbanization and people's urban orientation movement are mostly responsible for the miserable slum conditions in the urban area. This caused exerted severe pressure on public services in the slums of Khulna cities. As a result, slums environment and service facilities condition such as sanitation, fresh drinking water supply condition is in under miserable conditions. According to BBS 2015, there are 1134 slums in Khulna city. Yet most of the people of the slums in Khulna city do not have proper or well sanitation system and knowledge about hygiene. This will be a major challenge to ensure availability and sustainable management of water and sanitation for all within the agenda of Sustainable Development Goals 2030.

Bangladesh is one of the most densely populated country in the world living approximately 1101 people per sk.km. About 36.63% of people lives in urban area of Bangladesh where 51.1% of these urban population lived in slums (World Bank, 2015). The population is increasing tremendously in the urban slums but the facilities are not increasing in comparison with its population growth rate [3], [4]. One-fourth of the population now lives in urban areas and population density is about two hundred times higher than the national outline and population growth is nearly twice the national average. Approximately 172000 people live in the 1134 slums in the slums of Khulna City which comprises 8.14% of the total area of Bangladesh and the sanitation situation in these slums is not good [5]. About 2.6 billion people around the world lack adequate sanitation [4]. Khulna City Corporation (KCC), many national and international Non-Governmental Organization (NGOs) are demonstrating sanitation services in many urban slums through various sanitation projects. The lack of improved sanitation facilities is a common feature of slum people's everyday lives. Rupsha slum, Montu Colony slum and Railway Colony slum are the biggest slums in Khulna city and these are the government slum. But sanitation condition in these slums is very poor and almost all of the household use the community sanitary latrines provided by different NGOs like ASHA, BRAC, WaterAid, Nobolok etc. Because of various difficulties such as resource challenges, lack of coordination, lack of skilled labour and modern technologies, nepotism, corruption, etc., these latrines fail to meet the demands of slum dwellers and, as a result, the sanitation condition in the slums is deteriorating, endangering the urban health and living environment and eliminating slums sustainability. Moreover, the world is now more concerned about achieving sustainability to achieve Sustainable

Development Goals (SDGs). So, assessment of slums sanitation condition and challenges is seemed to be more important issue to concern about. This study aimed to assess the present status of sanitation facilities and measuring the sustainability of sanitation services by using the Analytic Hierarchy Process (AHP) in the major urban slums of Khulna City Corporation.

Sanitation is essential for sound and healthy urban life. The provision of sanitation services to rapidly growing urban populations is one of the most tenacious challenges in the world [6]. A sustainable sanitation service is a system that is accessible to the community and local authorities over a long period of time, without adverse environmental effects. For urban slums, sustainable sanitation needs to address not only technology implementation, but also issues of ownership, costs and space [7]. The world is now more determined to ensure sustainability in all aspects of social, physical, economic, environmental issues and introduced "Sustainable Development Goals (SDGs)" after the era or "Millennium Development Goals". One out of 17 goals is "Ensure availability and sustainable management of water and sanitation for all". To achieve these goals, assessment of sanitation system in both urban and rural areas is important. The global population using safe sanitation services grew from 28% in 2000 to 43% in 2015 and 45% in 2017. But still 701 million people practiced open defection [8]. As the condition of sanitation system and sanitation service facilities in the urban slum is miserable, its assessment and development is most urgent at this moment. This study aims to assess the current sanitation condition and will measure the sustainability of sanitation services in the slums of Khulna city.

Researchers around the world has developed many tools and used many methods to assess the provided different service facilities at different spatial context [9]. Thomas Saaty introduced "Analytic Hierarchy Process" which is an effective tool to deal with complex decision-making and can assist expert and decision-makers in setting priorities and making best decisions [10], [11]. AHP is a powerful and well-accepted tool for comparing various criteria that prioritize, weigh and rank criteria based on expert opinion. Another model SERVQUAL is used in many previous researches. Literature shows that the AHP model is used to assess water service facilities [12], sanitation facilities [5], urban physical seismic vulnerability [13], health service facilities [14], business site [15], barriers to implement material efficiency strategy [16], medicine service facilities [17] and other utility services. Boukhari et al., [18] used AHP tool to assess the sustainability of water and sanitation service facilities and developed

three level of hierarchy based on 12 expert's opinion. [5] Evaluated sanitation service quality in Railway slum in Khulna Bangladesh based on customer satisfaction index. [13]. [13] Established a comparison among 13 vulnerability criteria in pairs by using AHP tool and measured them according to the expert opinions. This study will use the AHP tool for assessing the condition of sanitation service facilities and people's attitude in the major slums of Khulna City based on a questionnaire survey for measuring the sustainability of sanitation services. This study is expected to concern responsible authorities for removing all the constraints and solve all the problems associated with the sanitation system in the urban slums and to improve slum areas sanitation quality for developing a sound, sustainable, healthy and environmentally friendly urban space in Khulna city.

2. Methodology

2.1 Study Area

Khulna, the 3rd largest city of Bangladesh have 1134 slums with poor service facilities [5]. For the assessment of slums service facilities and measuring sustainability in this study, three major slums of Khulna City Corporation (KCC) has been chosen. Rupsha Slum, Railway Colony Slum and Montu Colony Slum. Railway slum is a living place for 1052 households and 4556 people [5], Rupsha slum is for 3700 households and 15876 people [19], and Montu Colony slum is for 350 households. Rupsha slum covers 0.95 sq.km area, Montu Colony Slum covers 0.90 sq.km and Railway colony cover 0.47 sq.km areas of Khulna City (BBS, 2015). These three slums were selected as the study area from Khulna City to ensure that representative data are obtained. These selected slums present a clear picture of existing sanitation services of the slums within KCC area.

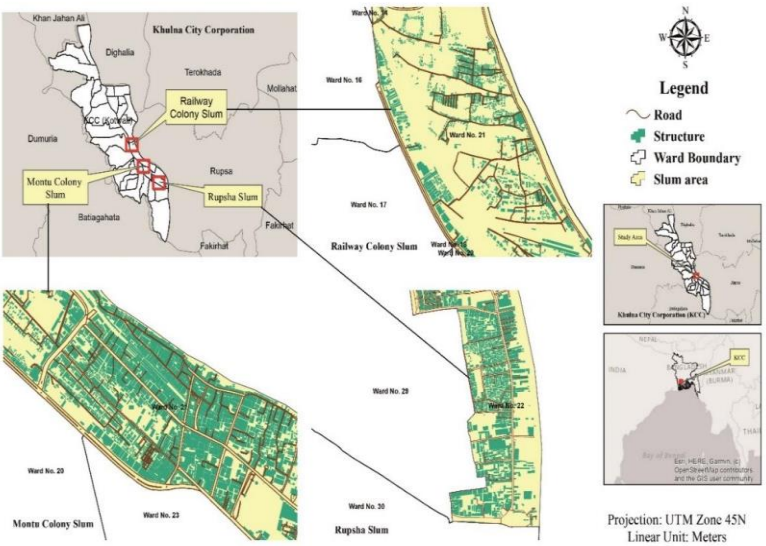


Figure 1: Illustration of Study Slum Area in Map. (Author, 2020)

2.2 Questionnaire Design

The study aims to assess the current sanitation service condition and to measure the sustainability of sanitation services in the major slums of Khulna City Corporation. Several reconnaissance surveys have been done before making the research questionnaire to draw an overall condition and find details of the problems and to made an effective questionnaire. A questionnaire containing 30 questions under five criteria (Social, economic, environment, governance, Health and hygienic) related to sanitation system and service condition has been made to collect information from the people of the slum. Another questionnaire survey has been conducted for KCC and NGOs to assess the conditions in their perception. For a better understanding of experts and slum people, the questionnaire is developed in both the English and Bengali versions.

2.3 Sampling and Data Collection

Around 5102 HH were located in the study area. For the field survey a total of 300 households were randomly selected and surveyed from the slums, where 150 households were from Rupsha slum, 80 households were from Montu Colony slum and 70 households were from Railway Colony slum (Mawlana Vasani

Community-3). The confidence level has been considered 95% with 5% marginal error during the determination of sample size.

$$n = \frac{N}{1 + Ne2}$$

$$=5102/\{(1+2650*.05^2)\}$$

$$=370.92 \approx 300(\text{Approximately})$$

Where, n= sample size; N= Household Size; e= marginal error (5%). Several household's doors to door field survey has been conducted to collect the primary data. Secondary data were collected from KCC, NGOs and other secondary sources. After the collection of data from the slum dwellers and NGOs, three expert surveys were conducted to determine the weight of selected five criteria of the AHP questionnaire.

2.4 Analytic Hierarchy Process (AHP)

AHP is one of the multi-criteria decision-making approaches by which the weights of the evaluation elements are calculated through pair comparisons done by expert's judgments. Thomas Saaty introduced "Analytic Hierarchy Process" which is an effective tool to deal with complex decision-making and can assist expert and decision-makers in setting priorities and making best decisions [10], [11]. To achieve a realistic result, experts from all relevant fields, including scientists, administrators and policy-makers can engage in the decision process. AHP follows 3 steps illustrated in figure 2. The first step involves structuring the decision issue in a hierarchical system by defining the elements (dimensions, parameters and indicators) that are relevant to our goal, namely the sustainability of Slum Services. During the second step, we will set up a matrix of comparison during pairs for all the rates to determine the value of each. Then, it measures global weights. Pairwise comparisons were performed for each level of the hierarchy (level 1 ¼ dimensions, level 2 criteria ¼ 'Ci' and level 3 ¼ indicators 'Ii'). For each comparison, the experts determined the relative importance using pairwise comparisons by the values were suggested by Saaty [10] whose meanings are indicated in Table 1. The comparison leads to obtain of the decision matrix.

$$A=[a_{ij}]=\begin{matrix} 1 & a12 & \dots & a1n \\ 1/a12 & 1 & \dots & a2n \\ \dots & \dots & \dots & \dots \\ 1/a1n & 1/a2n & \dots & 1 \end{matrix}$$

A is the decision matrix for comparison was developed in the first step on the basis of expert opinion on a scale of 1–9 where 1 means two factors are equally

important and 9 indicates that one parameter is extremely important than another. Table 1 illustrates the scale of importance established by Saaty [20]. In the second step, the weight of each factor is calculated using the equation 1 and 2.

Unnormalized value, $mi = \sqrt[n]{RMV}$ ……. (1)

Normalized value= $\frac{mi}{\sum_{n=1}^{n} mi}$ ……. (2)

Here, RMV= Row Multiplied Value and mi= unnormalized value of i[th] parameter and n= total influential parameters. Weight consistencies between judgements are measured in 3[rd] phase by using the equations 3 and 4.

Consistency Index, $CI = (\lambda max - n)/(n-1)$ …….. (3)

Consistency Ratio, $CR = CI/RI$ ……... (4)

Where, I= Eigenvalue of the pairwise comparison matrix.

RI= Random inconsistency index, can be determined by table 2.

λmax= The principal eigenvalue.

Table 1: Saaty numerical scale for pairwise comparison of AHP

Intensity of Importance	Definitions	Description
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another

5	Strong importance	Experience and judgment strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme	The evidence favouring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity 'k' has one of the above non-zero numbers assigned to it when compared with activity 'i', then 'i' has the reciprocal value when compared with 'k'	A reasonable assumption

Source: [10] and [5]

Table 2: Random Inconsistency Index (RI) value

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.52	0.89	1.11	1.25	1.55	1.40	1.45	1.49

Source: [10] and [5]

The matrix has considered inconsistency if CR>0.1 and the pairwise comparison must re-perform between indicators and sub-indicators. All that remains is to measure different results by choosing the best indicators for the sustainability of the Sanitation services in slum area, where the results with the greatest final weights are identified.

3. Analysis and Findings

The whole analysis is divided into parts. One represents the current scenario of slums sanitation system and another one represents the measurement of sustainability of sanitation service facilities in the three major slums of Khulna City Corporation.

3.1 Current Sanitation Condition

3.1.1 Existing Toilet Facilities

Questionnaire based field survey analysis shows that about 83.4% people said that they used common or shared toilet and 16.6% people used their own toilet.

Table 3: Frequency of existing toilet facilities in the slums area

Existing Toilet Facilities	% of people used
Common/shared	83.67%
single/private	16.33%

(Source: Field Survey, 2019)

The scenario of these 3 slums are public slums and most of the dwellers uses shared sanitation. Again, all of the slums seem to use more sanitary latrine than pit latrine and no sanitary latrine because of NGOs' and Government organization (KCC) activity on sanitation improvement of slums. Although most of the latrines are provided by different NGOs (like Nobolok, Caritus etc.) and very few households have their owned latrine.

Figure 2: NGO provided toilets condition in the slums. Source: Author, 2019

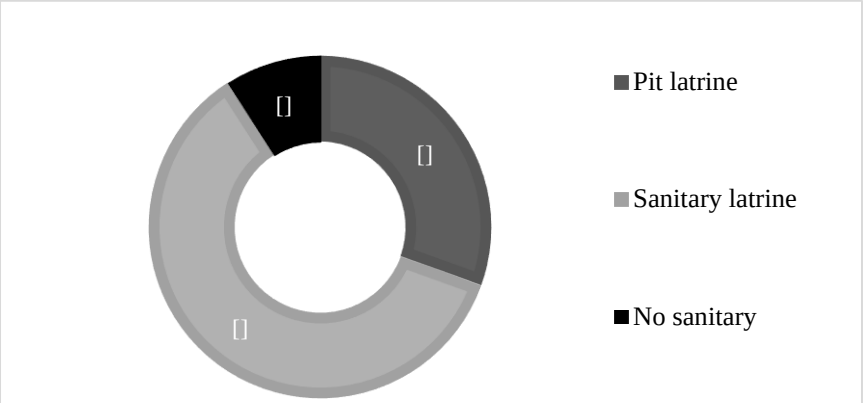


Figure 3: Types of Defecation in Slum area (Source: Field Survey, 2019)

About 85% people said that septic tank was present where community toilet facilities exist and 15% people said there was no faeces disposal system especially in single latrine facilities because this latrine are pit latrine or hanging latrine types and which linked to the nearby drain or water bodies(ponds).

Figure 4: Poor and unhygienic latrine condition at the study area. Source: Author, 2019

Rupsha slum existing toilet facilities comparatively better than another two slums. Because there few numbers of household used per latrine (12 to 15 HH per latrine). These are provided by NGOs. People waited averagely 2 to 5 minutes for using the latrine. Where Montu colony slum and Railway colony slum showing different image because there much people using a latrine (20 to 25 HH per latrine) and people waited more than 5 minutes at peak hour (especially in morning). For this reason, some slum dwellers made single toilet at their houses and maximum toilets are pit latrine or hanging latrines which connected to the nearest drain or water bodies.

Table 4: Slum Wise Common Toilet Facilities

Slum	Users number of HH per latrine	Rent	waiting time (At peak hour especially in morning time)
Rupsha	12 to 15	No	2 to 5 min
Montu colony	20 to 25	No	>5min
Railway Colony (Mawlana Vasani Community-3)	20 to 25	No	>5min

(Source: Field Survey, 2019)

After four years of SDGs adaptation, it is found that there are not enough toilet facilities for all the households in the government slums of Khulna City. As a result, people sometimes have closets in rail line or in the open space. Field surveys have shown that toilets are not regularly cleaned. Again, the maintenance system and water supply system are also found in poor condition.

3.1.2 Source of water for toilet use

Table shows that people uses only two types of water sources for sanitary uses. About 92.33% people, which means almost all people collect water from shallow tube well for toilet work. Only a few numbers of people having ponds near houses uses ponds water.

Table 5: Source of Water for Toilet Use

Sources	Number of response person	% of response person
Hand washing stand	0	0
Deep tube-well	0	0
Shallow tube-well	277	92.33
Pond water	23	7.67
Others	0	0

(Source: Field Survey, 2019)

About 78% surveyed person said the distance between toilet and water source is less than 3 meters. NGOs adhere to this distance when it comes to installing

toilets for hand washing issue to promote hygiene. And rest of the persons said that the distance almost 3 to 6 meters between the toilet and water source.

3.1.3 Level of satisfaction

Around 62.8% people said that they are not satisfied and 27.9% people said that they were satisfied with the existing sanitation facilities. The higher percentage of satisfied people are seen in the Rupsha Slum. It has been shown that the number of unsatisfied people has increased as the distance from the toilet to the home increases. The highest number of dissatisfied people have been found in the Railway Colony Slum. As there are only 2 community toilets in Railway Colony Slum, people face more problems here.

Table 6: Frequency of People's Satisfaction Level

Satisfaction Level	Frequency (Percentage)
Satisfied	27.9%
Unsatisfied	62.8%
Neither satisfied nor dissatisfied	9.3%

(Source: Field Survey, 2019)

The main reasons for respondents' satisfaction with sanitation facilities included cooperation among sharing households in cleaning the toilet (37.7%) and improved toilet type lined from the bottom (24.6%).

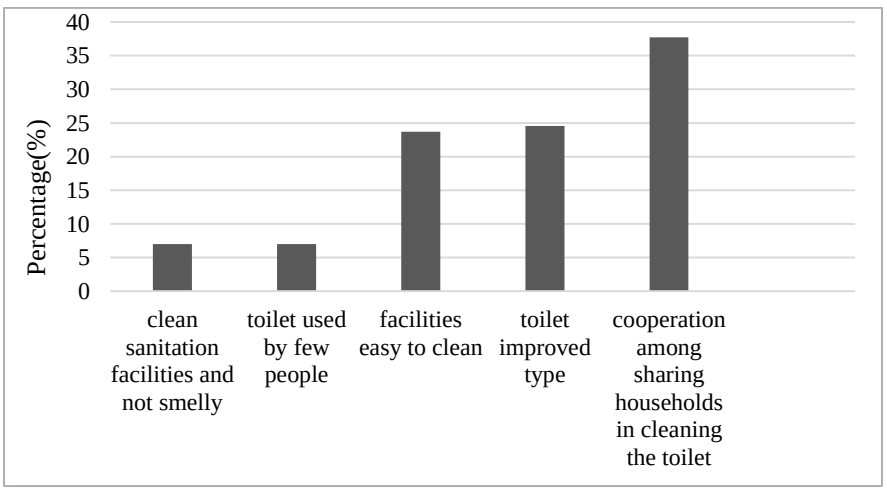


Figure 5: Reasons for the Satisfaction for Existing Sanitation Facilities. (Source: Field Survey, 2019)

The main reasons for respondent's dissatisfaction, as shown in figure 8, were sharing sanitation facilities with too many users (38.6%) and facilities that were dirty and smelly (25.9%). On the other single response question on cleanliness, only 1% of the respondents rated the toilets they use as very clean. Other responses on cleanliness of the toilet facilities used by household respondents.

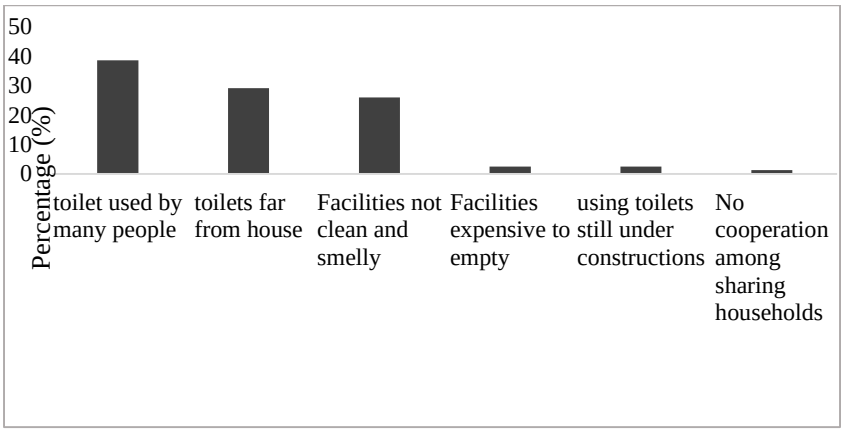


Figure 6: Reasons for the Dissatisfactions for Existing Sanitation Facilities. (Source: Field Survey, 2019)

3.1.4 Level of Cleanliness

Around 251 respondent people using common or shared toilet facilities where 84.1% respondent said that they clean their toilet once a week and 15.9% people said they cleaned toilet twice a week. And the toilet cleaned by themselves. On the other hand, around 49 respondent people used private or single toilet. When asked the question about cleaning the toilet they answered that when they feel toilet were very dirty and not usable then they clean their toilet.

Table 7: Level of Cleanliness in the Slums Area

Single Toilet	**Common/ Shared toilet**	
	Frequency of cleaning	Percentage
	Once a week	84.1%
	Twice a week	9.9%
	Once in a day	6%

Clean the toilet when it is dirty and not usable	Different households clean the toilet

1. 3.1.5 The Impact of Toilet Distance from the Community

From the field survey, it is found that some of the toilets are denoted separately for men and women. Figure no 7 shows that toilets located beyond 10 meters from the house make women feel insecure for themselves at night and for the privacy and safety of the entire family especially children.

Table 8: Frequency of HH in different distance from the toilet

Distances	% of response person HH located under that distance
1-3 meters	34%
4-6 meters	23%
7-10 meters	29%
>10 meters	8%
within house	6%

(Source: Field Survey, 2019)

In addition, there is a tendency to waste time when a person visits the toilets, and there are long waiting periods due to many users, which leads to incontinence. Long distances to the toilet leads to people relieving themselves in buckets, plastic bags and bushes. Because of ensuring the security and privacy of their family at night only 6% people have built their own toilet in their house. Toilets within 1-3 meters of reach in figure 7, pose bad odor due to poor construction, in sufficient cleaning and ventilation. Bad odor attracts flies which spread diseases through food and water contamination. There provided lighting system for these toilets is poor. This figure depicts that insecurity is a major concern for women regardless of the distance of the toilet from the house. This is due to poverty, unemployment, poor governance and overcrowding in slum area of Khulna.

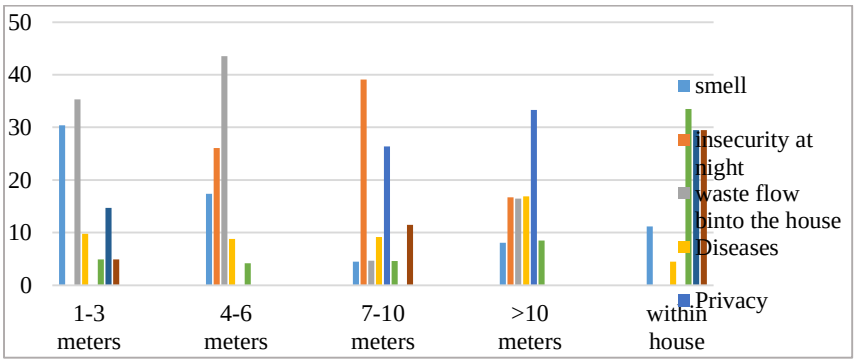


Figure 7: The impact of distance of toilet from HH in the community. (Source: Field Survey, 2019)

3.1.5 Perceived Impacts on environment

There 80.30% of the slum dwellers opined that they face serious odor pollution. As per their speech there are several reasons responsible for this odor pollution. First of all, it is seen that the septic tanks are not being cleared regularly, even in some cases it is cleaned only once in two years. Consequently, unbearable smell comes out from the toilets. More than that sometimes the toilet flashing pipes gets broken and thus bad odor emerges. Especially in the summer and rainy season this odor pollution reaches to an intolerable condition. On the other hand, 63.3% people in figure 6 stated that they face air pollution as well. Actually bad smell spreads with the flow of air and in this way the air gets polluted. Air pollution also created respiratory problem to the slum dwellers. On the contrary, almost 60% of the total respondent have given bad remarks in surface water condition.

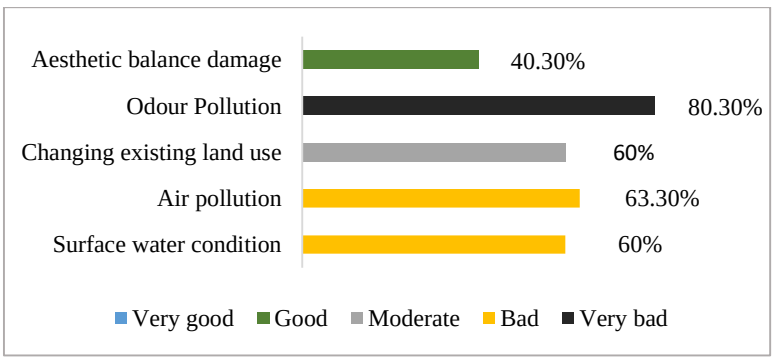


Figure 8: Visible Impacts on Environment in study area (Source: Field Survey, 2019)

Specially, in the Montu Colony several number of hanging toilets were seen right on the bank of water bodies. As a result, after defecation the wastes are dumped into the water and thus the water gets contaminated with many micro-organisms which creates various types of serious diseases like diarrhea, dysentery etc. In the Rainy season the ponds get overflown and that contaminated water with the dumps of those hanging toilets gets into the households. In this way people get sick with several waterborne diseases. Moreover, people from the nearby disaster-prone areas migrates to Khulna. So almost 60% people (see Figure 8) have given average opinion on changing existing land use. 40.30% people said that the aesthetic balance is good in balance there. In the Montu Colony the aesthetic balance is quite better than the Rupsha and Railway Colony slum.

3.1.7 Health and Hygienic

3.1.7.1 Hand Washing Activities

During survey about 60% people said that they wash their hand with soap after going to toilet. That means still 40% people don't wash their hand with soap after toilet work. The percentage of people who wash their hand with soap after work and before eating is about 12% and 6% respectively. More than 90% people don't wash their hands with soap before eating. Such unconsciousness is one of the major reasons of spread of diseases in the slums.

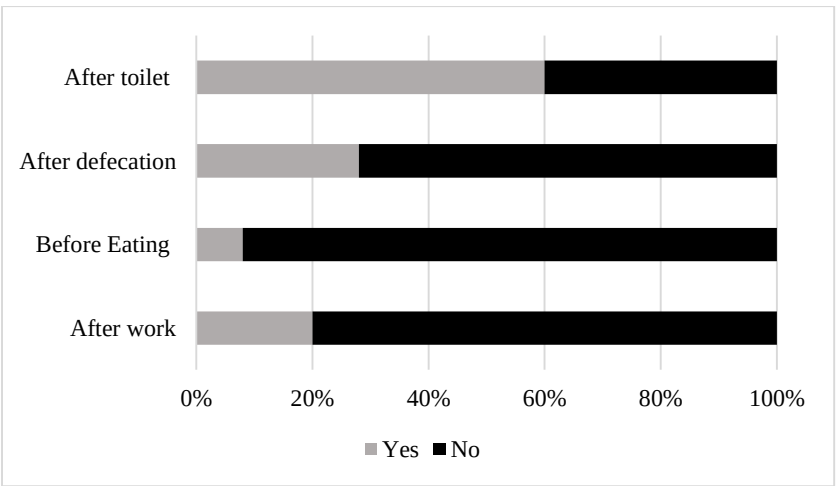


Figure 9: Hand washing activities in study area (Source: Field Survey, 2019)

Figure 9 shows the percentage of people responded 'No' is higher in all cases. They blame poverty for this poor condition.

3.1.7.2 Common Diseases

According to survey data, it is seen that fever is common disease in the slum area. About 34% and 6% people said they often fall in fever and diarrhea correspondingly. The duration of these diseases sustain almost 3 to 7 days. Maximum people (about 30%) guess that the diseases come ones in three months. They all estimate that they fall in sick less than the before. In Montu Colony slum, an NGO name BRAC provides health caring facilities like doctors visit once in a week and take BDT 10 per person as fee. People can buy medicine at low price from them.

3.1.7.3 Existing Health Caring facilities

No health caring facilities located in the slums and the slum dwellers going Khulna Medical College or other govt. clinic for health caring facilities. But sometimes it is very difficult to go specially when children (under 5 age) become sick and need quick health caring support. In Montu Colony Slum a NGO's BRAC providing health caring facilities like a doctor comes once a week and BDT 10 visits per person and people can buy medicine at low price.

Field survey analysis shows that only 10% people boil/filter the drinking water to drink it. But all of them are positive about the neatness of their house. The result for washing fruits/vegetables is also affirmative. About 83% people washes fruit/vegetable before eating.

GO and NGOs run some lessons to teach about hygienic matters. From the survey it is seen that about 76% people believe they learn about hygiene and it is very helpful for them. On the other hand, about 24% people cannot get change to receive the lessons from the NGO/GO. So this lesson does not bring any help for them.

3.2 Sustainability Measurement of Sanitation System

3.2.1 AHP Analysis

3.2.1.1 Selecting the Criteria and Indicators

The criteria and indicators for assessing the sustainability of sanitation facilities for the selected slums in Khulna are presented in Figure 8. A questionnaire was given to each expert and they determined the dimensions, criteria and indicators

on the basis of their knowledge, experience and background in the management of sanitation facilities especially in slum area. The experts' opinion taken from-

- Abdullah Al Mamun (Project Manager, WASH4UrbanPoor Project; Nobolok)
- Albino (Project Manager, Urban DRR Project; Caritas)
- Anisur Rahman (Conservancy Officer, KCC)

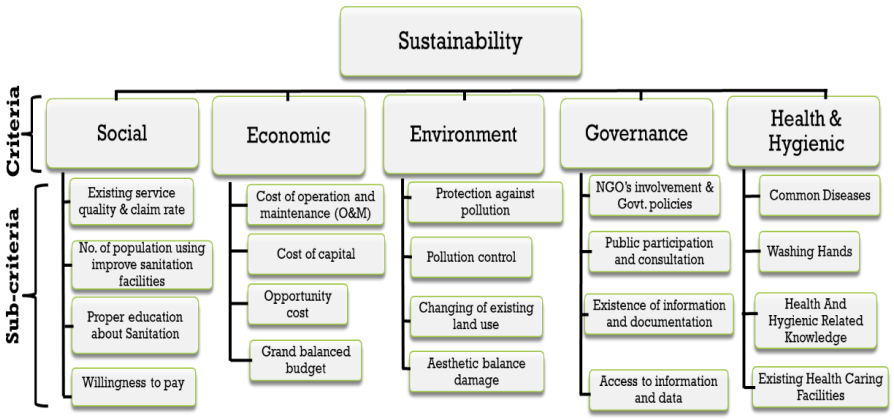


Figure 10: Selecting of criteria and sub-criteria

3.2.1.2 The pairwise comparisons

For a pairwise comparison of each criterion and indicator consulting with experts. Then expert makes his judgment using the Saaty scale (Table 1) and delivers his own matrix of comparison in pairs. The decision matrices for criteria and indicators are then calculated the average of each individual priority of the perspective of five decision matrices (Tables 9).

Table 9: The matrix of pairwise comparison of five criteria

Criteria	Social	Economic	Environmental	Governance	Health & Hygienic	Relative priority	Relative Priority (%)
Social(C1)	1.0	5	5.0	6.0	4.0	0.580	58%

Economic (C2)	0.2	1.0	2.0	4	2.0	0.107	10.7 %
Environmental(C3)	0.2	0.5	1.0	2.0	0.333	0.093	9.3%
Governance(C4)	0.167	0.25	0.5	1.0	0.5	0.064	6.4%
Health & Hygienic (C5)						0.156	15.6 %

λ_{max} = 5.408; *CI*= (λ_{max} -n)/(n-1) =0.102 [Here, n=5];

CR=(*CI/RI*) = (0.102/1.12) =0.091≤ 0.10≈ consistent

3.2.1.3 Manual AHP Calculation

Iteration-1

Criteria	Social	Economic	Environmental	Governance	Health and Hygienic
Social(c1)	5.002	16	35	50	22.665
Economic(c2)	1.968	5	13	17.2	7.466
Environmental(c3)	.917	2.667	4.999	7.866	3.466
Governance(c4)	.609	1.835	3.835	5.002	2.334
Health and Hygienic(c5)	1.534	4.25	9.25	13.5	4.999

$$A(1) = A^2 = A * A$$

Raw sum	Normalized raw sum
128.667	0.535

44.634	0.186
19.915	0.083
13.615	0.057
33.533	0.140
240.364	1

Iteration-2:

Criteria	Social	Economic	Environmental	Governance	Health and Hygienic
Social(c1)	153.821	377.383	959.436	1356.69	584.139
Economic(c2)	45.661	130.426	281.89	4.4.683	174.596
Environmental(c3)	24.523	59.824	153.957	217.147	93.693
Governance(c4)	16.801	40.897	105.113	148.707	64.138
Health and Hygienic(c5)	40.409	99.464	253.194	375.574	155.058

$$A(2) = (A(1))^2 = A(1) * A(1)$$

Raw sum	Normalized raw sum
3431.469	0.580
632.573	0.107
549.144	0.093
375.656	0.064
923.699	0.156

5912.541	1.000

Difference between iteration 1 and 2 is-

Iteration 1	Iteration 2	Difference
0.535	0.580	-0.045
0.186	0.107	0.079
0.083	0.093	-0.010
0.057	0.064	-0.007
0.140	0.156	-0.017

Preference:

Table 10: Ranking of five main criteria

Social(C1)	**0.580**	**Rank 1**
Economic(C2)	0.107	Rank 3
Environmental(C3)	0.093	Rank 4
Governance(C4)	0.064	Rank 5
Health and Hygienic(C5)	0.156	Rank 2

From the result it was shown that the experts have attributed a great importance to the two criteria's social and health and hygienic, whose weights are 58% and 15.3%. No. of people using improved sanitation facilities and washing hands with the weights of 60.8% (table 11) and 59.6 % (table 15) are the most important indicators of social and health and hygienic criteria's respectively. In the economic criteria, the highest weight was given to the indicator of cost of operation and maintenance 52.3% (Table 12).

Table 11: Paired comparison matrix for the Social (C1) attribute

Criteria	No. of population using improve	Existing service	Proper education about	Willingness to pay	Relative	Relative

	sanitation	quality & claim rate	Sanitation		priority	Priority (%)
No. of population using improve sanitation facilities	1	5	4	7	0.608	60.8%
Existing service quality & claim rate	1/5	1	2	5	0.206	20.6%
Proper education about Sanitation	1/4	1/2	1	3	0.132	13.2%
Willingness to pay	1/7	1/5	1/3	1	0.054	5.4%

λ_{max} = 4.178; *CI*= (λ_{max} -n)/(n-1) =0.059 [Here, n=4];

CR=(*CI/RI*) = (0.059/.90) =0.065≤ 0.10≈ consistent

Table 12: Paired comparison matrix for the Economic (C2) attribute

Criteria	Cost of operation and maintenance	Cost of capital	Opportunity cost	Grand balanced budget	Relative priority	Relative Priority (%)

Cost of operation and maintenance	1	3	5	5	0.523	52.3 %
Cost of capital	1/3	1	3	5	0.260	26.0%
Opportunity cost	1/5	1/3	1	3	0.118	11.8%
Grand balanced budget	1/5	1/5	1/3	1	0.099	9.9%

λ_{max} = 4.198; *CI*= (λ_{max} -n)/(n-1) =0.066 [Here, n=4];

CR=(*CI*/*RI*) = (0.066/.90) =0.073≤ 0.10≈ consistent

Table 13: Paired comparison matrix for the Environmental (C3) attribute

Criteria	Protection against pollution	Pollution control	Changing of existing land use	Aesthetic balance damage	Relative priority	Relative Priority (%)
Protection against pollution	1	3	2	3	0.431	43.1%
Pollution control	1/3	1	1/4	1/3	0.087	8.7%
Changing of	1/2	4	1	3	0.323	32.3%

existing land use						
Aesthetic balance damage	1/3	3	1/3	1	0.159	15.9%

λ_{max} = 4.214; *CI*= (λ_{max} -n)/(n-1) =0.071 [Here, n=4];

CR=(*CI/RI*) = (0.071/.90) =0.079≤ 0.10≈ consistent

Table 14: Paired comparison matrix for the Governance (C4) attribute

Criteria	NGO's involvement & Govt. policies	Existence of information and documentation	Public participation and consultation	Access to information and data	Relative priority	Relative Priority (%)
NGO's involvement & Govt. policies	1	3	5	7	0.556	55.6 %
Public participation and consultation	1/3	1	3	5	0.258	25.8 %
Existence of information and documentation	1/5	1/3	1	5	0.137	13.7 %

Access to information and data	1/7	1/5	1/5	1	0.049	4.9%

λ_{max} = 4.240.; *CI*= (λ_{max} -n)/(n-1) =0.080 [Here, n=4];

CR=(*CI/RI*) = (0.080/.90) =0.089≤ 0.10≈ consistent

Table 15: Paired comparison matrix for the Health and Hygienic (C5) attribute

Criteria	Washing Hands	Health And Hygienic Related Knowledge	Existing Health Caring Facilities	Common Diseases	Relative priority	Relative Priority (%)
Washing Hands	1	5	4	7	0.596	59.6%
Health And Hygienic		1/5		1	0.206	20.6%
Existing Health Caring Facilities	1/4	1/2	1	3	0.132	13.2%
Common Diseases	1/7	1/5	.333	1	0.066	6.6%

λ_{max} = 4.178; *CI*= (λ_{max} -n)/(n-1) =0.059 [Here, n=4];
CR=(*CI/RI*) = (0.059/.90) =0.065≤ 0.10≈ consistent

The indicator of the protection against pollution had the highest weight 43.1% (table 13) to the environmental criteria. The NGO's involvement & Govt. policies and public participation and consultation indicator which are belong to

the governance criteria's respectively with the weights of 55.6% and 25.8% have the highest weight and importance.

From the results it was consider that the three criteria: social, health and hygienic and economic as the most important aspects of sanitation facilities in the selected slums of the Khulna City. According to the results the most important indicators in the eyes of expert are no. of population using improve sanitation facilities, washing hands, existing service quality & claim rate, cost of operation and maintenance (O&M) which are most important indicators to get sanitation services of the selected slums of Khulna City towards sustainability. And the indicators of access to information and data and existence of information and documentation do not have a big role in the sustainable management of sanitation facilities in the selected slums of Khulna City because of decision makers and service facilities provider do not take consultation of the public in decision making and users do not have access to information and sanitation service related data in slum area.

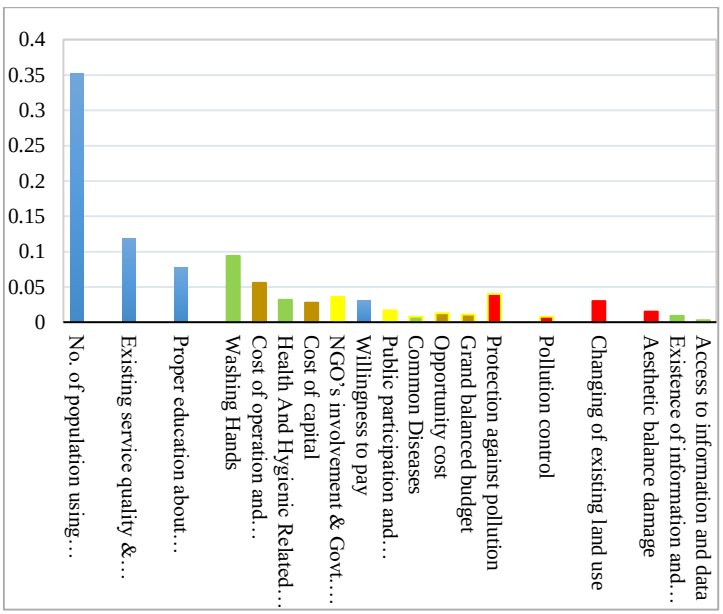


Figure 11: The Weight of 20 Indicators Which Obtained from AHP

Then based on the model's equation, according to Eq. (1) to (4), and the hierarchical structure of the indicators had been created for the Rupsha slum, Montu Colony slum and Railway colony slum. To do so, scores on a 1-5 scale are set up with increasing importance for each attribute, and therefore, the

sustainability of every slum will be measured. Table 16 shows the detail of the weightage of the Rupsha slum.

Table 16: The hierarchical structure of the indicators and detail of the weightage of the Rupsha slum

Dimension	Criteria	Sub-criteria	Weightage	Score (scale 1-5)	Weightage Score
Sustainability	Social (0.580)	No. of population using improve sanitation facilities	0.352	5	1.760
Sustainability		Existing service quality & claim rate	0.119	4	0.476
		Proper education about Sanitation	0.077	4	0.308
		Willingness to pay	0.031	3	0.093
	Economic (0.107)	Cost of operation and maintenance (O&M)	0.056	4	0.224
		Cost of capital	0.028	4	0.112

	Opportunity cost	0.013	3	0.039
	Grand balanced budget	0.011	5	0.055
Environment (0.093)	Protection against pollution	0.040	4	0.160
	Pollution control	0.008	4	0.032
	Changing of existing land use	0.030	4	0.120
	Aesthetic balance damage	0.015	3	0.045
Governance (0.064)	NGO's involvement & Govt. policies	0.036	4	0.144
	Public participation and consultation	0.017	3	0.051
	Existence of information and documentation	0.009	3	0.027

		Access to information and data	0.003	4	0.012
		Washing Hands	0.094	5	0.470
	Health & Hygienic (0.156)	Health And Hygienic Related Knowledge	0.032	4	0.128
		Existing Health Caring Facilities	0.021	3	0.063
		Common Diseases	0.008	4	0.032
Total			1.00	-	4.361

The same procedure has been carried out to obtain weighting for the Montu Colony slum and Railway colony slum. Table 17 shows the final classification obtained by the AHP model to measure the sustainability considering the all criteria's whose are related to the sanitation facilities of these three slums of Khulna City, and it shows in descending order.

Table 17: Final Score of Sustainability for the Study Area

Name of the slum	Final Score
Rupsha slum	4.361
Montu Colony slum	4.061
Railway colony slum	3.955

Analysis shows that Rupsha slum has the highest weightage 4.361. Because of much number of people using improved sanitation facilities, existing service quality and NGOs involvement (Providing much no. of improved sanitation facilities and impart knowledge about hygiene through WASH related project) better than Montu Colony slum and Railway colony slum (Mawlana Vasani Community-3). So it can be said that on the basis of results, sustainability achieved easily in Rupsha slums than Montu Colony, Railway Colony slums (Mawlana Vasani Community-3).

Although AHP analysis indicates a moderately good condition of the slums, but considering the overall situation, it can be concluded that the sanitation system in the slums is poor. After the end of MDGs and four years of SDGs, the sanitation systems of the Khulna City government's slums visualize an unsatisfactory progress towards sustainability.

4. Conclusion

Ensuring "clean water and sanitation" is one of the 17 goals of Sustainable Development Goals (SDGs) aimed specifically to ensure availability and sustainable management of water and sanitation for all within 2030. Providing safe, sustainable, environmentally friendly and hygienic sanitation service to all the inhabitants of the country has been a major responsibility to the government. For this, assessment of the existing sanitation condition of any area is important. This study assessed the current sanitation condition in the three major slum of Khulna city and also introduced AHP methods to measure the sustainability of sanitation service facilities in these slums. The analysis shows that 62.8% people of the study area are not satisfied with the existing sanitation services which can be improved by providing more toilets in the slums. Only 6% people wash their hands before eating while 40% people don't wash their hands after defecation. This has resulted in the illness of 34% people. The poor sanitation condition has resulted in the odor pollution, air pollution and the spread of diseases. The AHP analysis shows that the final score for sustainability by Rupsha slum, Montu Colony slum and Railway colony slum are 4.361, 4.061 and 3.955 respectively which indicates the poor achievement of sustainability. The AHP process which was judgement by three experts shows that the social (58%), health and hygiene (15.6%) and economy (10.7%) criteria had more priority than others environmental and governance. Several NGOs are involved to improve the current condition of these slums. The poor sanitation condition can be improved by promoting education, awareness, taking initiatives such as hand washing, cleaning and providing sanitation service facilities as needed. This study will be helpful in city planning and municipal service facility planning and will help to

the responsible authorities to concern and promote sustainability for a sound, healthy and environmentally friendly city.

5. References

[1] R. Subbaraman and S. Murthy, "The Right to Water in the Slums of Mumbai, India," Bull World Health Organ, vol. 93, pp. 815-816, 2015.

[2] M. Z. Alam, M. A. Rahman and M. A. A. Firoz, "Water Supply and Sanitation Facilities in Urban Slums: A Case Study of Rajshahi City Corporation Slums," American Journal of Civil Engineering and Architecture, vol. 1, no. 1, pp. 1-6, 2013.

[3] M. . S. H. Swapan , A. U. Zaman, T. Ahsan and F. Ahmed, "Transforming Urban Dichotomies and Challenges of South Asian Megacities: Rethinking Sustainable Growth of Dhaka, Bangladesh," Urban Science , vol. 4, no. 1, p. 31, 2017.

[4] I. B. Muhit, S. T. Chowdhury, N. Nahid and M. F. Zaman, "Hygiene Condition of Water Use and Sanitation Facilities at Urban Slums: Analysis of Port City Chittagong, Bangladesh / Wyposażenie Sanitarne W Slamsach Miejskich - Analiza Na Podstawie Miasta Portowego Chittagong, Bangladesh," Civil And Environmental Engineering Reports, vol. 16, no. 1, pp. 153-166, 2015.

[5] M. S. Alam and M. Mondal, "Assessment of sanitation service quality in urban slums of Khulnacity based on SERVQUAL and AHP model: A case study of railwayslum, Khulna, Bangladesh," Journal of Urban Management, 2018.

[6] K. Andersson, S. Dickin and A. Rosemarin, "Towards “Sustainable” Sanitation: Challenges and Opportunities in Urban Areas," Sustainability, vol. 8, pp. 1289- 1303, 2016.

[7] A. Rosemarin, "Sustainable sanitation and water in small urban centres," Water Science and Technology, vol. 51, no. 8, pp. 109-118, 2005.

[8] United Nations, "Special edition: progress towards the Sustainable Development Goals," United Nations, Geneva, 2019.

[9] M. L. Kansal, I. J. Ndimbo and S. K. Chandaniha , "Urban water service quality assessment in Tanzanian towns of Songea and Mbeya," Sustainable Water Resources Management, vol. 3, pp. 491-501, 2017.

[10] R. W. Saaty, "The Analytic Hierarchy Process- What It is and How It is Used," Mathematical Modelling, vol. 9, no. 3-5, pp. 161-176, 1987.

[11] T. P. A. Pacemska, M. Lapevski and R. Timovski, "Analytical Hierarchical Process (Ahp) Method Application In The Process Of Selection And Evaluation," in International Scientific Conference "UNITECH 2014", Gabrovo - Bulgaria, 2014.

[12] S. Hamchaoui, A. Boudoukha and A. Benzerra, "Drinking water supply service management and sustainable development challenges: case study of Bejaia, Algeria," Journal of Water Supply: Research and Technology-Aqua, vol. 64, no. 8, pp. 937-946, 2015.

[13] M. S. Alam and S. M. Haque, "Assessment of Urban Physical Seismic Vulnerability Using the Combination of AHP and TOPSIS Models: A Case Study of Residential Neighborhoods of Mymensingh City, Bangladesh," Journal of Geoscience and Environment Protection, vol. 6, no. 2, 2018.

[14] K. Schmidt, I. Aumann, I. Hollander, K. Damm and J.-M. G. v. d. Schulenburg, "Applying the Analytic Hierarchy Process in healthcare research: A systematic literature review and evaluation of reporting," BMC Medical Informatics and Decision Making, vol. 15, 2015.

[15] C. Ching, J. Yap and Y. T. Choo, "Analytic Hierarchy Process (AHP) for business site selection," in Proceedings of the Sixth International Conference on Computer Science & Computational Mathematics (ICCSCM 2017), Langkawi, Malaysia, 2017.

[16] F. H. Ho, S. H. A. Rashid and R. A. R. Ghazilla, "Analytic Hierarchy Process-Based Analysis to Determine the Barriers to Implementing a Material Efficiency Strategy: Electrical and Electronics' Companies in the Malaysian Context," Sustainability, vol. 8, pp. 1035-1051, 2016.

[17] A. Esmaeili and R. A. Kahnali, "An integration of SERVQUAL dimensions and logistics service quality indicators (A case study)," International Journal of Services and Operations Management, vol. 21, no. 3, pp. 289-309, 2015.

[18] S. Boukhari, Y. Djebbar, H. Amarchi and A. Sohani, "Application of the analytic hierarchy process to sustainability of water supply and sanitation services: the case of Algeria," Water Supply, vol. 18, no. 4, pp. 1282-1293, 2018.

[19] M. Rana, "Status of water use sanitation and hygienic condition of urban slums: A study on Rupsha Ferighat slum, Khulna," Desalination, vol. 246, no. 1-3, pp. 322-328, 2009.

[20] T. Saaty, "The Analytic Hierarchy Process," in Decision Aids for Selection Problems. Springer Series in Operations Research, Springer, New York, NY, 1996, pp. 49-68.

Research Paper

PROBLEMS AND CONTRIBUTIONS OF ROOFTOP GARDENING: A CASE STUDY OF KHULNA CITY

Naila Ferdous Nitol, Department of Urban and Regional Planning, Khulna University of Engineering & Technology, Khulna; Bangladesh

Tusar Kanti Roy, Department of Urban and Regional Planning, Khulna University of Engineering & Technology, Khulna; Bangladesh

Md Sabbir Hossain, Department of Urban and Regional Planning, Khulna University of Engineering & Technology, Khulna; Bangladesh

Abstract

Now a days, rooftop gardening is a popular topic in developed countries. But in Bangladesh still it is not so popular and most of the building owners are not aware of making garden on the building roof. Rooftop garden is very helpful for our environment as well as increasing the scenic beauty of the roof. This study evaluates the present condition of rooftop gardening in Khulna city including the problems and contributions of rooftop gardening in this city and the study area is Nirala residential area. The survey was done over 30 buildings in the residential area which have rooftop garden. The survey has covered many factors about rooftop gardening like problems, limitations, economic, thermal, mental benefits, labor, maintenance system, mental refreshment etc. Results showed that majority of the rooftop gardeners belonged to the group of old age and small family size with high annual income. Majority of them had low experience on rooftop gardening. More than half of the respondents has small size (≤1000 ft 2) roof area suitable for gardening. The rooftop gardeners earned very poor economic benefit from the garden compared to bearing large expenditure for it. Most of the respondents preferred rooftop garden as a hobby and aesthetics. Again, many respondents considered it as an aspect of ecological balance. Vegetables and flowers are the most dominating plants in the study area for rooftop gardens.

Keywords

Rooftop Gardening, Plant Types, Economic Benefits, Environmental Benefits

1. Introduction

Basically, rooftop gardening means making garden on the roof of the building. It keeps the building cold in very hot weather. If it can be maintained properly it

will help for food security, poverty reduction and creating scenic beauty. Urbanization is increasing worldwide, particularly in developing countries, with an annual urban growth rate of 3.6% between 1950 and 2005, versus only 1.4% in industrialized countries. In addition, urban agriculture and use of land have risen suddenly due to increase in food demands in many cities. Urbanization has been swiftly and continually expanding worldwide over the last few years (Islam, 2004). All kinds of trees can be planted on roof if there are enough space and maintenance system. It can also help reducing unemployment problem. Through urban agriculture, city Residents can learn to sustain themselves with food that they have produced with their own hands, but if urban food production is to reduce hunger and poverty, then it must also be part of a broader strategy (Akram-Lodhi, 2011) (Tilman, et al., 2002) (Aubry, et al., 2012) (Bianchini & Hewage, 2012).

A beautiful garden can make the mind fresh and it is very helpful for better physiological restfulness. As the concept of resiliencies associated with diversity, (Bohn & Viljoen, 2010) it may be well described by a RTG grouping together the inhabitants of a building (being an inter-generational and inter-ethnical blend of people), which inevitably will grow a range of different plants (Fraser & Kenney, 2000), yielding considerable biodiversity within the garden. Under these circumstances each of the proposed RTGs may group residents together into a dense network (Jafari, et al., 2015) decreasing isolation through sharing of gardening inputs and knowledge (Wakefield, et al., 2007) and promoting a participatory approach to community development (Saldivar & Krasny, 2004).

Trees reduce the temperature of the nature. Rooftop gardens help to keep the temperature of the building's cold in very hot weather. A rooftop garden not only can create a very beautiful scene but also keep the environment fresh and calm. (Kaplan, 1979) These garden trees can help for the reduction of hot weather. (Begum, et al., 2021) Global driver of change in land-use, there have been few attempts to quantify provision of ecosystem services for cities. One service that is an increasingly important feature for mitigation of climate change is the biological carbon storage associated with urban areas. (Kosareo & Ries, 2007)

Though the practice of rooftop gardening is not so popular in our country it is very much cutler in developed countries like – USA, Canada, Singapore and other European countries. Given that more than half of the world's population live in urban areas (Orsini, et al., 2013), the world's cities are responsible for the majority of carbon dioxide (CO2) in the atmosphere (Girardet, 1999). Rooftop gardening can create employment for poor people because still in our country

mainly rich people do it as hobby. Rooftop gardening is an economically benefited project as well as ensuring food security, poverty reduction and employment generation. It can create a good urban agricultural phase (Tilman, et al., 2002) (Brown & Bailkey, 2002). This reduces the energy demand for space conditioning significantly in spring and summer.

In addition, rooftop gardens delay run-off and reduce the run-off rate and volume. These qualities are important in storm water management strategies in big cities. The findings are significant under the current climate regime and they may prove to be of even greater significance in the future when increased variability from climate change is manifested at the regional scale (Liu, 2002). But our government has no specific policy, provision, rule or regulations for rooftop gardening. Some NGOs are working for it at present time. The direct effects of planted roof are their thermal benefits in reducing surface temperatures of roofs and heat transfer into the rooms underneath. It will directly contribute to improving indoor thermal environment and the thermal performance of buildings (Begum, et al., 2021). It is good news for Bangladesh that recently our government has taken a step to reduce 5% holding tax for the buildings which have rooftop garden. The objectives of this study were to investigate the present scenario of rooftop gardening in Khulna city and investigating the problems and contributions of rooftop gardening in Khulna City.

2. Study Area

This work on rooftop gardening has done in Nirala Residential Area of Khulna city. Khulna is the third largest city in Bangladesh. It is located on the banks of the Rupsha and Bhairab River. It lies between 21°41' and 23°00' north latitudes and between 89°14' and 89°45' east longitude (BBS, 2011).

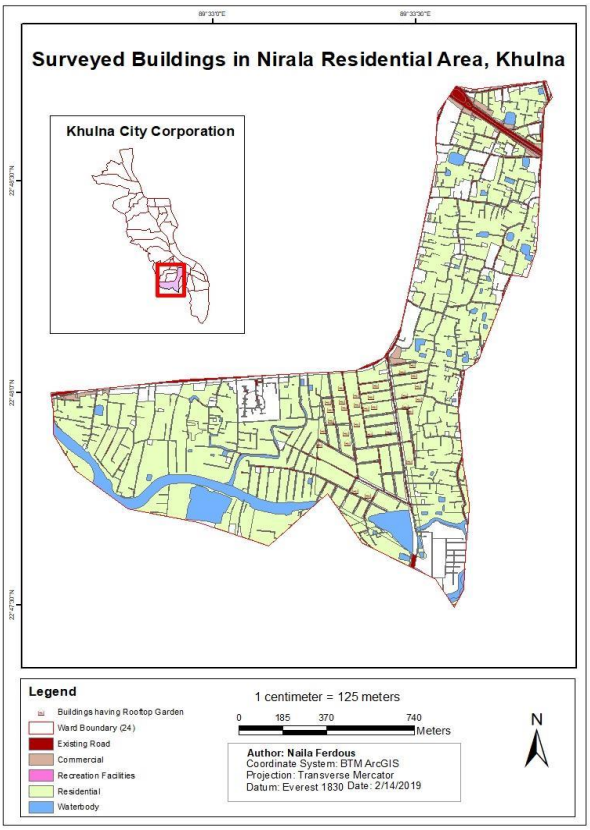


Figure No 2: The GIS map of the surveyed building's locations

Source: Author, 2019

The figure 2 represents the GIS map. Here the location of 30 surveyed buildings in Nirala residential area have been shown.

3. Methodology

3.1 Conceptualization Phase

Literature Review

At the first stage literature review was done by reading books, journals, papers about rooftop gardening to know about rooftop gardening in details as well as the present condition of rooftop gardening in Bangladesh especially in Khulna city and different foreign countries.

Objective
After conceptualization the research objective was selected according to the research topic and working method.

3.2 Pre-Data Collection Phase

Study Area Selection
After selecting the objectives, the study area was selected and the study area was Nirala Residential Area.

Sample Size Determination
After selection the study area, 30 buildings were selected that have rooftop garden in Nirala residential area.

Questionnaire Preparation
Questionnaire is necessary to collect the required data. So, A Questionnaire based on user's opinion was prepared for collecting the data. Question was asked about plant types, garden area, labor, working hour, problems, contributions, economic benefit, environmental aspects etc.

3.3 Data Collection

Primary Data Collection
Primary data was collected by physical survey, questionnaire survey and expert opinion survey.

Physical Survey

Physical survey was carried to evaluate the existing conditions of the study areas. The survey was done to comprehend the rooftop garden quality such as number and types of trees, gardening type, source of water for gardening, problems, contributions etc. which have important impact on rooftop gardening.

Questionnaire Survey

A questionnaire was developed for conducting the research which contained 45 questions accordance with research objectives. The questionnaire is based on:

1. Problems of the garden
2. Rooftop area and garden area
3. Plant Types
4. Economic Benefits

5. Environmental Aspects

6. Finance

7. Contribution of the garden

Secondary Data Collection

The study area map, the information about the study was collected from the respondents which had been chosen as selected buildings.

3.5 Data Analysis

After completing the data collection, they were analyzed according to the objective of the study. Computer software MS WORD, MS EXCEL, SPSS and GIS had been used for graphical analysis and presentation. Descriptive statistics, different tables, diagrams used to analysis the collected data.

3.6 Findings and Recommendation

After analyzing data, the final output was documented as a report. The found outcomes were interpreted in a descriptive way which can be easily understood. Quality of rooftop garden in different buildings had been identified. Some recommendations were also made according to the study findings.

4. Result and discussion

Rooftop gardening might be an alternative to overcome this land scarcity. The present study analyzes the scenario of rooftop gardening, its problem confrontation and its effects on the surroundings. Nirala residential area of Khulna city of Bangladesh were purposively selected for the study from where a total of 30 rooftop gardens were randomly selected for face-to-face interview. . Results showed that majority of the rooftop gardeners belonged to the group of old age and small family size with high annual income. Majority of them had low experience on rooftop gardening. More than half of the respondents has small size (≤1000 ft 2) roof area suitable for gardening.

The rooftop gardeners earned very poor economic benefit from the garden compared to bearing large expenditure for it. Most of the respondents preferred rooftop garden as a hobby and aesthetics. Again, many respondents considered it as an aspect of ecological balance. Vegetables and flowers are the most dominating plants in the study area for rooftop gardens. Main intercultural operations included irrigation, weeding, training/pruning and control of insects and diseases. Common fertilizers used in the study area were cow dung, compost, urea, potash and sesame cake.

Excessive heat, lack of proper nourishment and roof load are the most severe problems. There are showed positive impacts in case of green roof than empty roof. Thus, the overall results indicate great contributions of rooftop gardening in urban areas in terms of environmental reclamation.

4.1 Mental and Environmental issue

- In case of environmental advantage all people said rooftop garden can create a beautiful scenario on roof and most of them think it also helps to reduce temperature in very hot weather.
- Planted roof can offer thermal protection, which may reduce the thermal load applied to buildings.

Source: Field Survey 2019

Figure 01: A well planned rooftop garden that increases scenic beauty

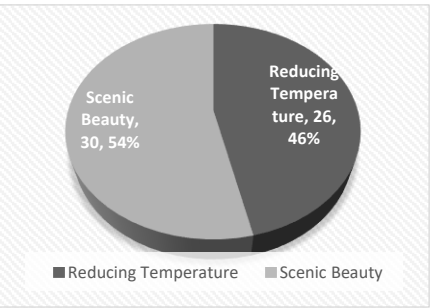


Figure 02: Percentage of response about mental & environmental issue

- If widely adopted, rooftop gardens can reduce the urban heat island, which would decrease smog episodes, problems associated with heat stress.
- A planned rooftop garden can be a cause of mental peace and refreshment for people.

4.2 Labour issue

- Most of the owner have labours for the maintenance of garden.
- According to people's opinion the labours water the plans and do what is needed for taking care of the garden regularly.
- If it is needed they pelt extra soil on the roof for the garden and use pesticides, fertilizer etc.
- People who does not have labour they do the above things by their own self.

- Majority of the rooftop gardeners belonged to the group of old age.

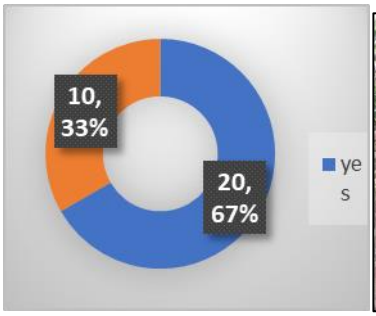


Figure 03: Percentage of how many respondents have labour or not

Figure 04: A garden totally maintained by labour

Source: Field Survey 2019

4.3 Causes behind rooftop garden

- All most all people make rooftop garden as a hobby and only a few amounts of people earn money from it.
- But people who do it as a hobby maximum of them are conscious about aesthetic view, well planned garden making and scenic beauty

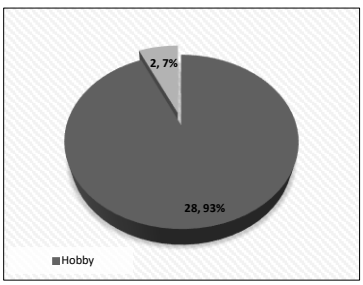


Figure 05: Percentage ratio of hobby & earning money

Figure 06: A fruit garden in Rooftop

- A few people can earn money from the garden because their garden belongs a huge area and they can cultivate (almost all) vegetable and fruit and sell them.

4.4 Problems behind rooftop garden

- Excessive hit is the main problem for rooftop gardening according to the opinion of the people but lack of materials and maintenance system are also problems. In this study money is not a problem.
- Sometimes plants become destroyed for lacking of irrigation, weeding, training and control of insects and diseases.
- People who does not have labour cannot give time properly always.

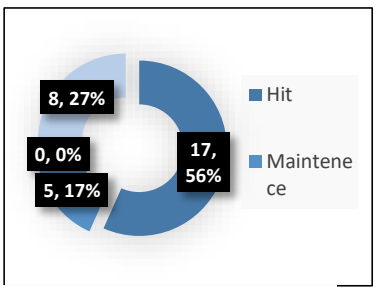


Figure 08: An unmaintained garden

Source: Field Survey 2019

problem of rooftop gardening

4.5 Financial problem

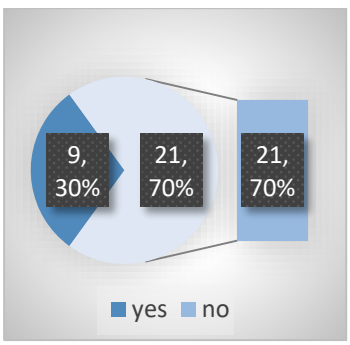


Figure 07: Percentage ratio of having financial problem or not

Figure 08: A well-planned Rooftop Garden

Source: Field Survey 2019

- Some people have found who want to make a well-planned rooftop garden in a large scale but they cannot do it for financing problem like labour cost, maintenance cost, extra plant or soil, fertilizer, pesticides and many necessary materials buying cost etc.

- For rooftop gardening maximum people do not have financing problem according to the field survey.
- People who do not have financing problem they try to take care of their garden properly and provide all necessary things needed for the garden.
-

4.6 Economic condition of the owner

- According to the field survey people who makes rooftop garden are maximum rich people, a few are middle class people and the poor people do not do it.
- Majority of them have small family size and high annual income rate.
- Low income people cannot imagine to make a rooftop garden only because of their financial problem. But maximum people have a hobby of their own garden.

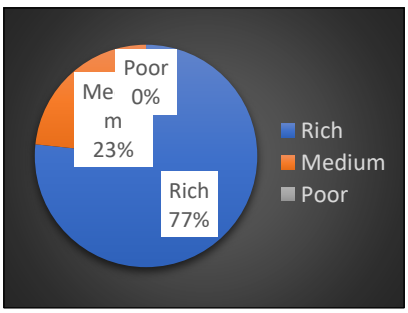


Figure 09: Percentage of people having different economic conditions who had rooftop gardening among the respondents

Figure 10: Garden in the portion of the roof

Source: Field Survey 2019

4.7 Used rooftop area for the garden

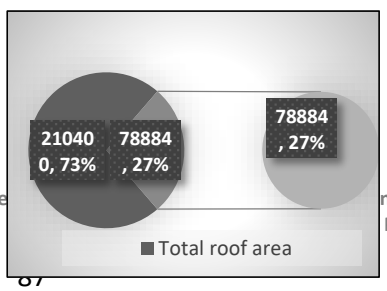


Figure 11: Garden in the portion of the roof

Figure 12: Percentage of properly used area for gardening and also unused

- Maximum are successful in making good rooftop garden but lack of proper maintenance resulted in a lot of damage to trees.
- The main cause of destruction of plant is lack of training and proper knowledge.
- Majority of the people has low experience.
- Many people are not aware of planting trees on roof in a planned way.
- In maximum buildings the area used for rooftop gardening is approximately half of the total roof area.
- The gardens which are made in a large scale, they mostly cover entire area of the roof.
- For better maintenance and want of some free space on the roof many people use about half of the roof area for making rooftop garden.
- The gardens which are made in a large scale, they mostly cover entire area of the roof.
- For better maintenance and want of some free space on the roof many people use about half of the roof area for making rooftop garden.

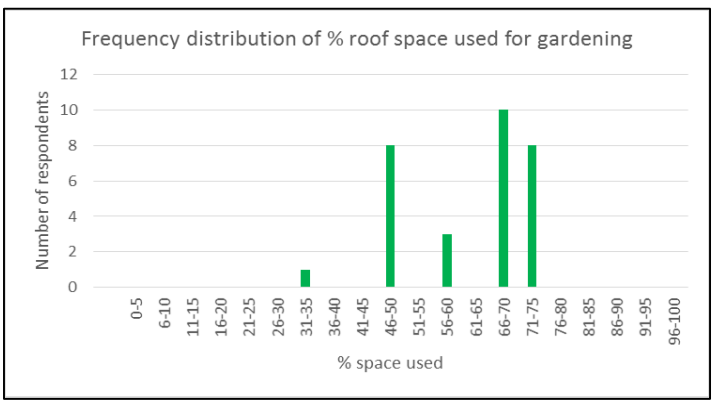


Figure No 5.7.7: Percentage of maximum, minimum and average area used for
gardening

Source: Field Survey 2019

- Minimum 32% of roof space used for gardening
- Maximum 75% of the roof space used for gardening
- On average 62% of the roof space used for gardening

Table: Overall problems and contributions of rooftop gardening in Khulna city

Problems	Contributions
1. Lack of awareness, experience and proper training.	1. Planted roof can offer thermal protection, which may reduce the thermal load applied to buildings.
2. Not giving enough time for taking care of the garden.	2. Rooftop gardens can reduce the urban heat island, which would decrease smog episodes, problems associated with heat stress.
3. Lacking of irrigation, weeding, training and control of insects and diseases.	3. A planned rooftop garden can be a cause of mental peace and refreshment for people.
4. Some people cannot bear the labour cost, maintenance cost and other necessary cost for a planned rooftop garden.	4. A few people can earn money from the garden because their garden belongs a huge area and they can cultivate (almost all) vegetable and fruit and sell them.
5. Maximum high-income people do not observe if their labours take proper care of their garden or not.	5. Rooftop garden may play a vital role for the ecological balance in the city if it is made in a broader scale.
6. Many people start it as a hobby but they cannot take care of the plants properly, that's why plants get destructed.	6. Now a days, rooftop gardening can be a good strategy for urban agriculture where there is lack of agricultural land in urban area.
7. Because of rapid urbanization it is hard to get enough space on the roof to make a garden.	7. If most of the people of the city start to make rooftop garden it will be a very effectual strategy to reduce pollution and heat island effect in Khulna city.

5. Conclusion

The study investigates the present scenario of rooftop gardening of Nirala Residential Area in Khulna city and there is also both problems and contribution of it. According to the survey result this case study shows that the present condition of rooftop gardening is not so good in Nirala Residential Area. But day by day it is becoming a hot topic in our country like other developed countries. For this research the thinking and working for rooftop gardening of the owns was investigated.

This study shows that mainly rich peoples have rooftop garden. They take rooftop garden as a hobby. So, they have enough financial capability. Some people face problems for rooftop gardening like lack of proper maintenance or money etc. But most of the rich owners have enough space, maintenance system and labour. Many people start it as a hobby but in some cases, they cannot take care of the plants properly, that's why plants get destructed. Because of rapid urbanization it is hard to get enough space on the roof to make a garden. Rooftop garden does not harm the building in a large scale, rather than it increases the beauty and also decreases temperature in hot weather. A few people can earn money from the garden because their garden belongs a huge area and they can cultivate (almost all) vegetable and fruit and sell them. Rooftop gardening can be a good strategy for urban agriculture where there is lack of agricultural land in urban area. As our government is now paying concern about rooftop gardening, so it can be a very good way to save our urban environment as well as it can increase the scenic beauty of the roof which can be a reason for the mental refreshment of the owners in city area. Now a days several NGOs are working on it. Some people has already taken good initiative for their rooftop garden and they make it not only a garden but also a source of income. If most of the people of the city start to make rooftop garden it will be a very effectual strategy to create a way of income, reduce pollution and heat island effect in Khulna city.

6. References

Akram-Lodhi, A. H., 2011. World Food Security: A History since 1945. Canadian Journal of Development Studies, pp. 605-608.

Aubry, C. et al., 2012. Urban agriculture and land use in cities: an approach with the multi-functionality and sustainability concepts in the case of Antananarivo (Madagascar).. Land Use Policy, 29(2), pp. 429-439.

BBS, 2011. s.l.: Bangladesh Bureau of Statistics.

Begum, M. S., Bala, S. K., Islam, A. S. & Roy, D., 2021. Environmental and Social Dynamics of Urban Rooftop Agriculture (URTA) and Their Impacts on Microclimate Change. Sustainability, Volume 13.

Bianchini, F. & Hewage, K., 2012. Probabilistic social cost-benefit analysis for green roofs: A lifecycle approach. Building and Environment, Volume 58, pp. 152-162.

Bohn, K. & Viljoen, A., 2010. The Edible City: Envisioning the Continuous Productive Urban Landscape (CPUL). Field, Volume 4.

Brown, K. H. & Bailkey, M., 2002. Urban agriculture and community food security in the United States, s.l.: Urban Agriculture Committee of the Community Food Security Coalition.

Fraser, E. & Kenney, W. A., 2000. Cultural background and landscape history as factors affecting perceptions of the urban forest. Journal of Arboriculture, 26(2), pp. 106-113.

Girardet, H., 1999. Creating Sustainable Cities. s.l.:s.n.

Islam, K. M. S., 2004. Rooftop Gardening as a Strategy of Urban Agriculture for Food. s.l., Urban Horticulture.

Jafari, N. et al., 2015. Benefits of Roof Garden In Order to Usage of Urban Agriculture at Roof Garden in High-Rise Building in Malaysia. Advances in Environmental Biology, pp. 86-91 .

Kaplan, S., 1979. Perception and Landscape: Conceptions and Misconceptions. Nevada, National Conference on Applied Techniques for Analysis and Management of the Visual Resource .

Kosareo, L. & Ries, R., 2007. Comparative environmental life cycle assessment of green roofs. Building and Environment, 42(7), pp. 2606-2613.

Liu, K. K. Y., 2002. Energy efficiency and environmental benefits of rooftop gardens. Construction Canada, 44(2), pp. 20-23.

Orsini, F., Kahane, R., Nono-Womdim, R. & Gianquinto, G., 2013. Urban agriculture in the developing world: a review. p. 695–720.

Saldivar, L. & Krasny, M. E., 2004. Culturing Community Development, Neighborhood Open Space, and Civic Agriculture: The Case of Latino Community Gardens in New York City. Agriculture and Human Values, 21(4), pp. 399-412.

Tilman, D. et al., 2002. Agricultural sustainability and intensive production practices. Nature, Volume 418, p. 671–677.

Wakefield, S. et al., 2007. Growing urban health: Community gardening in South-East Toronto. Health Promotion International, 22(2), p. 92–101.

Research Paper

LIVELIHOODS AND CYCLIC MOVEMENT OF PEOPLE DURING THE MONSOON PERIOD AT PADMA RIVER CHAR: A CASE STUDY IN RAJSHAHI CITY

Md. Abu Sadath, Department of Urban & Regional Planning, Rajshahi University of Engineering & Tech
nology, Rajshahi-6204; Bangladesh
Rubayat Shariar Rupom, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh
Salma Jahan Prity, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh
FerdousFarhana Huq, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh
Muhaiminul Islam, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh

Abstract

Bangladesh's physical characteristics and monsoon environment make it highly vulnerable to natural disasters, mainly floods and erosion of river banks. As a result, the inhabitants of the char must migrate, and their settlements must be moved inside the char or outside the char from one location to another. The analysis is done on the basis of primary and secondary sources of data. The findings demonstrate the displacement interval in Char Khanpur every year. The cyclic displacement radius is 20 km, and the root causes of displacement are pulled, push, and cultural influences. An approach to adaptive protection is therefore required. The objective of this study is to contribute to the creation of a comprehensive adaptive plan for the sustainability of char-land settlement and livelihoods in the Ganges-Padma River basin in Bangladesh.

Keywords

Vulnerable, River banks, Migrate, Displacement, Comprehensive adaptive plan.

1. Introduction

Bangladesh is a country which is vulnerable to worldwide floods and river bank erosion and natural disasters (Lein, 2000). The country is located in the drainage basin Ganges-Brahmaputra-Meghna (GBM), covering an area of 1.76 million km2 and only 7.5 per cent in Bangladesh (Elahi, 1991). Bangladesh has 257 rivers and 59 of them are Transboundary Rivers that play an important role in flooding the deltaic floodplain (Adel, 2001). The Ganges-Padma is one of Bangladesh's potential rivers that created char-lands within the river channel (Baqee, 1998; Sarker and Thorne, 2006). During the monsoon (June-September) the excess water causes widespread flooding that destroys crops, infrastructure, char-land communities, communication networks and life (Baqee, 1998; Hofer, 1998). These frequent floods occurring in the char-lands are threats to human life, natural resources in terms of loss and damage resulting from the interactions between extreme geophysical events and precarious living conditions in the char-lands (Haque and Zaman, 1989; Hofer, 1998; Mafizuddin and Development, 1992). During the monsoon, the river inflow and rainfall lead to the annual flooding of large areas of the country. The major rivers are constantly changing courses in the active flood plains, resulting in both river bank erosion and accretion of new land (char) (Haque and Zaman, 1989; Islam and Rashid, 2011; Lein, 2000). It has been estimated that more than 12 million char people are affected by annual floods and erosion and battling monsoon floods and erosion and deprivation on the banks of the river (Baqee, 1997; Elahi, 1991; Schmuck-Widmann, 2001).

The cause of flooding in Bangladesh is due to monsoon rainfall in the GBM catchments; monsoon rain and runoff from heavy local rainfall melts snow and glacial ice in the Himalayas (Alexander, 1997; Islam, 1995; FAP, 1993). Until the 20th century, there are no comprehensive records of annual floods available including 1987 and 1988, 2002, 2004 and 2008. The latest flooded land area rose from 35% in 1974 to 71% in 2004 relative to the flooded land area in 1954 (Ahmed and Falk, 2008; Islam, 1995). The load of suspended sediments reached as high as 13 million tons per day during the flooding phase (Coleman, 1969). The newly formed bars and islands locally known as ' char or diara ' in the Bengali term are settled as new settlement frontiers by people from both banks and continue to be sources of perennial dispute between conflicting claimants (Baqee, 1993; Haque and Zaman, 1989; Schmuck-Widmann, 2001). Although erosion destroys ground, new lands periodically re-emerge from river beds in the middle of the river channels where they previously did not exist (Hutton and Haque, 2003). This is a fertile new land and a significant natural resource (Baqee, 1993). For its exceptional hydro-geological environment the char-land ecosystems are of great importance (Sarker and Thorne, 2006). The physical

characteristics of the geographic location, the morphology of the rivers and the monsoon climate make the char-lands very vulnerable to natural disasters (Baqee, 1998; Baqee, 1986; Coleman, 1969).

The Ganges-Padma River char-lands are experiencing dramatic changes in hydro-morphology due to natural and anthropogenic causes (Hofer, 1998). This is a meandering river which is highly affected by the river bank's erosion and accretion in the channel (Baqee, 1998; Baqee, 1993; Islam et al., 2010; Sarker and Thorne, 2006). Char Khanpur is a part of the active Ganges delta and is situated in the Ganges-Padma River main channel. Every year, the Char land is flooded and destroyed by monsoon rains, and consequently people need to evacuate their settlements and move from one location to another. Once new land appears in the river channel, the dwellers are displaced from the char, and return to the original char (Baqee, 1993; Elahi, 1991; Islam, 2010). The char-land is frequently subjected to flooding, massive erosion, landsliding of chars and drought. The char land lifestyle is a challenge and fragile (Lein, 2000). The char can only be reached by country boat, so people need to cross the channel to get the big hat (bazar) in the mainland. Agriculture and farming their own land are the primary sources of livelihoods in Char Khanpur. Most of the char residents are active in crop sharecropping, agricultural labors, running boats and fishing (Azim Uddin and Basak, 2012; Haque and Zaman, 1989). Char-land erosion, char livelihoods, and the cyclic displacement of people at Khanpur char are subject to flooding and char erosion. Nonetheless, in most cases, on the basis of data obtained, researchers have expressed different views on the char-lands ' social demographic and physical problems (Rahman and Siddik, 2018). The Geographers, however, gathered data and analyzed these on river basin socio-demographic and physical problems. Thus, the char-lands issues are not solved due to a lack of proper work in these fields.

2. Material and Methods

Based on primary and secondary data sources, the analysis was performed. Primary data on char-land degradation, settlement relocation, displacement of inhabitants, char subsistence data were gathered from Char Khanpur local people through PRA practices and informal interviews. The secondary data were collected from different journals, websites, and bulletins. In 2020, households covering the pattern of land ownership, tenancy, agricultural cropping system and labeling of crops, occupation, demographic characteristics, literacy etc. were collected. During data collection time in char-land, interdisciplinary approaches

were used. The secondary data inputs were obtained from various publications in Dhaka by government agencies, NGO reports and research organizations such as the Bangladesh Institute of Development Studies (BIDS), the Center for Integrated Rural Development for Asia and the Pacific (ClRDAP). To develop char-land use maps, erosion trends, settlement relocation patterns and cyclical displacement of people in the case of char-land, an integrated practice of the PRA (Participatory Rural Appraisal) method was used. After collecting all the data from different sources, data were organized in SPSS and maps were digitize using AutoCAD software. Finally, considering all the data and suggestions from the inhabitants, the research was concluded with some effective recommendations about the up-gradation of the livelihood of char Khanpur peoples.

3. Result and Discussion

This segment briefly addresses char peoples 'Demographic characteristics of char people, Agricultural Information, Facilities, and Expectations of the Char people's information.

3.1. Demographic characteristics of char people (before moving)

3.1.1. Formation of char

Char Khanpur is located on the India-Bangladesh border. It is not so a large populated place in Rajshahi city. Khanpur is located right next to the river Padma under Harian union of Paba upazila. Approximately 300 settlements are found here. The char was formed in 1947 and the present char people have inherited here since then. Gradually developments are found here likely mosques, tube-well, school-madrasa. This is how they build their settlements in Char.

Table 1 Timeline

Year	Event
1947	The char was formed.
1953	A mosque was placed.
1960	The whole char was submerged.
1965	A tube well was installed.
1971	Some of the freedom fighters came here and took their shelter.
1977	A primary school was established.
1982	The second mosque was placed.

1991	The second tube well was installed.
1996	Floods occurs and half of the char was wasted.
2001	The irrigation pump was installed.
2009	The third tube well was installed.
2011	Establishment of first school.
2012	The third mosque and a madrasa were established.
2014	The fourth tube well was installed.
2016	A secondary school established by Prothom Alo office.
2017	Solar system was installed in schools and few houses.

From **Table no 1** it is clear that, in 1947, the char was first formed. Gradually, people started coming there. In 1953, the first mosque was established. But in the catastrophic floods of 1960, the char land plunges under water. The most important event of the Char land was that, some freedom fighters took shelter in the great liberation war of 1971. After liberation war, gradually the Char land became full of population. In 2011, the first primary school was established in the Char land. In 2016, a secondary school was also established by 'Prothom Alo' organization. At present, the population of the Char land is 1000 and the shape of the char is gradually becoming smaller due to the river erosion.

3.1.2. Age & gender

A review of Char Khanpur's social image shows that most of the people there were middle-aged. Their age range was between 20 to 35 years. Almost half of population were female and rest were male. In char Khanpur, a small number of teenagers and old people were there

3.1.3. Educational institutions

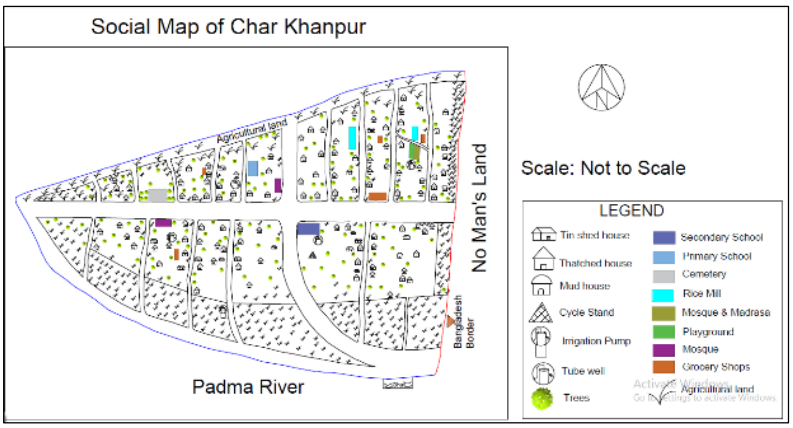


Figure 1 Social map of Char Khanpur

From the social map of Char Khanpur (**Figure 1)** it was found that, there exists only 1 primary school, 1 secondary school and 1 madrasa. Most of the people of Khanpur were illiterate. Only a few number had some bookish knowledge. Both the schools and madrasa were katcha and they were made with tin.

3.1.4. Occupational status

From social map of Char Khanpur shows that, Char Khanpur was an agrarian society. Most of the surface of this char seemed to be packed with different kinds of agricultural crops. Besides, some small grocery shops were also situated here. People lived in this village doing agricultural works, boatman and also worked as a day labor.

3.1.5. Monthly income

The monthly income of this char people was not enough. The people are mostly engaged with agricultural works and raising livestock. Due to less income they have no savings and lead poor life.

Table 2 Trend Analysis

Time Period	Agriculture	Char Land	Income
1950			
1960			
1970			
1980			
1990			

2000			
2010			
2020			

From **Table no 2** it was found that, in the 1950s, the people of char land had a lot of income. But the floods of 1960 caused them considerable damage. Due to the floods, char land was completely submerged and severe damage to the crop. As a result, the inhabitants of the char land had to move from the char and their income was greatly reduced. Although their incomes were seen to improve somewhat during the 1980s and 1990s, but the standard of living of the people gradually declined due to river erosion, floods, natural disasters etc. Today, in this twentieth century, the people of char land are living a very sorrowful life. Their income has almost gone. Also during the monsoon, they have to relinquish the char land.

3.1.6. Housing condition

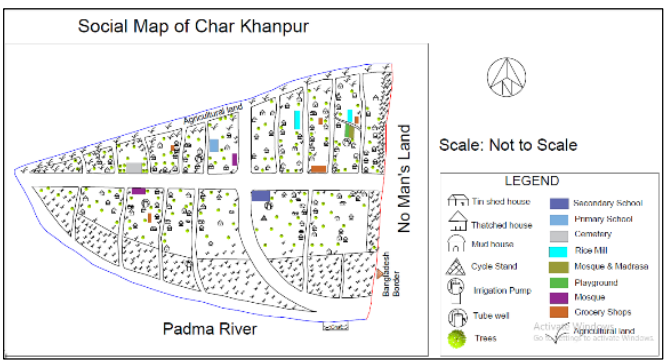


Figure 2 Social map

From **Figure no 2** it was found that, most of the houses of char land were built with tin or thatch**.** There were also some mud house due to the low economic condition of the people. Since the area was in the flooded region so, there had not been established any pucca settlements. Roads were also katcha and became muddy when it were half submerged.

3.2. Agricultural information

Agricultural crops

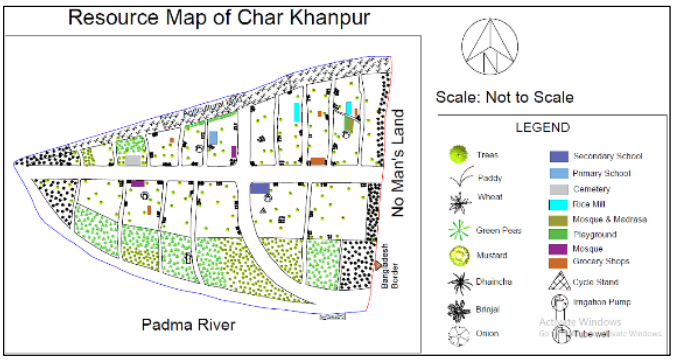


Figure 3 Resource map

Figure 3 demonstrate that, In Char Khanpur, people produce all types of agricultural crops. Among them paddy, wheat, green peas and onions are the main agricultural products. In dry season people produce brinjal, cucumber, paddy, wheat etc. In winter season they produce green peas, mustard, tomato, dhaincha etc. Besides, people nurturing domestic animals there. Among these domestic animals, cows and goats are main. But during the monsoon, everything sinks, so people's income stops. At this time they need to sell their livestock for earning their livelihood. The farming rate specially oxen increase before 3 months due to Eid-Ul-Azha. From **Figure no 4** it shows that, people of Khanpur produce Naksi katha, Shitol pati. These products are especially done by the rural women. During rainy season the elements for making shitol pati grow well. So, in the month of July and August, when people move to the flood shelter they prepare more shitol pati and nakshi katha for earning much money. People generally use boat as their transport medium to travel from char to Rajshahi city as there is no other transport mode. In rainy season, as the whole area become flooded and people need to move from the char so this two month July and August become the most sorrowful month in their life.

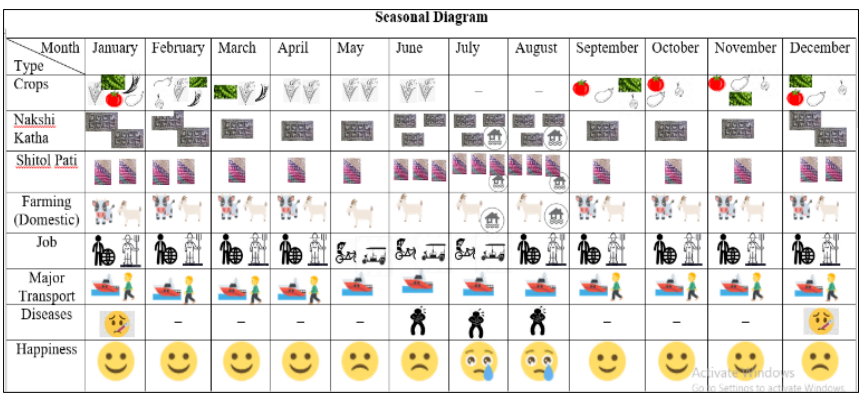


Figure 4 Seasonal diagram

3.2.1. Agricultural market & flood shelter

It was found that, people of Char Khanpur, earned their livelihood by producing agricultural crops and selling them to the local market of Rajshahi city. To sell their agricultural products they need to cross the Padma river. The first choice for selling their agricultural products was Shaheb bazar, Rajshahi. Almost half of the people were selling their agricultural products to Shaheb bazar. Rest were selling their products at Kazla bazar, Talaimari bazar and Katakhali bazar. To sell the agricultural products, they used boat and van to carry their goods. From the mobility map it shows that, at first they used boat to cross the river and after that they used van to reach their destination. From this map it is also clear that, Shaheb bazar was the most important place for them to sell their agricultural goods and after that Talaimari bazar was also prominent here.

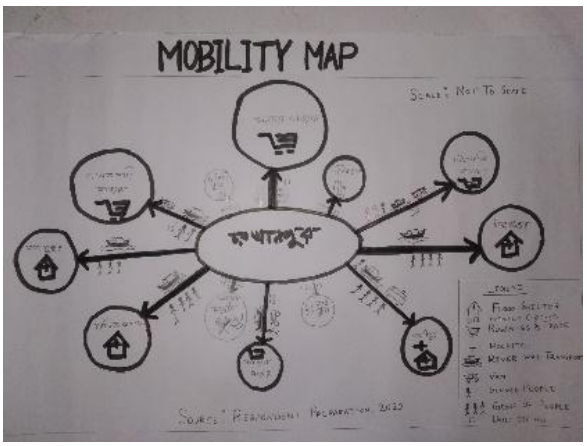


Figure 5 Mobility map

From **Figure 5** it also founds that, during flood time most of the people took shelter to the Radio center. Besides, Daspukur, Thakurpukur and Laxmipur was also used as flood shelter place for the people of Khanpur Char. People came to these flood shelters in groups. These shelters are approximately 20 km away from their char land. For entering these place they used boats as their main transport medium. And to carry the goods for selling, they used van as a transport medium.

3.3. Facilities

3.3.1. Utility services

It is very important to provide utility services to survive in a community. Because the quality of life of the people of a community is controlled depending on the utility sevices. In this char there is no enough facilities. There is no electricity system, less communication system, less educational facilities, less pure drinking tube-well and so on.

Table 3 Pair Wise Ranking

Problem	1. Lack of Electricity	2. Lack of River Embankment	3. Lack of Employment	4. Lack of Communication System	5. Lack of Health Facilities	6. Lack of Education System	7. Lack of Pure Drinking Water	8. Lack of Flood Shelters	Number	Ranking
1. Lack of Electricity	_	2	1	1	5	1	1	8	4	4
2. Lack of River Embankment	_	_	2	2	2	2	2	2	7	1
3. Lack of Employment	_	_	_	3	5	3	3	8	3	5
4. Lack of Communication System	_	_	_	_	5	4	7	8	2	6
5. Lack of Health Facilities	_	_	_	_	_	5	5	8	5	3
6. Lack of Education System	_	_	_	_	_	_	6	8	1	8
7. Lack of Pure Drinking Water	_	_	_	_	_	_	_	8	1	7
8. Lack of Flood Shelters	_	_	_	_	_	_	_	_	6	2

Table 3 it shows that, people of Char Khanpur were deprived from many facilities. Since the area was separated by Padma river from Rajshahi city, it was not possible to reach electricity there. From pair wise ranking it shows that, Lack of river embankment was a major problem here. Due to the river erosion, the shape of the char was gradually becoming smaller. So, it was the main problem for the char land people. After that, lack of flood shelter was also a main problem for the people of Khanpur char. There was no flood shelter in Char Khanpur. So, during monsoon, people need to move from the char which brings very negative impact on their life and economy. Also lack of health facilities, lack of communication system, lack of pure drinking water and lack of flood shelter were another problem there.

3.3.2. Institutions

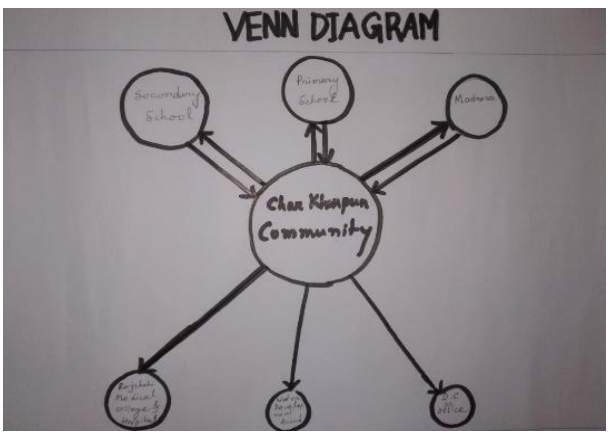


Figure 6 Venn diagram

There are some institution, which were directly involved in the lives of the Char people. Of these, some organizations were improving their standard of living on

the other hand, some organizations were bringing disappointment into their lives. **Figure no 6** shows that, there were 1 primary school, 1 secondary school and 1 madrasa in Char Khanpur. All of these institutions were tries to show them the light of education. So, these 3 institutions were very important in their life. There were no health care facilities in Char Khanpur. So if any people was getting sick, he had to be taken to the Rajshahi Medical college Hospital. Due to the lack of river embankment, the whole Char land became submerged during monsoon. People went to the water development board, hoping to put a dam in the river, but no hope could be found from the water development board. Similarly, they had to come back with frustration when they went to the Deputy Commissioner to get the ration. So, these 2 organizations were less important to their life.

3.3.3. Existing problem

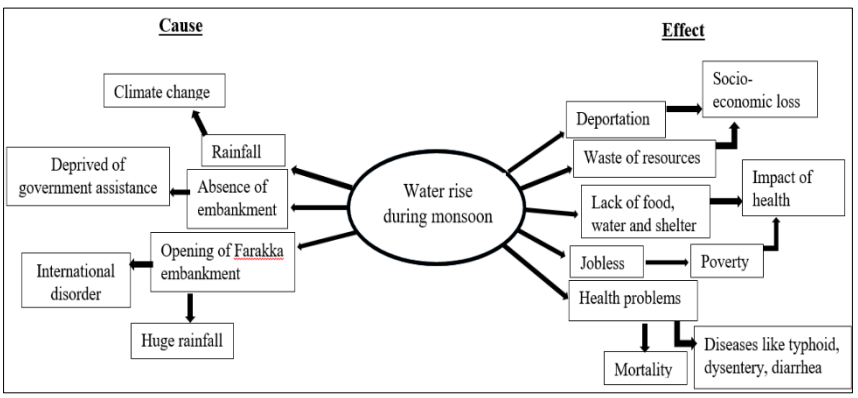


Figure 7 Cause Effect diagram

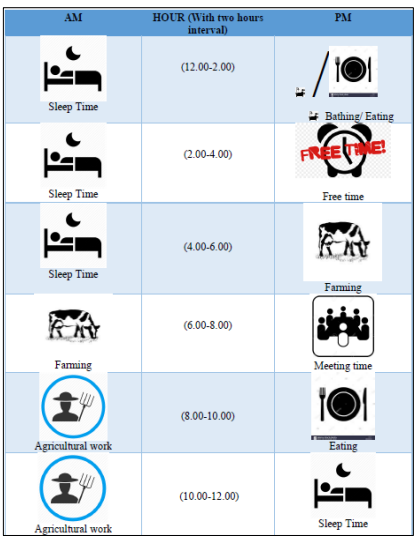
There were some problems which were found in Char Khanpur (shows in **Figure no 7**). Among these problems, water rising during monsoon period was the main problem there. To find out the reason behind water rising there came some point. Among them absence of embankment, rainfall, opening of Farakka embankment were main causes of water rising. Since, Bangladesh is a country of six seasons, it is rained here because of climate change. Lack of government support can be attributed to the absence of dams along the river. In addition, due to lack of International cooperation, the area became submerged due to the opening of the Farakka Dam by India. Now, if there focus on the effects, it seems that, due to the increase of water, Char land was severely damaged, all the resources was being wasted, people became jobless and they suffer from various types of health disease.

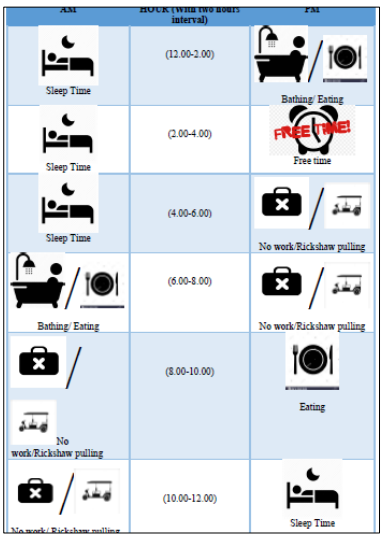
3.4. Demographic Information (after moving)

3.4.1. Occupational status

People of Char Khanpur moved from their place during rainy season and took shelter to the various portion of Rajshahi city.

Table 4 Daily Activity Schedule (Before & After migration)





From daily activity schedule it found that, before migration when people did agricultural works but during that time most of the people become jobless (**Table no 4).** They had no work to do and they passed the day without doing anything. Some people also ride auto rickshaw at that time but that was not permanent. When they moved from the Char, they need to sell their cattle. After selling the cattle, the money what they got from their customer, they lead their livelihood with it. Basically July and August, this 2 months were the time period when people needed to move from their Char land and took shelter to the flood shelters.

3.4.2. Season of unemployment

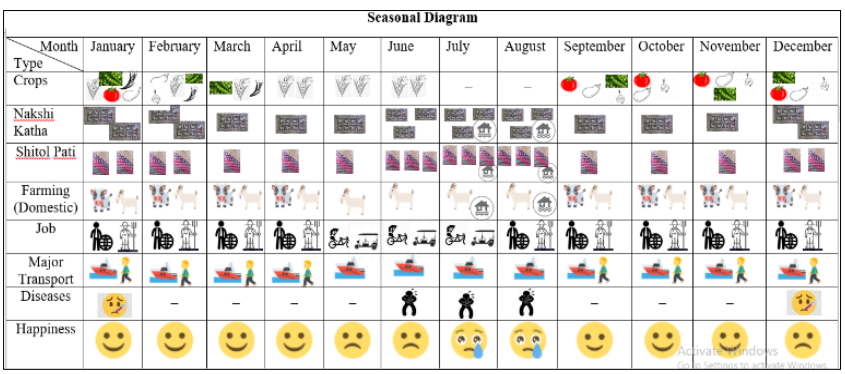


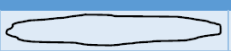
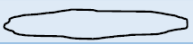
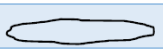
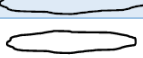
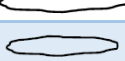
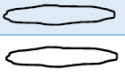
Figure 8 Seasonal diagram

From **Figure 8** it was found that, July and August were the month when people became jobless. These two months were the rainy season when the whole area became submerged. So, all their agricultural land, residential land everything became submerged under water. In these 2 months people took shelter to the various place of Rajshahi city and these 2 months were the most sorrowful months of their life.

3.4.3. Income satisfaction level

The people of char Khanpur move from their residence in rainy season every year. They take shelter in various portion of Rajshahi city and seek job for their livelihood. Most of them engage with pulling Rickshaw or van or auto bike temporarily. The money they earned is very little to maintain their family. As a result, most of the people are become so disappointed with their income after moving char.

Table 5 Trend Analysis

Time Period	Agriculture	Char Land	Income
1950			
1960			
1970			
1980			
1990			
2000			
2010			
2020			

From **Table no 5** it seems that, day by day people's income gradually decreasing. In the past period, the area of the char land was much big. But due to the lack of river embankment, the char land gradually became smaller. The available land for cultivation also became smaller. So, people got less opportunity to cultivate and their income became also low.

3.5. Expectations of the char people

3.5.1. Expectation from government

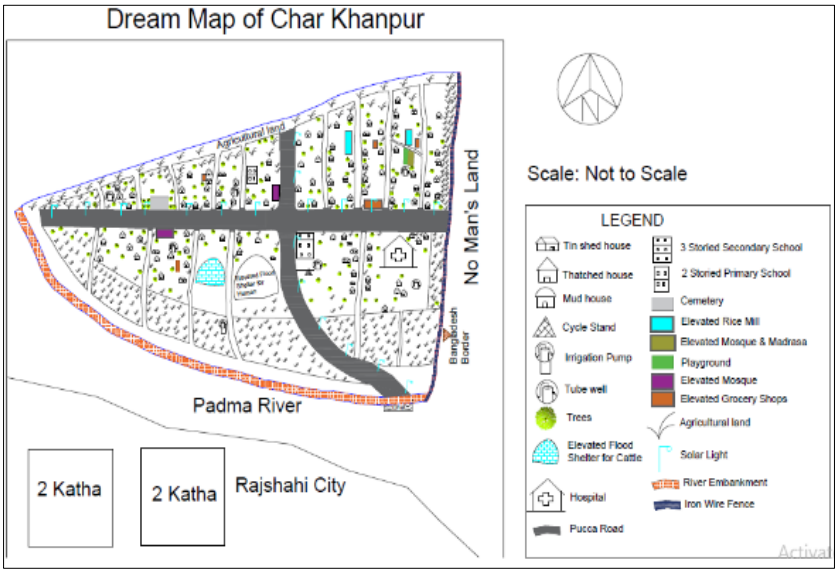


Figure 9 Dream map

People of Char Khanpur were deprived from many facilities. There was no one to look at their suffering. They didn't even get any help from the government. There was no shelter, no health care facilities and no electricity. Yet the people there were dreaming of living, dreaming and hoping to get support from the government. In this dream map (**Figure no 9)**, all their hopes had been raised. Due to the lack of dams in the river, all their hopes and desires were broken. So a dam on the southern side of the river had been proposed by this map. Besides, during floods people had to leave the Char due to the lack of shelter in the area. So the people of Char land wanted an elevated shelter where people and livestock could take shelter during floods. As the road they used was katcha, it became inappropriate for monsoon use. So, they had demanded from the government to construct the road. In addition to this, all the demands of fixing the school, installing solar lamps on the side of the road etc. had emerged through this Dream map. Fulfilling these dreams would change their lives. After all, their quality of life would improve.

4. Conclusion

Since Bangladesh is vulnerable to worldwide floods, riverbank erosion and natural disasters, the people along the riverbank area are at risk during the monsoon period. Every year when flood occurs, the Char land is flooded and destroyed by monsoon rains and consequently people need to evacuate their settlements and move from one place to another. Riverbank erosion remains as a continuous threat to the riparian inhabitants. As a result, a large number of people

is displaced due to erosion. They loss their land and migrate to another place to make new settlements. These environmental refugees become vulnerable as a whole in every sense. This study has been undertaken to assess the existing livelihood pattern of the char dwellers of the study area and analyze the movement of char people during the monsoon period. The result clearly shows that most of the char dwellers are either poor or hardcore poor. Most of the cases, they live from hand to mouth after movement. Overall, the status of the livelihood is not satisfactory so before deteriorating situation to beyond control, it is high time to take necessary actions to stop forceful displacement and livelihood management of the victims. This study suggests to ensure education facilities, increase some generating options, ensure medical treatment, improve structural development like embankment, road network and electricity supply in order to improving the livelihood status of the char dwellers of the study area. So, this type of proper steps should be taken, Government has to pay attention as well as the local authorities should be more functional to make such improvements.

Acknowledgement

We would like to thank MD. Abul Kashem, senior citizen of Char Khanpur, who assisted us in conducting the survey. Finally, we want to express our gratitude to the anonymous reviewers for their constructive comments for the improvement of the paper.

5. References

Adel, Miah M (2001) "Effect on water resources from upstream water diversion in the Ganges basin", Journal of Environmental Quality, 30**,** 356-368.

Ahmed, Raquib Falk, Gregor C (2008) "Bangladesh: environment under pressure", Journal of Geographische Rundschau, 4**,** 12-18.

Alexander, David (1997) "The study of natural disasters, 1977–97: Some reflections on a changing field of knowledge", Journal of Disasters, 21**,** 284-304.

Azim Uddin, Afm Basak, Jk 2012. Effects of Riverbank Erosion on Livelihood. Unnayan.

Baqee, Abdul (1998) "Peopling in the land of Allah Jaane. Power, peopling and environment: the case of char-lands of Bangladesh", University Press Limited, Dhaka, Bangladesh**,** 1-87.

Baqee, Ma (1986) "Violence and agricultural seasonality in char-lands of Bangladesh", Journal of Asia Pacific Journal of Development, 29**,** 25-36.

Baqee, Ma (1993). The settlement process in the char-lands. Dissertation for the Doctoral Degree (unpublished). Department of Geography.

Baqee, Ma (1997) "Coping with floods and erosion in Bangladesh char-lands", Asia Pacific Journal of Development, 4**,** 38-52.

Coleman, James M (1969) "Brahmaputra River: channel processes and sedimentation", Journal of Sedimentary geology, 3**,** 129-239.

Elahi, Km (1991) "Riverbank erosion, flood hazards and population displacement in Bangladesh", Impact Study Project. Jahangirnagar University, Savar, Dhaka.

Fap (1993) Flood Action Plan, The dynamic physical and human environment of riverine char-lands: Meghna, Dhaka: Floods plan coordination organization, MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL, DHAKA.

Haque, C Emdad Zaman, Muhammad Q (1989) "Coping with riverbank erosion hazard and displacement in Bangladesh: Survival strategies and adjustments", Journal of Disasters, 13**,** 300-314.

Hofer, Thomas (1998) "Floods in Bangladesh: a highland-lowland interaction?".

Hutton, David Haque, C Emdad (2003) "Patterns of coping and adaptation among erosion-induced displacees in Bangladesh: implications for hazard analysis and mitigation", Journal of Natural Hazards, 29**,** 405-421.

Islam, M Aminul (1995) Environment, Land Use, and Natural Hazards in Bangladesh, University of Dhaka.

Islam, Md Fakrul Rashid, Anm Baslur (2011) "Riverbank erosion displacees in Bangladesh: need for institutional response and policy intervention", Bangladesh Journal of Bioethics, 2**,** 4-19.

Islam, Shafi Noor (2010) "Char-lands erosion, livelihoods and cyclic displacement of people in Ganges-Padma River Basin in Bangladesh", Journal of Asia-Pacific Journal of Rural Development, 20**,** 151-174.

Islam, Shafi Noor; Singh, Shilpa; Shaheed, Hasibush Wei, Shouke (2010) "Settlement relocations in the char-lands of Padma River basin in Ganges delta, Bangladesh", Journal of Frontiers of Earth Science in China, 4**,** 393-402.

Lein, Haakon (2000) "Hazards and'forced'migration in Bangladesh", Norsk Geografisk Tidsskrift, 54**,** 122-127.

Mafizuddin, Mirza %J Elahi Km, Sharif Ahm R, Kalam Akam Eds. Bangladesh Geography, Environment Development, Bangladesh National Geographical Association, Jahangirnagar University, Momin Offset Press, Dhaka (1992) "The physiography of Bangladesh: An overview"**,** 20-25.

Rahman, Ma Siddik, Ma (2018) "Livelihood Analysis of the Char Dwellers Using Capital Asset Framework", Journal of Journal of Environmental Science Natural Resources, 11**,** 27-36.

Sarker, Maminul Haque Thorne, Colin R (2006) "Morphological response of the Brahmaputra–Padma–Lower Meghna river system to the Assam earthquake of 1950", Braided rivers: process, deposits, ecology management, 21**,** 289-310.

Schmuck-Widmann, Hanna (2001) Facing the Jamuna River: Indigenous and engineering knowledge in Bangladesh, Bangladesh Resource Centre for Indigenous Knowledge.

Research Paper

Application of Electricity Generating Paving Slabs in Dhaka City: A Sustainable Pathway to Smart City

Umme Nabila Samanta
Department of Geography and Environment, University of Dhaka
Bangladesh

Abstract

Since smart technologies have emerged, urban and regional planning is expected to go through major transformations. The technologies have been predicted to significantly modify the existing developing strategies and can lead to sustainable solutions such as the application of electricity-generating paving slabs. Though the paving slabs can generate a small amount of energy, it has the potential to mitigate the electricity shortage in Dhaka City. The electricity-generating paving slabs allow people to take footsteps, which in return offer generation of electricity for their community. In the last few years, many countries around the world have adopted technology for making their cities smarter. The one company that has made the footsteps into 'green' energy is Pavegen System. The paper presents the application of Pavegen electricity-generating paving slabs in Dhaka city, the sustainable pathway of making Dhaka the smartest urban territory. The author of the paper has described the strategic application of the innovative technology in Dhaka city for instant energy generation. The latest invention engages people of a community to generate clean electricity for a sustainable world.

Keywords

Green energy; electricity generating paving slabs; sustainable city planning; pedestrians flow; Dhaka City

Introduction

1.1. What is Electricity generating paving slabs?

In the present era of pollution, we search for ways to ensure development which produces less pollutants and alternative sustainable low-power renewable sources of electricity that does not harm the environment. There are many options to achieve the purpose, one of them is the Electricity generating paving slabs. One particular type of paving slabs made with metal which can gather the

pressure from footsteps and process it within a short time, convert the energy into 'green' energy in the form of electricity. Instead of going to its inside mechanism, you can only talk about the hardware used by the paving slabs. The electricity generating paving slabs include several power-generating units or several electric motors in a single electric machine unit that generate electricity. (Patlins et al. 2019)

1.2. What is a Smart City?

A city which is advanced in information and communication technology and improves the citizen's life. Being a smart city is the dream of every city region and its people. The ultimate goal of smart cities is upgrading people's life and behavior through smart inventions and data analysis. [12]

1.3. Objective

The prime concern of the paper is to overview the application of electricity generating paving slabs by Pavegen System in Dhaka city that can mitigate the electricity shortage to some extent and make Dhaka a smart city.

Application of Electricity Generating Paving Slabs in Dhaka City

The paving slabs mentioned here are from a foreign company Pavegen System. The main objective of the paper is to show how effective the Pavegen electricity generating paving slabs are in the context of Bangladesh.

2.1. Electricity Generating Paving Slabs from Pavegen System:

2.1.1. Pavegen System, Company:

The London based company; Pavegen Systems is manufacturing a paving slabs technology that is able to generate electricity from processing the pressure from footsteps. These slabs are designed to convert the received energy into small amounts of electric power that can be used instantly or stored for further use. Through the procedure, Pavegen and the countries where the technology is applied, are able to harvest the unused and extra useful energy of the footsteps. In this way, greater sustainability can be achieved that results in reversing climate change. Moreover, pressure will be lessened on the non-renewable resources of a country. Pavegen literally means 'The Next Step' in utilizing the collective force of many. Pavegen has successfully implemented over 150 projects in 30 countries since its beginning in 2009, with global brands including Coca-Cola, Lexus, Adidas, ShellSchneider Electric, and Westfield. (Arnoud, 2017)

2.1.2. How they generate energy

"Pavegen floor tiles consist of three components: an electromagnetic generator, a composite tile, and people." [4]

The Pavegen system uses multifunctional custom flooring. Mainly, their tiles or paving slabs are electro-magnetic. When people deliver pressure from footsteps, the weight causes electric-magnetic induction generators to vertically relocate. This causes a rotatory motion that creates off-grid electricity. In addition, there is a wireless API (Application Programming Interface) with each tile. API helps communicating real-time movement data analytics at the same time providing power when and where it is required. Moreover, Pavegen creates connectivity to a variety of mobile devices as well as surrounding building management systems.

2.1.3. How much energy can be generated

Each Pavegen tile can produce minimum 3 joules (1W = 1 J/s) to maximum 5 watts of energy when someone walks over. This power can be easily utilized in environmental sensors, LED lighting and screens and for storage in batteries. Pavegen tiles connect to the people of a community through their footsteps and generate 2-5 joules of electricity. [4] Laurence Kemball-Cook, the CEO of Pavegen System once said in an interview, "Ten slabs around a streetlight would power it all night long from the energy generated during the day. You can get 20 or 30 seconds of light from a small light fitting from one footstep. We are working on much bigger systems right now. Imagine covering Trafalgar Square with these slabs and harnessing all the electricity from the thousands of people who walk across it every day." (Lovell, 2011). In addition, the slabs can store the energy generating all day, upto 3 days in an on-board battery. (Webster, 2011)

2.1.4. How does it connect the community and people

Pavegen tiles work with the community, within the community and for the community of a county. The people feel the joy of contributing to the electricity generation for them and the near future. Instantly, the clean-electricity generated by the tiles are shown on the data screens and display monitor beside the tiles path and showcase how much energy is generated with each step. Also, Pavegen's kinetic systems deliver a sense of ownership among the citizens by putting the smart city at their feet. The exciting lighting, wayfinding, gamification displays, and more. Are encouraging people to engage leaving more footsteps on the paving slabs. [4] The display installations provide data analytics on how much energy is being generated and when. With the help of Low-Power Bluetooth beacons, Pavegen also communicates with users' smartphones. They constantly provide rich customer analytics data via a permission-based rewards system by self owned mobile application 'Pavegen GO'.

Pavegen Go:

Pavegen System adds a mobile application to their service to provide a relationship between the community and its people. The app helps a society to understand citizens' values and beliefs as well as their behaviour. Pavegen GO allows the owner of the tiles (local authorities, building owners) to share ideas and values that will help to build better and more connected cities. The app also provides interesting reward points on the basis of each citizen's contribution. The Pavegen's digital offering gives these rewards to citizens for maintaining meaningful relationships with them.

2.1.5. Application of Pavegen tiles

2.1.5.1. Case Studies:

Smart City Development, Bangalore

In 2018, Pavegen System successfully installed the electricity generating paving slabs on Intel India's newly opened design house 'SRR4'. A walkway at the entrance of the building. Each time their employees steps on the walkway, off grid clean electricity will be generated. The walkway of 7.7 sq metres can produce up to 4 joules of energy or up to 7 watts of continuous footstep of the employees. At the entrance of the building, there is a bright LED lighting display, which is powered by- the electricity generated from the paving slabs. An Intel India official said in an interview, "The energy produced will be displayed on an intuitive dashboard with responsive graphics that create an interactive experience to users and customers." The main fact is, the paving slabs contribute to the total reduction of CO2 emissions by 37% of the building. [6]

Dupont Circle, Washington DC, USA

Pavegen helped to convert a concrete crossing zone into a modern park with sustainability. The park is situated.by the White House, Washington DC. [4] Patrick Davies, the deputy British ambassador, said, "Imagine this on a large scale, in cities with millions of people walking over it every day. Whatever your views, it's generating power for low cost, and it's completely renewable because people are going to walk along here all the time. So what's not to like?"

The project added 194 kinetic pavers which cost About $100,000. The city usually spends almost the same amount for developing underground and other site work to support the high-tech system. [7] The District Department of Transportation estimated that about 1,000 people will use the way home across these grey Pavegen triangles during the evening rush. The ground below them which are now electricity generating paving slabs- will turn their foot movement into usable power. Little of that power will be seen instantly. But the majority of the charge will get stored in batteries, and then will be used at night. The lights will be used to keep the lights at the circle of the park. As the system is entirely off the grid, if there is not enough pedestrian movement during the day, the lights at the park might be a little dimmer than on a busy day at night. [8]

2.2. Application of Pavegen Tiles in Dhaka City

2.2.1. Energy Access in Dhaka City:

The ratio of access to electricity of people in Bangladesh has gone up to 59.6% in 2012, and almost 76% by 2016. According to IEA's 2008 estimates, around 1.5 billion people have no access to electricity, which is 20% of the total population. 52% of the total population who are living in Dhaka city have partial electricity access. On the other hand, only 10-15% of the rural population have electricity access. [15] Therefore, the electricity from footsteps will have a revolutionary impact on the overall image of Bangladesh in front of the world.

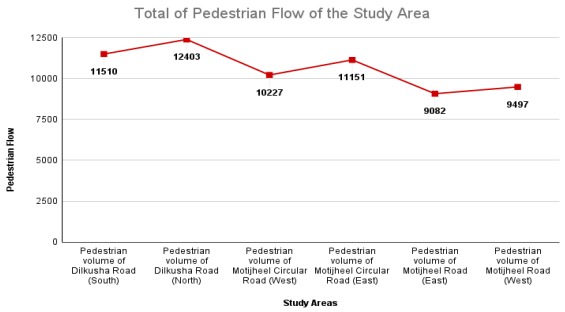
2.2.2. Study Area:

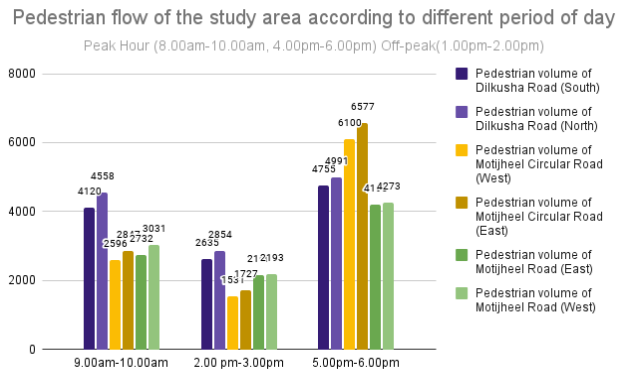
From a research by Rahman & Noman, 2018 on the pedestrian flow of Motijheel, a picture of approximate footsteps on a single day can be drawn. Motijheel (46 sq.km) is an administrative division of Dhaka city, the capital of Bangladesh. Being the Central Business District (CBD) of Dhaka city, the largest number of corporate headquarters of the country are concentrated here. Motijheel is a perfect place for working with modern footway design and safety of pedestrian facilities. All classes of people use the footway to reach their desired places. Therefore, more footsteps than any other areas of Dhaka city are concentrated in this particular area. For this reason, Motijheel has been chosen for estimating the effectiveness of the Pavegen paving slabs. The study area of this research is Dilkusha Road, Motijheel circular road and at the South side of Shapla Chattar (Motijheel road).

2.2.3. Pedestrian movement in Motijheel

The major three roads of the study area are Motijheel circular road, Dilkusha road and Motijheel road. The footpath or footways are a width of gradually 3.5 meter, 3 meter and 2 meter each of the side. Through the survey it has been observed that the majority of the pedestrian ways are made with concrete. Pedestrian volume flow has been counted three times a day- 9:00 am to 10:00

am and 5:00 pm to 6:00 pm are the peak hour and 2:00 pm to 3:00 pm as an off peak hour.





2.2.4. Amount of Power Generated

Kemball-Cook once said he took the pavers to an outdoor festival where 250,000 footsteps created enough juice to charge 10,000 cell phones (Peters, 2011). According to Lawrence Berkeley National Laboratory (Standby Power, 2011), each cell phone needs about 3.68W per hour and 2 hours is needed to be fully charged. The energy generated by each footstep is calculated according to the statement,

$$10000*2*3.68Wh = 73.6kWh$$

Energy per footstep = 73.6kWh / 250000 footsteps = 0.294Wh per footstep on average

If the total pedestrian flow of the study areas are accumulated, there will be a huge amount of foot-traffic.

Table: Daily, Monthly and Annual Electricity Generation by Pedestrian Flow in the Motijheel Area

Area	Total flow of Pedestrian	Generated energy (Wh) by Pavegen in a single day (each passerby will step on at least two tiles) (1 Wh= 3600 joules)	Generated energy (Wh) by Pavegen in a month (5 days a week, 4 weeks a month)	Generated energy (Wh) by Pavegen annually
Pedestrian volume of Dilkusha Road (South)	11510	3372.43	67448.6	809383.2
Pedestrian volume of Dilkusha Road (North)	12403	3634.079	72681.58	872178.96
Pedestrian volume of Motijheel Circular Road (West)	10227	2996.511	59930.22	719162.64
Pedestrian volume of Motijheel Circular Road (East)	11151	3267.243	65344.86	784138.32
Pedestrian volume of	9082	2661.026	53220.52	638646.24

Motijheel Road (East)				
Pedestrian volume of Motijheel Road (West)	9497	2782.621	55652.42	667829.04
Total		18713.91	374278.2	4491338.4

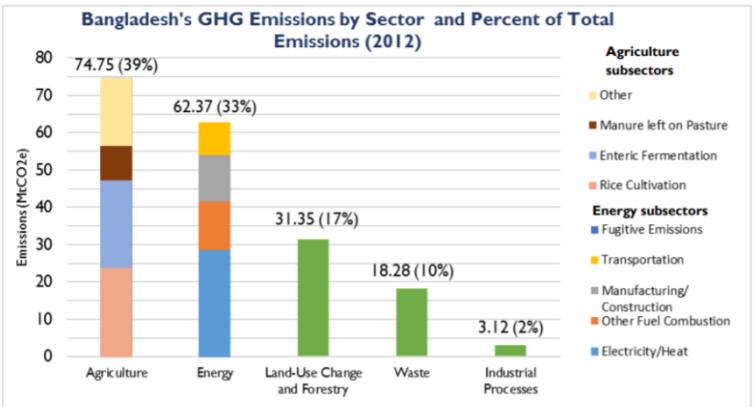
2.2.5. How this energy can be used

The huge amount of power can easily fulfill the necessity of daily minimum electricity for a family. Also, people can generate electricity for the street lights at night time only by their footsteps.

LED lights	Ceiling Fans	Street Lights
A LED light requires 60 watts on average Total number of LED lights= 18713.91/60= 312 Total number of LED lights= 18713.91/100= 188	A ceiling fan requires 88 watts on average Total number of Ceiling fans= 18713.91/88= 213	A Street light requires 80 watts on average Total number of Street lights= 18713.91/80= 234

2.2.6. Impact on Environment

Reducing GreenHouse gas: Electricity generating process contributes about 28-29% to the total 62.37% emission of GHG gasses in Bangladesh. By using our footsteps of green energy, the amount will be easy to lessen within a few years. Therefore, the electricity generating paving slabs can replace the traditional way of power generation.



Diminishing Car tyre waste:

Car tyres are the most problematic source of waste among all the pollutants in the world. Bangladesh is contributing the majority of scrap car tyres in the world's total wasted car types; the amount is around 1.0 billion. Bangladesh alone is responsible for 150,000 tons. These tyres are mainly used in brickfields, road construction and many industrial purposes. When the smoke from these burning tyres pass into the human body through the respiratory system, the small particles stay inside the lungs and generate different diseases. They also damage crops and trees. (Chowdhury, 2017)

The top surface of the Pavegen tile is made up of 100% recycled car tires. [4]. Though, generally the piezoelectric material used in these types of applications, in the construction of the Pavegen the material has not been used at all. PZT is one of the hazardous materials because of lead (Cramm et al., 1970). Thus, Pavegen tiles will not contribute to environmental pollution, on the other hand, reduce the detrimental wastes.

2.2.7. Social Impact:

When people receive rewards in the Pavegen Go application, this encourages them to involve more to the project. Also, they can use the rewards into different fields. The Bangladeshi Government, can avail various facilities for the people who are getting highest reward points. Therefore, an interactive relationship will happen between the people and the Government as well as with the society.

Conclusion

After investigating economic, environmental and social impacts of implementing the electricity generating paving slabs, it can be concluded that Dhaka city will be a modern city which can provide electricity to almost each house of low-income people.

• Over the 5 year lifespan of the Pavegen tiles, the CO2 emissions will be reduced in a great extent,

• The paving tiles are recyclable, so there will be not e-waste,

• Based on many sources and investigation,, the new electricity generating paving tiles will promote involvement, and responsibility of the community people.

• The slabs will be a beneficial project for both the country and specially its citizens. In conclusion, Dhaka will be recognized as a smart city from now.

References

1. Patlins, A., Hnatov, A., Arhun, S., & Dzyubenko, O. (2019). "Design and research of constructive features of paving slabs for power generation by pedestrians." Transportation Research Procedia, 40, 434–441. https://doi.org/10.1016/j.trpro.2019.07.063
2. Arnoud. (2017, April 14). Pavegen: Energy for cities through the power of footsteps. Smart City Hub. Retrieved October 15, 2021, from https://smartcityhub.com/energy/pavegen-energy-through-the-power-of-footsteps/.
3. Lovell, J. (2011, November 14). Paving slab generates electricity with footfalls. Scientific American. Retrieved October 15, 2021, from https://www.scientificamerican.com/article/paving-slab-generates-electricity-footfalls/.
4. Pavegen | Sustainability through the power of footsteps. (n.d.). Retrieved October 15, 2021, from https://pavegen.com/.
5. Webster, G. (2011, October 13). Green sidewalk makes electricity -- one footstep at a time. CNN. Retrieved October 15, 2021, from https://edition.cnn.com/2011/10/13/tech/innovation/pavegen-kinetic-pavements/index.html.
6. DH News Service. (2018, November 16). Intel's 'Walking Power Project' in Bengaluru. Deccan Herald. Retrieved October 15, 2021,

from https://www.deccanherald.com/business/intels-walking-power-project-703144.html.

7. Laris, M. (2016, November 30). This Dupont Circle sidewalk turns footsteps into power. The Washington Post. Retrieved October 15, 2021, from https://www.washingtonpost.com/local/trafficandcommuting/this-dupont-circle-sidewalk-turns-footsteps-into-power/2016/11/30/c69263f8-b020-11e6-8616-52b15787add0_story.html.
8. Brueck, H. (2016, November 18). In Washington, DC, people are using their feet to turn on the lights. Forbes. Retrieved October 15, 2021, from https://www.forbes.com/sites/hilarybrueck/2016/11/18/pavegen-energy-generating-sidewalk/?sh=a420f3578da8.
9. Rahman, M. M., & Noman, A. A. (2018). “Capacity Analysis of Pedestrian Facilities in Motijheel CBD Area: Problems and LoS Aspects,” 113–124.
10. Peters, D. E. (n.d.). Stepping Up to a Bright Idea - Marketing, News, and Educational Communications. Marketing, News, and Educational Communications. Retrieved November 24, 2011, from http://cahnrsnews.wsu.edu/2011/11/01/stepping-up-to-a-bright-idea/
11. Standby Power : Data. (n.d.). Standby Power. Retrieved November 24, 2011, from http://standby.lbl.gov/summary-table.html
12. What is a smart city? TWI. (n.d.). Retrieved October 15, 2021, from https://www.twi-global.com/technical-knowledge/faqs/what-is-a-smart-city.
13. Chowdhury, A. T. A. (2017, October 19). Turning waste tires into energy. The Financial Express. Retrieved October 15, 2021, from https://thefinancialexpress.com.bd/views/turning-waste-tires-into-energy.
14. Cramm, J., El-Sherif, A., Lee, J., & Loughlin, J. (1970, January 1). “Investigating the feasibility of implementing Pavegen energy : Harvesting piezoelectric floor tiles in the new sub.” Open Collections. Retrieved October 15, 2021, from https://open.library.ubc.ca/soa/cIRcle/collections/undergraduateresearch/18861/items/1.0108404.
15. Bangladesh Energy Situation. energypedia. (n.d.). Retrieved October 15, 2021, from https://energypedia.info/wiki/Bangladesh_Energy_Situation.

Research Paper

PEOPLE-CENTRIC PUBLIC SPACE THROUGH DOCUMENTING PUBLIC LIFE: A Case of Sheikh Kamal Soroni.

MARJUKA SALEH, Department of Urban & Regional Planning,
Jahangirnagar University; Bangladesh

Abstract

The character of a city is defined by its streets and public spaces. Dhaka has a few open spaces and day by day it is decreasing. In addition, existing open spaces are not working effectively. The street as a public space can solve the recreational needs of the people. In public space planning, design and structure always get serious attention, but public life and the interaction between life and space is completely neglected.

The study first represents an overview of public life and public space, and then tries to investigate the relationship between life and space to design a people friendly public space. It also aims to develop recommendations for redesigning public spaces that invite public life. Public life data is collected by intercept survey, people-moving map, activity mapping and public space data is collected by place-inventory survey, building-façade activation and level of connectivity.

It is evident from the study that people live in the space but they don't love it as existing design and plan ignore them. Public space is frequently used by a specific age-group: the middle aged people. Urban children and aged people are almost missing. 83% of the footpath area is somehow occupied and obstructed. Only 7% building facades offer vibrant life.

The paper proposes a people-friendly public space design by prioritizing life which meets three purposes: movement, meeting place and market place. The proposed design is developed to give motors vehicles and NMT with separate lanes for safety and comfort of people. It recommended taking a National Footpath Policy and Public Life Department for documenting public life in the city.

It is an urgency to design the space from people's perspective by respecting their sense and perception.

Keywords

Public Space, Public Life, Public Life Data

Introduction

1.1 Problem Statement

Huge population and unplanned urbanization creates a crisis in its urban environment. Dhaka has little amount of open space and day by day the amount is decreasing. The more important thing is that the amounts of existing open spaces are not working properly.

Khan (2014) reports that lack of integrity and poor connection of public spaces make it less accessible to the users. According to Draft Dhaka Structure Plan (2016-2035), under the RAJUK area only 1142.42acres (0.30%) of land is used for recreational activities which is as low as 0.07 acre per 1000 population. Despite of this scarcity it is possible to redesign many public spaces in ways that serve a variety of needs and purposes (WHO Regional Office for Europe, 2017). According to Gehl (2010), the most common feature of cities is that people using "city space in great numbers have been increasingly poorly treated" (p. 3) and users are actively involved when "they are observed, their activities and behavior mapped in order to better understand the needs of users and how city spaces are used" (Gehl and Svarre, 2013, p. 3). They believe that in public space planning, design and structure always get serious attention, but public life and the interaction between life and space is completely neglected. Montgomery (2013) indicates Peñalosa and Mockus views of opposite answers on fixing hardware (public space and infrastructure) or software (citizen's attitude and behavior) of a broken city.

Gehl (2010) points out that in cities of developing countries like Dhaka numerous daily functions take place in city space as culture, climate and economic conditions has great impact on living condition and life qualities in these cities. "Almost all cities have a traffic department and precise data on how many cars drive through major arteries while departments for 'pedestrians and public life' are almost unknown, as are headcounts of people" (Gehl and Svarre, 2013, p. 13). Hence Gehl and Svarre (2013) further criticize architects and urban planners have been only "dealing with space, the other side of the coin – life – has often been forgotten" (p. 2). "Integration of various activities and functions in and around public spaces allows the people involved to function together and to stimulate and inspire one another" (Gehl, 1987, p. 101). This study would try to interlink life with public space. It may help to invite people in the city to take daily life "under decent conditions" with the built environment "instead of fighting against it" (Gehl and Svarre, 2013, p. 3).

The study first represent an overview of public life and public space, then it tries to investigate the relationship between life and space to design a people friendly

public space. The paper also aims to develop recommendations for creating public spaces that invite public life.

1.2 Research Questions and Objectives

Research questions of this study are:

1. How do lives unfold in city space?
2. How can documenting public life help to design a people-oriented public space?

The objectives that help achieve this research aim are:

1. To explore the scenario of the existing public spaces through documenting public life.
2. To design a lively, safe, sustainable, healthy and human-oriented public space.

Methods

An interdisciplinary approach is needed to study how life unfolds in public places based on the physical characteristics and urban atmosphere. For the purpose of this paper, the three elements are investigated trough three lenses. First lens looks at the analyzing public life on space which investigates who are in the public space, what are they doing, how they feel about the place. Second focus of this paper is the physical characteristics of places. Third focus is to design a people-centric public space that attracts public life. This is done addressing the people's need, comfort and opportunities of the space derived from data collection and data analysis.

2.1. Research Matrix

Table 1: Research Matrix of the study.

Objectives	Research Question	Method	Tool	Data
To explore the scenario of the	How do lives unfold in city space?	Observation	Counting	Number of people, age group, gender division, how many people

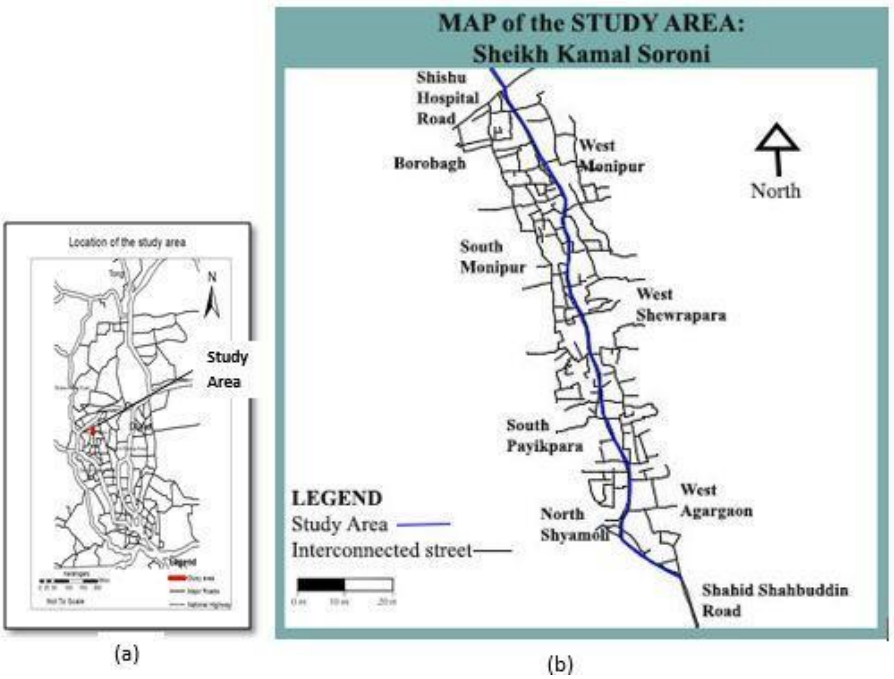
Objectives	Research Question	Method	Tool	Data
existing public spaces based on public life data.				are moving and how many are staying
			Mapping	Stationary activities, in space over times.
			Place inventory and experience assessment of space	Inventory of the physical features and assessment of the experience that the spaces offer.
			Social Space Survey	Investigate whether the space has designed elements to invite diverse public and social interaction.
			Building-facade activation	Rating building facades adjacent to the public spaces as vibrant, active, dull and inactive based on their characteristics.

Objectives	Research Question	Method	Tool	Data
			Photographing	Showing the interaction or lack thereof between urban form and life.
			Keeping a diary	Explanations and descriptions of facts and figures in detail.
		Participant Survey	Semi-structured Questionnaire	On specific issues and topics

(Source: author 2019)

Study Area Profile

The study "Kamal Soroni" is located under zone 4 (Mirpur-Kazipara, Gabtoli) of Dhaka North City Corporation area. It is indicated as connective road in DAP (2016-2035) report. The northern part of it is connected with Mirpur Road through Shahid Shahabuddin Shorok and Sayed Mahbub Morshed Road at Shisu Mela and meets to Mirpur 2 main road through Shishu Hospital Road at National Heart Hospital and Research Institute in the southern part. The length of the study area "Kamal Soroni" is 3.14 km which has passed through ward no 27, 28, 14 and 13 respectively. Government acquired land in 2012 for the construction of the road and it was open for use in 2014. Local name of the road is "60 Feet Road" and this name is more popular.



(Source: Edited from Open Street Map)

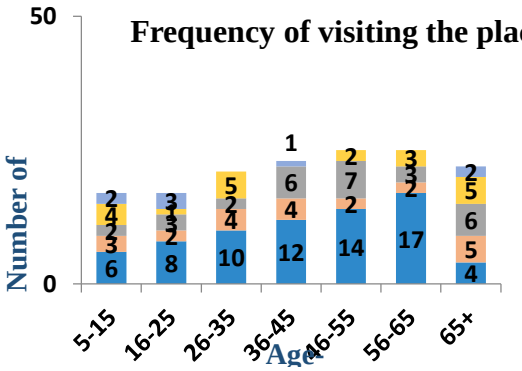
Fig 1: (a) Location of the study area in Dhaka city. (b) Map of the study area.

Case Study Analysis and Findings

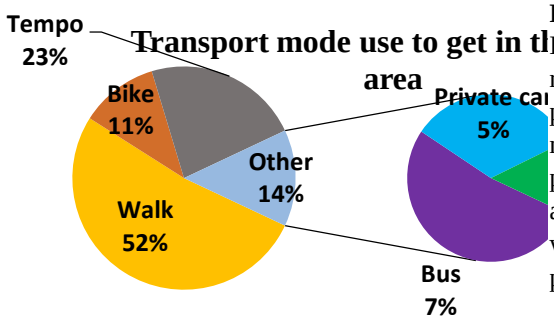
4.1 Public Life Data Analysis and Findings

Table 2: Public Life Data analysis and findings of Sheikh Kamal Soroni.

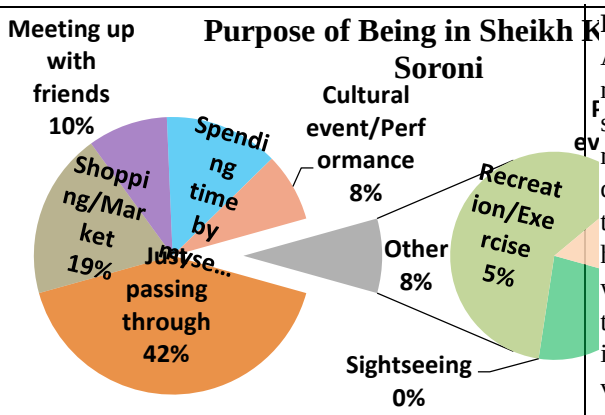
Individual Data of Participant Survey



Findings:
Middle-age group visiting the study area daily is the highest. Children (5-15 age) and aged people visited the place most of the time monthly and weekly.



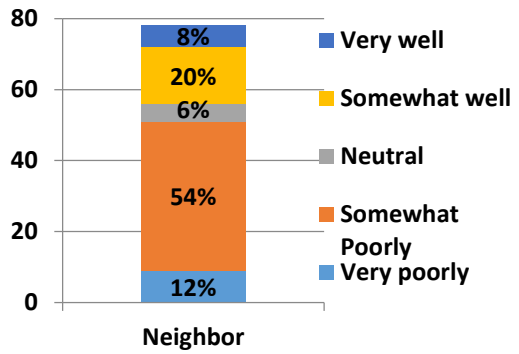
Findings:
Half of the respondents are pedestrians. This means majority of the people in the study area come from walking distance place.



Findings:
Almost half of the respondents use the study area for only reaching the destination. None of the respondents came here for sightseeing, which indicates that the space is not interesting to the viewers.

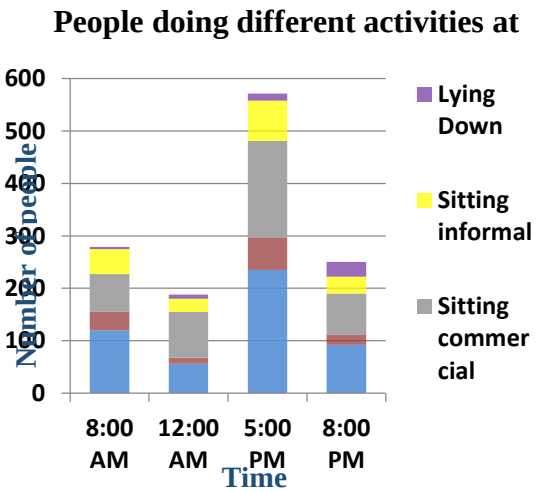
Neighbor's feeling of personal safety

Findings:
Most of the neighbors rated their personal safety being poorly treated. 66% neighbors think that

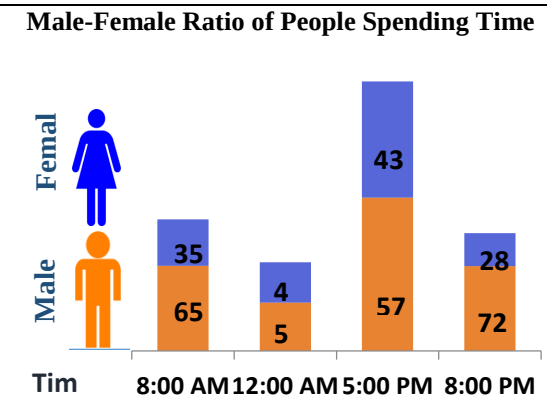


their personal safety is poor due to movement heavy vehicles on the street and intrusion of people from outside the local area.

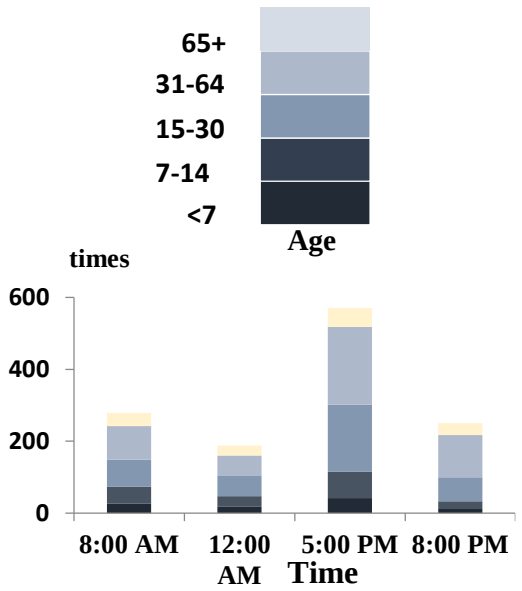
Stationary Activity at Sheikh Kamal Soroni



Findings:
People are mostly seen spendingtime.in.the. morning and afternoon. At 12 a.m. least people are observed in the.study area and at 5 p.m. highest number.of.people.spending.time.is.observed.Majority.of.people.spend.time by standing in the study area.



Findings:
In the morning male spend 2 times more time than female. The ration of male and female is almost equal at 12 o' clock and in the afternoon. But at night male are seen 3 times more than female.

Spending time by different age-group at different	Findings:
	Middle age group people are seen spending time highest. And in the afternoon it is the highest number for all age-group. People below 7 years old and more than 65+ years old are hardly seen.

(Source: Field Survey, 2019)

4.2 Public Space Data Analysis and Findings

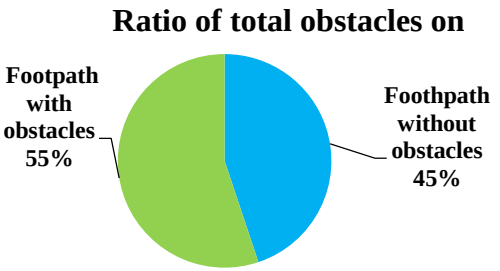
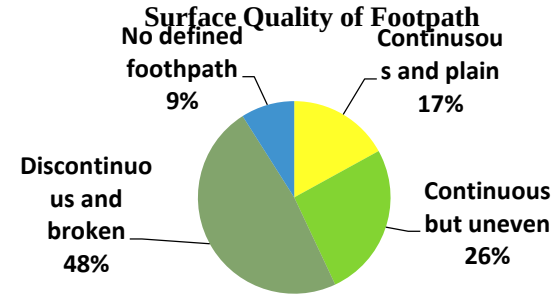
Site Experience: The space does not have areas that provide shade or shelter. Generally, it does not offer areas to spend time, sit and rest. There is no area to be active or play. It is not comfortable to have a conversation with another person in this space. Presence of vegetation (tree, plantings, etc) is low. Trees are only seen in the median of the road. Overall visual environment is unattractive. At night, the space is not well-lit due to insufficient number of street lights. Safety is hampered due to dominance of vehicular traffic, lack of lighting and state of cleanliness. The area is not accessible by people with disability. Heavy traffic is observed from 7:30 am to 10:00 am and 6:30 pm to 9:30 pm. Road crossing is not safe at all. Pedestrian way is broken and discontinuous that creates barrier for walking.

(a) (b)

Fig 2: (a)Indigenous plantation in the study area. (b) Trashes on footpath.

4.3 Pedestrian Way

Table 3: Public Space Analysis of Footpath

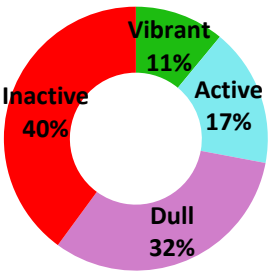
	**Findings:** More than half of total footpath area has obstacles which creates barrier to the pedestrians.
	**Findings:** Almost half of the footpath surface is discontinuous and broken due to lack of repair and maintenance.

(Source: Field Survey, 2019)

4.4 Building-Façade Activation

Table 4: Building façade activation analysis

Buiding Facade Activation At Kamal Soroni

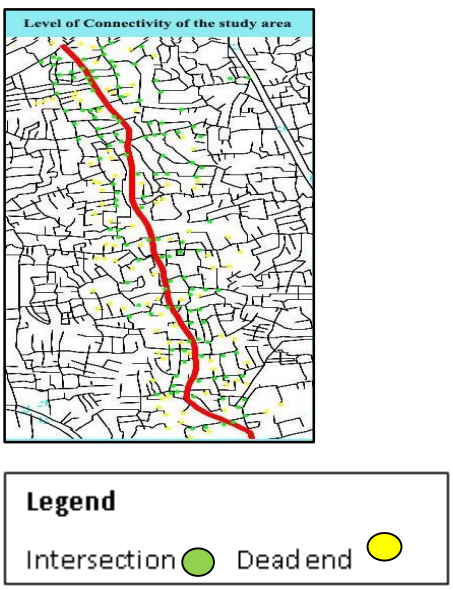


Findings:
Majority of the building facades are inactive. Second highest category of building facades is dull.

(Source: Field Survey, 2019)

4.5 Level of Connectivity

In the study area Lower connectivity is seen at South-west part of the study area at Shahid Shabuddin road Intersection point. Large scale building and large plot sizes are connected with a few streets only. But higher connectivity is observed towards North-east side of the study area.



(Source: Edited from Open Street Map.)
Figure 3**:** Map of street connectivity of the study area (Not to scale).

Proposed Design of the Study Area

The main aim of this design proposal is to encourage more people to walk and cycling as a part of their daily activities. Priority of local people has taken as first consideration. Elements are arranged in such a way that users can have their daily necessary within walking distance. Main features of this proposed design are:

- Separate lane for NMT and motor vehicles.
- A continuous and barrier-free pedestrian and bicycle network.
- A spontaneous and vibrant market place.
- A meeting place with lots of seating facilities.
- Active building facades with lots of characters, detailing, transparent with more doors and windows.
- Removal of trash, construction materials, electric pole, vehicle parking from sidewalks.

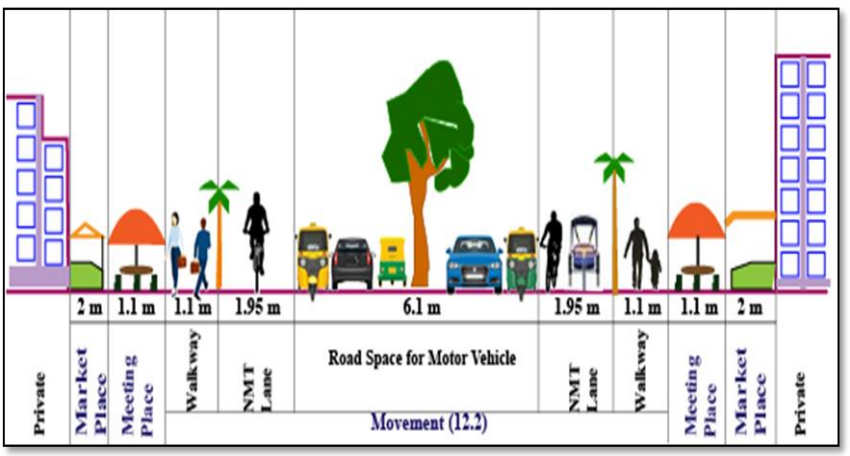


Figure 4: Proposed design of the study area.

Design Cost: To solve existing problem of the study area footpath needed to be redesigned. As 48% of footpath area is somehow broken and there is no defined footpath of almost 0.28 km, so total 58% of footpath area needed to be constructed. From the observational analysis it is found that there is lack of public seating which has resulted less social interaction and spending time activity in the study area. Trees are only planted on the median which provide shade only to the vehicles. There is a need of greenery and shades in pedestrian way.

Table 5: Cost of proposed design.

Structure	Dimension (m)		Quantity	Total length (m)	Cost per unit (BDT)	Total cost (BDT)
	Length	Width				
Pedestrian way/footpath	1789.8	2.13	1	1789.8	3200.00 per sq. m.	12193824.00
Cycle lane	3140	1.84	1	3140	1400.00 per sq. m.	8088640.00
Public seating	1.07	0.23	125		500.00 tk per unit	62500.00
Dustbin			314		1000.00 per unit	314000.00
Greenery (tree planting)	6280	0.5	310		150 per tree	46500.00
Total cost						**20705464.00**

(Source: DAP report, 2016-2035, modified)

Conclusion

For decades, urban planning was dominated and driven by a strong focus on cars, but this is now changing to a focus on creating cities for people that have balanced mobility systems and in which active mobility is encouraged. The ways in which many public spaces are planned and designed have resulted in them becoming "anti-spaces" for people: spaces that do not contribute positively to city life and whose recreational, economic and democratic value to society has been squandered. Better understanding of how the physical environment and public spaces influence users' experience can be realized with public life documentation. This paper sought to outline a research methodology currently under development for investigating how people use public spaces. The process of experiencing space is a multifaceted phenomenon, which could not be targeted simply through existing methodologies. In this regard, this study aimed to investigate life in space: who are using, how they are using it, what is the linkage

between life and space, what are the activities happening in public space. However, the physical environment is not the only attribute which can affect how a space is experienced. Individual characteristics and cultural background can influence the way a person engages with a space.

References

Montgomery, C. (2013). Happy City: Transforming our lives through urban design. Canada: Doubleday Canada.

Detailed Area Plan (2016-2035), Survey Report, Part A and B, RAJUK 2017.

Gehl, J. (2010) Cities for people. Washington: Island Press.

Gehl, J. and Svarre, B. (2013) How to study public life. Washington: Island Press. Available at: https://centercityphila.org/uploads/attachments/cit0ddf07000df6qd3srp2m4u-gehl-svarre-study-public-life.pdf

Khan, M. (2014) 'Study of Open Spaces in the Context of Dhaka City for Sustainable Use: A Syntactic Approach', IACSIT International Journal of Engineering and Technology, 6(3). Available at: http://www.ijetch.org/papers/704-W30022.pdf

WHO Regional Office for Europe. (2017). Towards More Physical Activity in Citie. s.l.: s.n.

Environmental Impact Assessment (EIA) of a Project of Sreemangal Paurashava: An Analytical Study moving towards Environmental Sustainability

Mohammed Saiful Islam
Town Planner, Laksam Paurashava
Ministry of Local Government, Rural Development and Cooperatives
Government of the People's Republic of Bangladesh
E-mail: saifulurp29@gmail.com

Abstract

Environmental Impact Assessment (EIA) is a legitimately recognized measure of controlling the excesses of developers. Moreover, it is a planning and management tool for sustainable development to design the possible mitigation procedure. Presently, EIA practice around the globe is studied on the basis of three significant phases, namely – Screening; Scoping; and Administration. Besides, environmental sustainability is defined as liable interaction with the environment to avoid declining of natural resources and consent for continuing environmental quality. Therefore, the objective of this article is to illustrate to what extent mitigation measures are appropriately required to attain the environmental sustainability in the context of proposed Auditorium cum Community Center of Sreemangal Municipality. The study is mostly analytical in nature and mainly based on primary data and information, although a number of information has been collected from secondary sources as well. All observations and findings of the analysis have been assumed that the project, if implement, would not endure substantial negative impact neither on ecological nor on Physicochemical or any of the ingredients of those components. In addition, the project would be helpful to enhance positive socio-economic impact through the increasing of employment of local people and financial permanent benefit to the Municipality by revenue generation.

Keywords: EIA; mitigation measures; project; screening; sustainability.

1. Introduction

1.1 Preamble

Environmental Impact Assessment (EIA) is the process of assessing the environmental effects of proposed project based on information gathered, which will be taken into account by the proponent as part of the project design/plan (Macaulay and Richie, 2013:628), and by the decision-making body in authorizing the accomplishment of the project (Hakes, 2007:3). EIA recognizes to achieve two objectives. The first one is to determine whether the project will have an important impact on the environment (Wood, 2008:22) and the second one is to maintain sustainable development (Sadler, 1996). Moreover, the role of EIA is beyond the decision to proceed appears to be unexplored within the theory and most importantly in the real world situation (Bailey, 1997:323). Therefore, to understand the full potential of EIA, it is significant to observe how EIA works in the protection of environment and attainment of project sustainability (Bailey, 1997:324).

Bangladesh initiated Environmental Impact Assessment (EIA) guidelines in 1992 for water sector development. Then the country enacted EIA legislation in 1995 and EIA rules in 1997 (Momtaz, 2002:163). Department of Environment (DOE), under the Ministry of Environment and Forest, is the regulatory body responsible for enforcing the Environmental Conservation Act 1995 (ECA'95) and the Environmental Conservation Rules 1997 (ECR'1997) (BCAS, 1999:43). The significant phases in the development of an EIA study according to EIA guidelines of DOE to achieve environmental sustainability are – Environmental Screening; Identification of significant environmental issues and how these will be resolved; and adequacy of mitigation measures and the Environmental Management Plan (EMP) (Ahmed and Harvey, 2004:66). At present, all major donor agencies working in Bangladesh have their own EIA guidelines (Momtaz, 2002:163). Besides, World Bank (WB) has been a development partner of the country for a long time. It has developed its own EIA procedures for projects funded by it (Momtaz, 2002: 173).

Sreemangal Paurashava has a four storied Auditorium cum Community Center (partially ground floor is completed) with modern facilities. However, a Sub-project titled "**Vertical Extension of Mohsin Auditorium cum Community Center**" has been adopted in the Sreemangal Five Year Capital Investment Plan (2017-2022) which would be financed by the Municipal Governance and Services Project (MGSP). Besides, the aim of Sreemangal Paurashava is the creation of an urban liveable environment, where people irrespective of their socio-economic, demographic and religious identities can live and enjoy today within affordable means without sacrificing interests of tomorrow (Master Plan, 2013). Therefore, considerable social, economic as well as environmental benefits may be obtained with the full construction of Mohsin Auditorium cum Community Center. It would be helpful for accommodating social gathering

increase the facilities of different occasion or festival. Community Centre will bring a new life style on several occasions for the citizen and tourist as well. It will also increase financial permanent benefit to the Municipality through revenue generation.

1.2 Contextual Brief

Prompt project development in human civilization across the world has led to the requirement of strengthen environmental regulation in turn to protect the environment, its features and inhabitants from the negative consequences of development without roasting urbanization. As a result, Environmental Impact Assessment (EIA) is a legally recognized measure of controlling the excesses of developers or proponents (Macaulay and Richie, 2013:628). As early as 1969 in the United States, Environmental Assessment (EA) had become a practice with legal provisions (Zhu and Lam, 2009:4). After few years, other countries around the globe followed suit and now Environmental Impact Assessment (EIA) has become the general term used to describe the development (Macaulay and Richie, 2013:628). Nowadays, EIA practice around the world is examined on the basis of three important stages (Figure 1), namely – Screening; Scoping; and Administration (Wiesner, 1995).

Screening is carried out to determine whether a development project requires an EIA or not because not all projects entail an EIA. The method of screening differs from one country to another. In Bangladesh, colour bands are used to simplify the screening process. All development projects are divided into four coloured categories – Green, Orange A, Orange B, and Red – based on the location and environmental significance of the proposed project. Green projects do not require any initial assessment or EIA while Orange A and B projects require limited assessment, and Red projects require both initial assessment and EIA (Ahmad and Wood, 2002:214).

At the end of the screening implementation, those projects that do not need EIA will move over to the regulatory authority for approval. However, if the project has the possible to threaten the environment, then scoping is likely to be carried out. Scoping involves the decision that will be made about which impact categories will be encompassed in the EIA. It is considered as a critical element in the EIA process and therefore, requires clear guidance to be provided to those who will carry out the EIA (Bond, 1999).

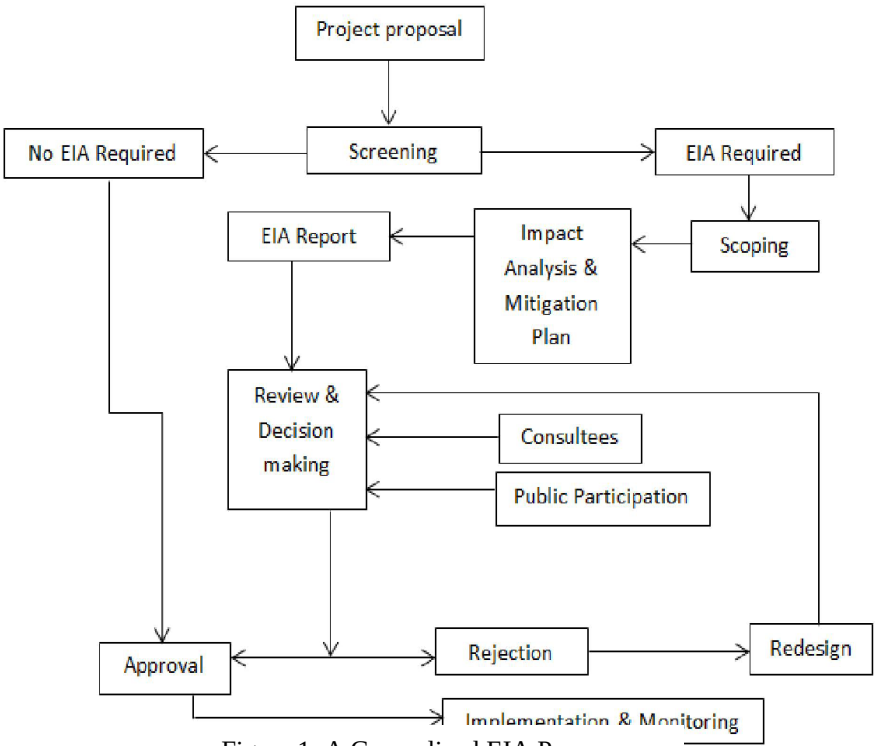


Figure 1: A Generalized EIA Process.
Source: Wiesner, 1995.

Subsequently, t ... of EIA states clearly who adn ... some countries, the regulatory body carries out both functions; in some others, the regulatory body administers whilst the proponent performs the EIA through a hired consultant/team of experts (Macaulay and Richie, 2013:630). Moreover, Consultees/review panels are often required by the regulatory authority for better decision-making. In addition, public review or participation is a basic part of EIA and the right to appeal in case of a project proposal rejection is officially granted in some counties. All the same, the project proponent carries out the EIA through hired consultants in Bangladesh (Macaulay and Richie, 2013:632).

However, an area of 0.247 (999.574 Sq.m) acres of the Sreemangal Paurashava owned land has been identified and selected for the proposed project development. The proposed site is well connected with Dhaka-Sreemangal road. The adjacent areas are Ward No. 3, 5, 6 and 9 where about 40 percent households of the municipality are situated in and around the proposed Auditorium cum Community Center (CIP, 2018). The Municipality proposed to establish such a community center with the monetary support of Bangladesh Municipal Development Fund (BMDF) which is financed by the World Bank (WB). The

project as proposed to be constructed under the overall technical guidance of BMDF entrusted for ensuring an environmental friendly planning, design and construction of physical structures qualitatively and enhancing a user friendly operation and management system. The Municipality rightly planned for such a modern community center with the realization of felt need of city dwellers. Even so, there is a recognition that development could not be sustained if due consideration was not given to environmental protection. Therefore, the government of Bangladesh, with the view of providing the conservation and improvement of environmental quality and controlling and mitigating pollution in the environment, enacted the ECA'95 and promulgated ECR'97 (BCAS, 1999:43). Besides, WB has an environmental section that examines EIAs for approval. WB rigorously follows its regional environmental strategies and guidelines in funding projects. For this purpose, projects are classified in three categories: i) Category A: Projects that are likely to have significant long-term impacts, and a full assessment is required; ii) Category B: Projects that are likely to create site-specific impacts and would not affect human population and environmental sensitive areas, as well as partial environmental assessment is required; and iii) Category C: Projects that are unlikely to have impacts on society and environment, and an EIA is not required for such projects (WB, 2000). Consequently, the aim of this paper is to explain to what extent mitigation measures are properly needed to achieve the environmental sustainability in the context of proposed Auditorium cum Community Center of Sreemangal Municipality.

1.3 Environmental Sustainability

Environmental sustainability is delineated as liable interaction with the environment to avoid lessening or dilapidation of natural resources and allow for long-term environmental quality. The exercise of environmental sustainability benefits to safeguard that the needs of today's population are met without jeopardizing the capability of future generations to meet their needs. Besides, it is apprehensive with whether environmental resources will be

secured and maintained for future generations. Hence, the concerned issues of

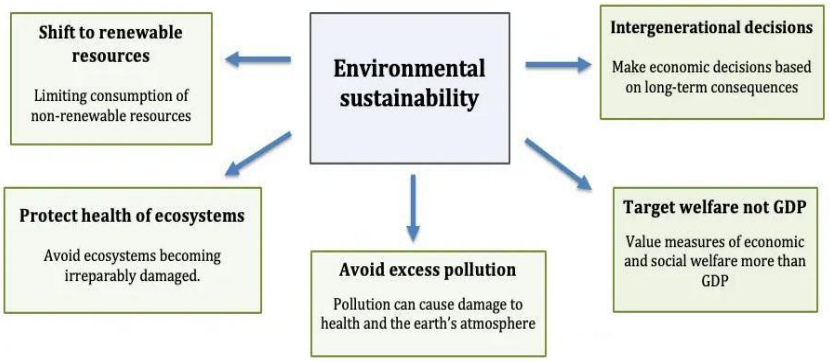


Figure 2: Issues of Environmental Sustainability.
Source: Pettinger, 2018.

environmental sustainability have defined in the figure 2 and discussed below:

1.3.1. Protect Health of Ecosystems: Ensuring protection of species diversity and ecological structure. Sometimes medicines require elements within specific plant species. If some species go destroyed, it limits future technological innovation.

1.3.2. Avoid Excess Pollution: Policies to ensure the environment of the earth does not decline to a point where future generations face water shortages, extreme weather events, and excess temperature.

1.3.3. Target Welfare not GDP: Value measures of economic and social wel tary val ıred rat rom protecting rainforests.

1.3.4. Intergenerational Decisions: When making economic decisions, it should be focused on implications for future generations, and not just the present moment. For example, burning coal gives a short-term benefit of cheaper energy, but the extra pollution imposes costs on future generations.

2. Methodology

2.1. Methodology

The study is mainly analytical in nature and predominantly based on primary data and information, although a number of information has been collected from secondary sources as well. Moreover, several journals, textbooks, periodicals, internet and other relevant materials were consulted and exploited as references to that for literature review and for other theoretical analysis. Furthermore,

Environmental Assessment was prepared based on the field observation of key environmental features of approximately 100 meters surroundings of the proposed project. Detail observation and assessment made on existing environmental features like road communication and connectivity, rush-hour traffic flow, local vehicle movement, accidental risks, drainage congestion, waste water discharge, solid waste disposal, surface water contamination, dust spreading, soil degradation, erosion, odor spread around, increased traffic movement includes social conflict etc. in and around the catchment or influenced areas (100 meters around) of the project. In addition, public consultation (figure 3) and participation ensured through organizing Focus Group Discussions (FGD) with local stakeholders. Besides, a semi-structured questionnaire survey (figure 4) was conducted and obtained necessary information, identified environmental and other problems, issues, concern and suggestions from the local people to substantiate the results of the study.

Figure 3: Public Consultation.
Source: Author, 2018.

Figure 4: Semi-structured questionnaire survey.

2.2. Land use/Environmental Features and Category of the Project

Land use pattern/environmental features of the catchment areas and probable impacts over those were observed and found that there was no agricultural land around the proposed community center; however offices, commercial, health, educational and residential areas exists as mentioned in below table 01.

Table 1: Land use features around the proposed Project

Sides/ Direction	Ward Nos.	Major Land use/Environmental Features

North	W # 6, 9	Road Side Shops, Vocational Training Institute, Udayan Girls High School, Residential And Dwelling Houses (12 Houses), Cover Drain
South	W # 6, 3	Sreemangal Rail Station, Railway Worker's Colony, Road side Shops
East	W # 5	Upazila Office, Temporary Car Station, Attar Jame Mosque, Pansi Restaurant, Pach Vai Restaurant, Road side Shops, Residential and dwelling houses (35 Houses)
West	W # 6	Sreemangal Paurashava Compound, Kitchen Market, Multi-purposes Markets, Road side Shops, Clinic, Cover Drain

Source: Field Survey, 2017.

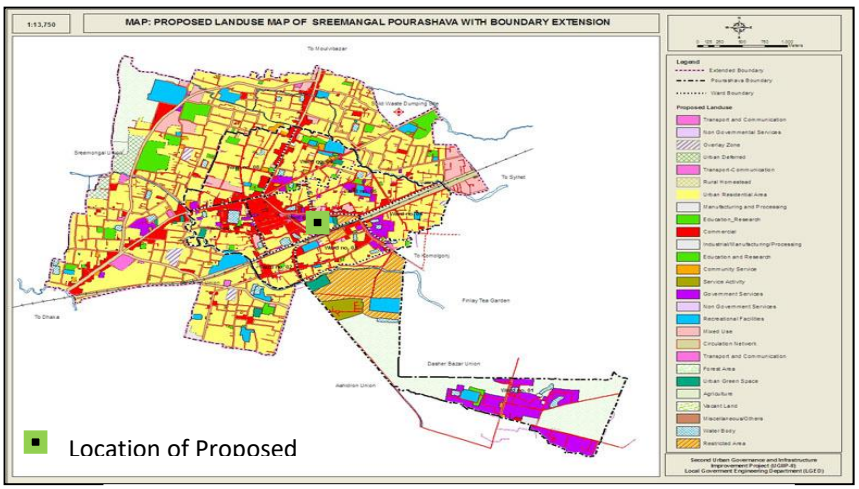


Figure 5: Location Map of the Proposed Project.
Source: Master Plan, 2013.

However, in view of the Environmental Conservation Rules (ECR 1997), the proposed project falls under the category **'Orange B'**, assumed to have moderately significant adverse environmental impacts may observed due to the implementation of the proposed project activities. Moreover, in consideration of the proposed project nature, i.e. potential adverse impact on human and environment includes natural habitats it has been categorized as **'Category B'** according to the World Bank classification.

3. Environmental Screening

The project has been selected through a careful Environmental Screening (ES) process following the guidance and the checklists in line with the requirements of DoE and WB. Environmental Screening ensures that environmental issues are properly identified in terms of extent of negative and positive impacts. To screen an environmentally sound project necessary field observation, consultation and discussion with local people, nearby inhabitants, business man and others made during the February, 2017 in the project area. Environmental Screening Checklist (ESC) of the Environmental Management Framework (EMF) of Municipal Governance and Services Project (MGSP) was followed for identifying the impacts and their extents. The screening data and information for this project have been analyzed and are shown in below.

○ 3.1. Potential Environmental Impact during Construction Phase:

(A) Ecological Impacts:

- Felling of Trees : Significant □ Moderate □ Minor □ **NO**□√
- Clearing of Vegetation : Significant □ Moderate □ Minor □ **NO**□√
- Potential Impact on Aquatic Species : Significant □ Moderate □ **Minor**□√ NO □

(B) Physico-Chemical Impacts:

- Noise pollution : Significant □ **Moderate**□√ Insignificant □
- Air pollution : Significant □ Moderate □ **Insignificant**□√
- Drainage congestion : Very likely □ Likely □ **Unlikely**□√
- Water pollution : Significant □ Moderate □ **Insignificant**□√
- Solid waste pollution : Significant □ Moderate □ **Insignificant**□√
- Construction wastes : Significant □ **Moderate**□√ Insignificant □
- Water logging : Significant □ Moderate □ **Insignificant**□√

(C) Socio-Economic Impacts:

- Traffic congestion : **Likely**□√ Unlikely □
- Health and safety : Significant □ Moderate □ **Insignificant**□√
- Impact on archaeological : Significant □ Moderate □ **Insignificant**□√
- Impact on historical : Significant □ Moderate □ **Insignificant**□√
- Employment generation : Significant □ **Moderate**□√ Insignificant □

○ 3.2. Potential Environmental Impact during Operation Phase:

(A) Ecological Impacts:

- Potential impact on species of aquatic : Significant □ Moderate □ Minor □ **NO**□√

(B) Physico-Chemical Impacts:

- Potential air quality & noise level : Improvement □ **No-improvement**□√ Deterioration □
- Drainage congestion : Improvement □ Minor Improvement□ **No Impact**□√
- Risk of Water pollution : Significant □ Moderate □ **Minor**□√
- Pollution from solid waste : Improvement □ **No-improvement**□√ Deterioration □

C) Socio-Economic Impacts:

- Traffic : Improvement □ No-improvement □ **Adverse**□√
- Safety : **Improvement**□√ No-improvement □ Adverse □
- Employment generation : **Significant**□√ Moderate □ Minor □

○ 3.3. Summary of probable Environmental Impacts of the Project

The environmental assessment has been conducted and observed that there will be no significant adverse environmental impacts with the establishment of this proposed project in the present location. During the assessment period, closely observed and shared all potential environmental features with local communities of different strata based on which adopted the screening process. Through the review and analysis of all observations and findings it has been assumed that the project, if implement, will not sustain notable negative impact neither on ecological nor on Physicochemical or any of the ingredients of those components. Moreover, the project will be helpful to enhance positive socio-economic impact through the increasing of opportunity for citizens to celebrate different social occasion with peaceful way as well as generating the income and employment of local people both in construction and operational phases. The screening process indicate that a few negative impacts may arise categorized as local in nature and low in magnitude, very minimal possibilities of adverse impacts on some of the parameters of the physical, biological or socio-economic environment of the project area.

4. Specific Impacts and Mitigation Measures

○ 4.1. During Construction Period

Precise impacts and mitigation measures during construction period have explored below:

○ 4.1.1. Earthwork

The proposed project work consists of no earth cutting, trenching, earth filling and land dressing. However, construction work consists of garbage cleaning and removal of unsuitable or any hazardous materials. These works lead dust blowing, noise and vibration which may be the discomfort to the dwellers in the north, nearby shops in the east and to some extent adjacent residential areas in the southern side includes pedestrians in the east-west road in front of the project site. Therefore, water spray through hand pipe or sprayer and necessarily by water spraying tanker of the municipality will be continued in working time at day time to control dust spreading both inside the project site and on the adjacent road. Moreover, adequate safety barrier will be provided with clear visible signs to alert both drivers and pedestrians.

○ 4.1.2. Air Quality and Dust

All civil construction works of the project will spread dust and emission (typically from concrete, cement, wood, stone and silica). Hence dust control through clean water spray would be used to dampen down the site and screened the whole site to stop dust spreading or alternatively, place fine mesh screening close to the dust source.

○ 4.1.3. Noise and Vibration

Construction site usually produce noise and vibration, mainly from brick breaking machines, equipment and machinery. Site workers' crowed radio sound is usual and common phenomenon in the construction site. Materials unloading are another disturbing exercise. Excessive noise is not only annoying and distracting, but can lead to hearing problem, high blood pressure, sleeping disturbance and extreme stress. Consequently, it is essential for reduce noise pollution through careful handling of materials; using modern and comparatively quiet power tools, equipment and generators; low impact technologies and wall structures as sound shields.

4.1.4. Rain Water Harvesting Reservoir

To meet the regular water demand for proper cleaning and maintenance purposes, availability of full time required quantity of water supply is very essential. Therefore, to reduce dependency on water supply system or tube well, a required number of water reservoirs can be built on the roof of the proposed auditorium

cum community center to harvest rain water in rainy season following rain water harvesting procedure.

4.1.5. Solar Energy and Glass Wall

Including all other amenities, increased electricity demand will be generated in the auditorium cum community center. Such an increasing demand can be reduced by using solar energy and glass wall. Installation of solar panel, regular maintenance of solar system, cleaning of glass is required for expected results.

4.2. During Operational Period

Specific impacts and mitigation measures during operational period have stated below:

4.2.1. Solid Waste Disposal

A considerable volume of solid and organic waste materials will be generated regular at the project area. Hence to make the community center floors clean, required numbers of small bins are to be placed at different corners of the all floors where the customers and visitors can put the solid waste easily within short distance and time during the various programs. The waste materials collector of the community center will collect solid waste carefully and fill garbage bins at the outside of the building regularly. Municipality covered truck or van in every day would collect those and will deposit in the specific secondary solid waste dumping station.

4.2.2. Waste Water Disposal

Waste water will generate from cooking and public toilets inside the community center which will pollute adjacent environment if not properly cleaned, drained or discharge and managed. Therefore, waste disposal system would be integrated by discharging waste water into soak pit and then to existing municipality drainage system.

4.2.3. Traffic Congestion

There is every possibility of traffic congestion at the in front road of proposed auditorium cum community center due to the increasing and rushing of customers and guests in the community center at day and night during the occasions and festivals. For these reasons, there will be basement area where car will be parked. Other than there will be entry and exit system in front of community center which will be controlled by police to be assigned by the Sreemangal Municipal Authority.

4.2.4. Fire Fighting Equipment

Every year large numbers of people die due to fire in Bangladesh. Therefore, safety against fire is a very important thing for the project. The installation of Fire Safety Equipment such as fire extinguishers and fire alarm systems in the project will diminish the risk of property being burnt down due to fire incidents and ensure the people safety as well.

4.2.5 Smoke Detectors

Smoke detectors will also be installed in the project to protect people and property by generating an alarm earlier in the expansion of a fire. People need time to react, and every second is critical during an actual fire event. A general rule of thumb and most smoke detector manufacturers' instructions state, that smoke detectors should be installed every 30 feet in straight runs, such as a hallway or large rooms without obstructions in the ceiling.

5. Institutional Arrangement

The Environmental Safeguard Compliance issues are directly vested the Municipality Officials; especially engineer in charge will be responsible for supporting the construction supervision with the facilitation of BMDF. The civil works contractors will implement the environmental mitigation measures. On the other hand, BMDF with the help of Environmental Safeguard Specialist will submit the monthly monitoring reports on Environmental Compliances to the World Bank.

6. Conclusion

The proposed project was selected through a close consultation with different tiers of the community people and consideration of the felt needs of them to enhance the social and carnival facilities in the city. However, as observed and assessed the impact on physical as well as socio-economic aspects relevant to the construction and operation of the proposed community center no significant adverse impact were observed. Moreover, potential positive impacts on diversified social and economic parameters are increasing of income and employment opportunities, promoting tourism industry, accommodating social gathering by increasing the facilities of different occasion and festivals.

7. References

ADB. 2012. "BAN: Strengthening Environmental Impact Assessment System and Its Implementation Practices", TA 7566-REG: Strengthening and Use of Country Safeguards Systems, Sub-project Proposal for

Bangladesh, Project Number: 44140, June 2012, Asian Development Bank, https://www.adb.org/sites/default/files/project-document/75141/44140-012-ban-subproject-01.pdf, retrieved on 26 January 2018.

Ahammed, R. and Harvey, N. 2004. 'Evaluation of environmental impact assessment procedures and practice in Bangladesh', Impact Assessment and Project Appraisal, vol. 22(1), pp. 63-78.

Ahmad, B. and Wood, C. 2002. 'A comparative evaluation of the EIA systems in Egypt, Turkey and Tunisia', Environmental Impact Assessment Review, vol. 22, pp. 213-234.

Bailey, J. 1997. 'Environmental Impact Assessment and Management: An unexplored relationship', Environmental Management, vol. 21(3), pp. 317-327.

BCAS. 1999. 'Guide to the Environmental Conservation Act 1995 and Rules 1997', Bangladesh Centre for Advanced Studies (BCAS), Dhaka: BCAS.

BMDF, 2017. 'Environmental and Social Safeguard Manuals', Bangladesh Municipal Development Fund (BMDF), Dhaka: the World Bank.

Bond, A. 1999. EIA in the European Union. Handbook of Environmental Impact Assessment (modified). Institute of Biological Sciences, University of Wales, Aberystwyth, UK.

CIP. 2018. 'Capital Investment Plan: 2017-2021', Sreemangal Paurashava, Local Government Engineering Division, Ministry of Local Government, Rural Development and Cooperatives, Government of the People's Republic of Bangladesh.

Hakes, P. 2007. The Essex Guide to Environmental Impact Assessment. Spring 2007. EPOA (Essex Planning Officers Association) (Ed.). 30, Viking way, Brentwood, Essex, CM15 9HX, pp. 3.

Macaulay, B.M. and Richie, S. 2013. 'Variation and Challenges in the Global Practice of Environmental Impact Assessment (EIA)', International Journal of Innovation and Applied Studies. Vol. 4(4), pp. 628-635, https://www.academia.edu/12499102/Variation_and_challenges_in_the_global_practice_of_environmental_impact_assessment_EIA, retrieved on 18 February 2018.

Master Plan. 2013. 'Sreemangal Paurashava Master Plan: 2011-2031', Local Government Engineering Division, Ministry of Local Government, Rural Development and Cooperatives, Government of the People's Republic of Bangladesh.

Pettinger, T. 2018. 'Environmental sustainability – definition and issues', Economics Help Organization, https://www.economicshelp.org/blog/143879/economics/environmental-sustainability-definition-and-issues/, retrieved on 27 March 2020.

PP. 2018. 'Project Proposal: IDA Credit No. 5339-BD, Sreemangal Paurashava, Moulvibazar', Municipal Governance & Services Project (MGSP), Bangladesh Municipal Development Fund (BMDF), Dhaka: the World Bank.

S. Momtaz, "Environmental Impact Assessment in Bangladesh: A critical review," Environmental Impact Assessment Review, vol. 22, pp. 163-179, 2002.

Sadler, B. 1996. 'Environmental Assessment in a changing world: evaluating practice to improve performance', Final Report of the Ministry of Supply and Services, Ottawa, Canada.

UGIIP-II. 2014. Social and Environmental Safeguard Monitoring Report, Second Urban Governance & Infrastructure Improvement (Sector) Project (UGIIP-2), LGED, LGD, MoLGRD&C, Government of the People's Republic of Bangladesh, ADB Loan No. 2462-BAN (SF), Month: March, 2014, http://www.lged.gov.bd/UploadedDocument/ProjectLibraryGallery/241/SES_Report-March-14.pdf, retrieved on 11 January 2018.

WB. 1997. 'The Impact of Environmental Assessment', A Review of World Bank Experience, World Technical Paper No. 363, Washington, DC: The World Bank.

WB. 2000. South Asia Environment Strategy—Main Report: work in progress. Dhaka: The World Bank.

Wiesner, D. 1995. EIA – Environmental Impact Assessment process: what it is and how to do one. Great Britain: Prism Press.

Wood, G. 2008. 'Thresholds and criteria for evaluating and communicating impact significance in environmental statements: 'see no evil, hear no evil, speak no evil'?', Environmental Impact Assessment, vol. 28, pp. 22-38.

Zhu, T. and Lam, K.C. 2009. 'Environmental Impact Assessment in China', Research Centre for Strategic Environmental Assessment, Nankai University and Centre for Strategic Environmental Assessment for China, the Chinese University of Hong Kong. pp. 3-72.

Research Paper

Impact of Covid-19 Pandemic on Medical Purposed Travel Behaviours

Ms Dilruba AFROZE, Research Assistant, BRTC, BUET, Bangladesh

Ms Nawshin BASHIR, Research Analyst, Innovations for Poverty Action, Bangladesh

Ms Nawshin TABASSUM, Lecturer, BUET, Bangladesh

Abstract

Covid-19 pandemic made changes in the day-to-day life of people and they had to adjust with new normal which in turn linked with their hospital visits to ensure health necessities and other needs. Using 240 data from an online-based survey, this paper aims to investigate the contrast of medical purposed travel behaviour of people of Dhaka before and during the Covid19 pandemic. Using descriptive analysis, socio-economic profile, travel frequency, mode choice, time, cost, distance of medical trip etc, of respondents were found to be the important parameters to figure out the difference between before and during a pandemic. The result indicates that various socio-economic factors and safety concerns played a significant role in the change of travel frequency and mode choice behaviour of the hospital visitors. During the time of Covid-19 restrictions, people generally prefer to travel less frequently than before and choose walking, CNG autorickshaw, private car rather than bus or other transit comparing to pre Covid-19 situation. Whereas, the impact of the pandemic is less significant in the case of travel time in comparison of before and during pandemic. Policymakers and urban planners can have some insights of the before and during situation of travel patterns of hospital visitors from the findings of this research.

1. Introduction

The sudden outbreak of Covid-19 significantly hindered mobility patterns across the world as well as affected people's travel behaviours. Travel behaviours demonstrate that some variables are significantly associated with changing patterns in which it varies from one study to another based on which approach or measures are taken into account to represent the findings. Transport sector across

the world continues to combat challenges in response to the global coronavirus pandemic (Pawar et al., 2020). Since the first case of Covid 19 identified in Bangladesh in March 8, 2020, it initiated travel restriction measures from the beginning of March 2020, although countrywide lockdown was not imposed until March 26, 2020 (Anwar et al., 2020). As a result, people need to change their travel behaviour considering the lockdown periods and also for hygiene/safety maintenance issues along with others. This change has affected medical purposed travel too which comes under the category of essential travel that is less subjective and can vary across different spatial locations with different access to health care and other essential facilities (Chen *et al.*, 2021).

Peoples' paying visit to any hospital (government or private), health care clinic or diagnostic centre comes under the category of "medical purposed travel or trip" and will be referred as hospital for this study. This study aims to conduct a comparison by assessing travel pattern change in "before" and "during" COVID-19 situations for medical purposed trip on the basis of socio demographic information, travel attributes and mode choice pattern.

Literature Review

A plenty of research carried out on travel behaviour or travel pattern comparing overall changes of before and during pandemic situations. (Abdullah *et al.*, 2020) explored the impacts of Covid-19 on travel behaviour and mode choice preferences before and during COVID-19. The result shows that trip purpose, mode choice, travel distance, and trip frequency for the primary travel were significantly different before and during the pandemic. This study also reveals significant shift from public transport to private transport and non-motorized modes as preferred during the pandemic. It was because people placed a higher priority on pandemic time for choosing a mode as compared to the general times. Another study conducted by (De Vos, 2020) explained that in response to COVID-19, people will reduce their travel, and will prefer to use active modes or cars over public transport. (Zafri *et al.*, 2021) also represented the demand for public transport decreased due to passengers' lack of convenience to maintain physical distance inside this mode, the demand for private automobiles and active transport modes (walking and cycling) increased during the period of pandemic. Another study exploring the influence of the Covid-19 pandemic on travel pattern and mode preferences in Pakistan shows a significant modal shift from motorbike to non-motorized modes for travel distances less than 5 km. Considering longer distances, people shifted from public transport to private cars. The study confirms respondents prefer mode during pandemic by

prioritizing safety issues such as hygiene, social distance, and cleanliness, etc., during the pandemic (Abdullah *et al.*, 2021).

(Jiao and Azimian, 2021; Politis *et al.*, 2021) aims to explore the relationship between socio-demographic and health factors and changes in travel behaviour during the second phase of this outbreak. From their results it was indicated that all socio-economic variables including age, gender, educational status, marital status, work loss, difficulty with expenses, household size, work type, income, health status, and anxiousness were significantly associated with changes in travel behaviour. Borkowski et al., 2021 explored everyday mobility changes in response to Covid-19. This study looked into the impact of the recent Covid-19 epidemic on the daily mobility of general people. This paper concentrated on modes affected and looked into differences between various societal groups. There were significant drops in travel times during epidemic situations. Those drops were uniform regardless of the age group and gender. The time decrease was found depending on the purpose of travels, means of transport, traveller's household size, fear of coronavirus, main occupation, and change in it caused by the pandemic. It was because, the more the respondent was afraid of coronavirus, the more she or he lessened the travel time.

Although various studies have been conducted on overall travel pattern change due to the pandemic situation. Very few studies were focused on essential purposed travel i.e medical purposed travel. Our aim is to fill the gap of this concern and look meticulous the factors affecting the change of medical purposed travel behaviour.

Methodology and Research Design

The study is designed to explore how an emergency situation like a pandemic can affect the medical purposed travel behaviour of people from different socio-economic background. To conduct this study, a web-based survey, both in Bangla and English version was designed to note the opinions and medical purposed travel pattern of respondents from diverse socio-economic background. The questionnaire survey was circulated through various electronic means such as social media sites, phones, electronic mails and promoted by using the professional and personal links. We had to rely on online surveys to avoid interpersonal contact amidst the pandemic situation and thus have some limitations for survey size. A survey was conducted from January 5, 2021 to March 5 2021 and after initial screening, 240 responses were finalized. The questionnaire was designed to gather information about the respondents' gender,

age, personal income, residence ward, occupation as socio demographic factors. The travel related attributes are assessed by asking about frequency, travel time preference, mode choice for visiting most visited hospital before Covid-19 and if there is any change in any of these attributes during Covid-19. There were also queries about if the respondents have switched to another preferable hospital for visit during the pandemic situation and what changes are occurred in the previous mention travel related attributes. Some of the questions left as open ended and some were close ended where the options are determined by authors from initial pilot surveying.

After finalizing the responses, vigorous descriptive analysis has been carried out by using MS Excel, SPSS, Power Bi and Arc GIS. The analysis is carried out in two fundamental categories: before Covid-19 and during Covid-19 situations. The attributes concerned with during Covid-19 situations are further categorized in three different contexts: Where the respondents made no medical purposed travel during the pandemic situation until the survey is carried out are term as "No Trip", context where respondents who made a medical purposed trip to the same hospital mentioned as most visited before Covid-19 but no change occurred in travel related attributes are referred as "No Change" and "Trip Change" referred to the situation where respondents made travel to same hospital but change occurred in any of the attributes" and the final context referred as "Hospital Switching" where respondents made travel to different hospital during Covid-19 time rather than the mentioned "most visited hospital" before pandemic situation. The result of the analysis is presented through different diagrams (Figure 1), maps and contingency tables.

The travel distances of respondents are measured by distance between their centroid of residence ward and hospital location. The analysis carried out in Arc GIS where, ward boundary centroid location is the origin point of the respondents and point locations found from the hospital shapefile works as the destination of the respondents. As the respondents are reluctant to share their actual location only the information of their residence ward is obtained and utilized.

Mode choice pattern of respondents' analysis involves heterogenous mode choice aspects. For example, a person can use single or multiple mode of transport to get access to hospital before or during pandemic situation. Therefore, this heterogeneity needs to be considered. Regarding this, at first, each trip fraction where a single mode is used between two transfer point/origin/destination is considered as trip and that's how 293 trip fractions found before and 138 trip fractions found during Covid-19 situation. Then

descriptive analysis was done for each trip fractions to assess the overall mode choice pattern of respondents. For context base analysis, Sankey diagram is used for inertia analysis of mode (single or multiple) for "Hospital Switch" and "Trip Change" context of which before and during pandemic situation will be different for mode choice (Anwari *et al.*, 2021). The other two contexts are explained through diagrams.

Result and Discussions:

4.1 Socio Demographic Information:

Table 1 demonstrates the Socio-demographic attributes of the respondents. Out of 240 respondents, females are of 143 in number (59.6%). In terms of age, (17-24) years is the dominant age group among respondents consisting approximate 37.1% of them and 33% belongs to (25-27) age group. According to data, Respondents are mainly students comprising 39.2% of all, 15% of them are job/service holders, 11% of them are teachers and rest of them are from other professions with only 1.3% as homemaker or housewives. Regarding the income, the analysis shows that 31.3% earn within 30000 to 50000 BDT, about 20% earn below 30000 BDT and 25% of them are dependent on others. This skewness of response occurred due to the digital surveying techniques adopted for Covid-19 restrictions, where only a limited portion of people are exposed and familiarized with internet and digital techniques. This is one of the limitations of the study.

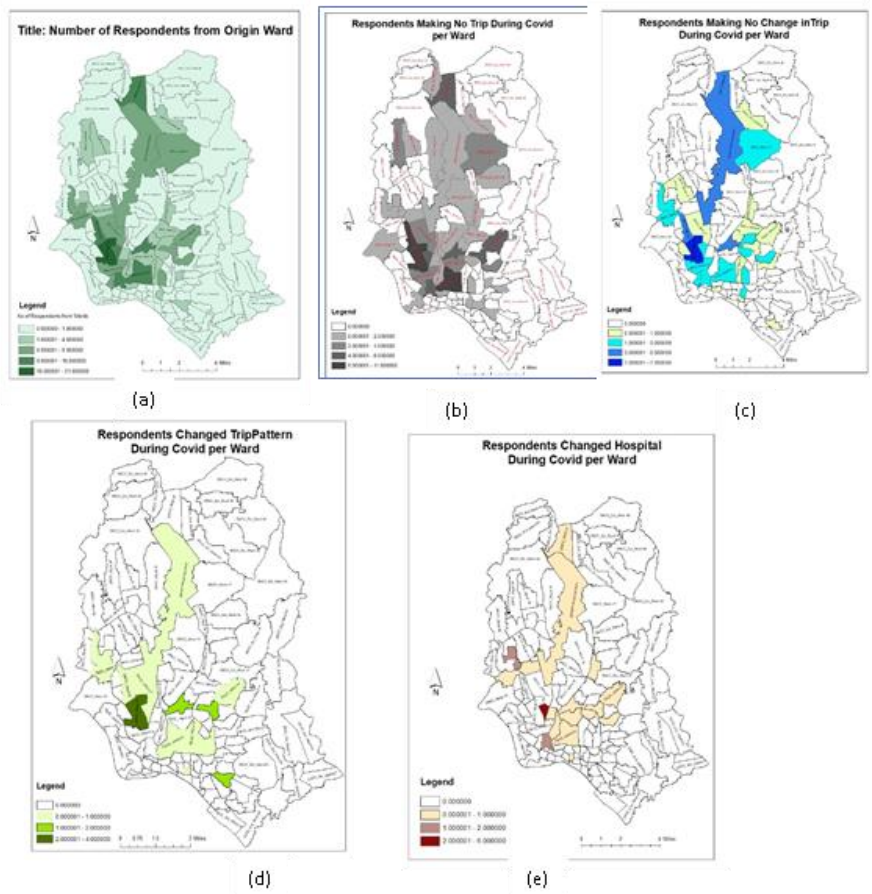


Figure 2: Ward wise showing the No of Respondents' origin (a), No of Respondents of "No Trip" per Ward (b), No of Respondents of "No Change" per Ward (c), No of Respondents of "Trip Change" per Ward (d), No of Respondents of "Hospital Switch" per Ward (e)

The spatial distribution of the respondents is considered by their residence ward as origin of travel. The table 1 shows that the respondents are from 56 different wards of two different city corporations but 8.8 % of them are from DSCC ward no 15. The other notable clusters found in ward no 17, 20, 26 of DSCC and 1,32,35 of DNCC consisting 4.6%, 6.7%, 6.3%, 4.6%, and 5.8% of respondents respectively (figure 1).

Table 1: Socio Demographic Information of Respondents

Socio-Demographic Information of the Respondents					
Sex		**Origin (DNCC-Ward No)**		**(DSCC-Ward No)**	
Variable	Count(%)	Variable	Count (%)	Variable	Count(%)
Female	143(59.6)	Cantonment and Airport	7(2.9)	Ward-12	4(1.7)
Male	97(40.4)	Ext Ward-40	1(0.4)	Ward-13	2(0.8)
Age Group		Ext Ward-49	2(0.8)	Ward-15	21(8.8)
Variable	Count(%)	Ext Ward-51	1(0.4)	Ward-16	2(0.8)
17-24	89(37.1)	Ward-01	11(4.6)	Ward-17	16(6.7)
25-27	80(33.3)	Ward-02	2(0.8)	Ward-18	6(2.5)
28-35	56(23.3)	Ward-06	3(1.3)	Ward-19	4(1.7)
>35	15(6.3)	Ward-10	5(2.1)	Ward-20	15(6.3)
Monthly Income Group		Ward-11	4(1.7)	Ward-21	3(1.3)
Variable	Count(%)	Ward-12	1(0.4)	Ward-23	6(2.5)
Dependent on others	60(25)	Ward-13	1(0.4)	Ward-26	11(4.6)
Below 30,000	49(20.4)	Ward-15	1(0.4)	Ward-27	3(1.3)
30,000-50,000	75(31.3)	Ward-17	6(2.5)	Ward-28	1(0.4)
50,000-70,000	21(8.8)	Ward-19	1(0.4)	Ward-32	1(0.4)
70,000+	35(14.6)	Ward-21	3(1.3)	Ward-36	1(0.4)
Occupation		Ward-22	3(1.3)	Ward-40	1(0.4)
Variable	Count(%)	Ward-23	2(0.8)	Ward-41	3(1.3)

Doctor	11(4.58)	Ward-24	1(0.4)	Ward-42	1(0.4)
Engineer	17(7.08)	Ward-26	1(0.4)	Ward-50	3(1.3)
Govt Service	5(2.08)	Ward-27	5(2.1)	Ward-53	1(0.4)
Job/Service holder	36(15)	Ward-28	2(0.8)	Ward-56	1(0.4)
Housewife	3(1.25)	Ward-30	5(2.1)	Ward-01	9(3.8)
Student	94(39.16)	Ward-32	14(5.8)	Ward-03	8(3.3)
Researcher	14(5.83)	Ward-33	1(0.4)	Ward-04	6(2.5)
Teaching	27(11.25)	Ward-34	1(0.4)	Ward-05	1(0.4)
Urban Planner	10(4.16)	Ward-35	14(5.8)	Ward-06	2(0.8)
Others	23(9.58)	Ward-36	3(1.3)	Ward-08	1(0.4)
				Ward-09	5(2.1)
N= 240, Ext stands for Extension;				Ext Ward 71	1(0.4)

4.2 Travel Patterns Before and During Covid 19:

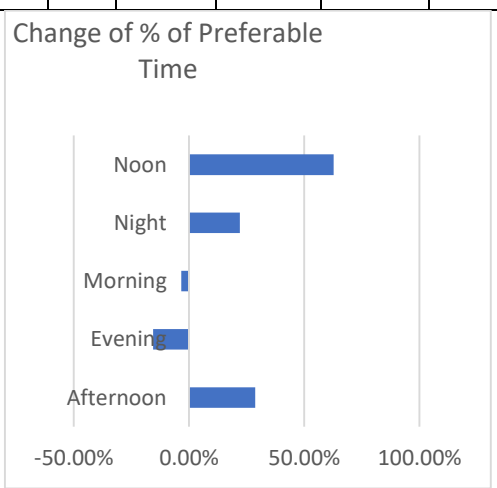
A descriptive analysis is used to demonstrate the change in travel time, travel cost and travel distance of before and during Covid-19 situation. The during Covid-19 situation consists of all three contexts where respondents made a medical purposed trip. Table 2 depicts the minimum, maximum, mean and standard deviation of all scale variables and count and percentage of nominal variables. The change of percentage of nominal variables are presented in graphical form. Here, TC, NC, HS stand for "Trip Change", "No Change", and "Hospital Switch" respectively.

Table 2: Travel Pattern Attributes of Respondents Concerning Before and During Covid-19

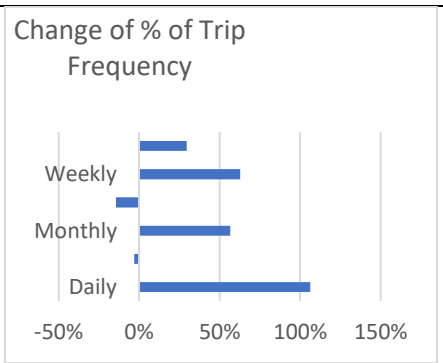
Attributes	Before Covid (BC)(N=240)			During Covid (DC) (N=117)					
	Min	Max	Mean	Min	Max	Mean (all)	Mean(TC)	Mean(NC)	Mean(HS)

Travel Distance (km)	0.2	15.46	2.21	0.29	10.17	2.3	2.11	2.29	2.50
Travel Time (min)	0	340	30.81	0	590	31.81	50.87	26.88	27.88
Travel Cost (BDT)	0	12000	233.86	0	3000	194.54	145	203.78	214.6

Preferable Time	BC	DC
	N =240	N= 117
	Count (%)	Count (%)
Afternoon	35(14.6)	22(18.8)
Evening	102(42.5)	42(35.9)
Morning	83(34.5)	39(33.3)
Night	10(4.2)	6(5.1)
Noon	10(4.2)	8(6.8)



Frequency	BC	DC
	N =240	N= 117
	Count (%)	Count (%)
Daily	7(2.9)	7(6)
Half-Yearly	57(23.8)	27(23.1)
Monthly	17(7.1)	13(11.1)
Occasionally	146(60.8)	61(52.1)
Weekly	5(2.1)	4(3.4)
Yearly	8(3.3)	5(4.3)



Travel Time, Travel Cost and Travel Distance

In this study, both the travel time and cost are measured by aggregating all the separate time duration and costs caused by using multiple modes or single mode for each trip. Euclidean distance between hospital location and centroid of origin ward is considered as travel distance which was measured by ArcGIS. According to Table 2, the overall mean value of both the travel time and travel distance has risen during pandemic situation comparing to the before pandemic time. However, in case of context base analysis the average distance covered by the respondents belonged to "Trip Change" category dropped by 2.11 km while other context maintained to rise the distance. Furthermore, the mean travel time of "Trip Change" category is substantially higher (50.87 min) than the other two categories which has increased the overall mean travel time of medical purposed respondents during Covid-19 time. In case of travel cost, the overall mean value of travel cost incorporating all context has dropped in during pandemic time. The individual context based mean values (BDT :145, 203.78 and 214.6) of travel cost also fell from mean travel cost (233.86 BDT) before Covid 19.

Preferable Travel Time and Travel Frequency

Table 2 exhibits that, respondents in the majority (42.5%) preferred visiting hospitals in evening times before the pandemic situation. A substantial change is perceived during Covid-19 time where the percentage drops by 35.9% although evening is still the highest % of respondents preferred time to visit hospital. This can be explained by context-based analysis showed in figure 2. The analysis shows that respondents in highest number (27 out of 69) from "No Change" group still prefer evening over any other time of the day to visit hospital where respondents in majority of "Trip Change" and "Hospital Switching" group prefer morning over others. However, noteworthy increase is depicted in case of noon and afternoon time its preference by the respondents has increased up to 6.8% and 18.8% from 4.2% and 14.6% respectively which can be described by context-based analysis too. A significant portion of respondents (12 out of 25) who switched hospital during covid time, inclined to visit hospital during noon or afternoon time.

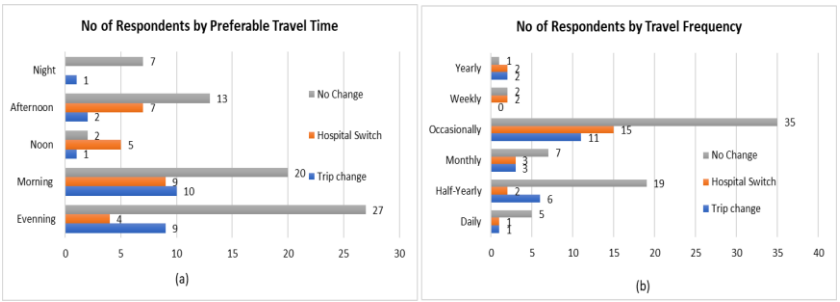


Figure 2 Number of Respondents Making Medical Purposed Trip by Preferable Time (a) Number of Respondents Making Medical Purposed Trip by Travel Frequency (b)

In case of frequency of visiting hospital, a decrease is observed in Table 2 depicting the fall of percentages during pandemic of the respondents who pay visit to hospital occasionally (at a random pattern) or half-yearly although these two segments still depict the highest percentage of the respondents. In addition to that, context-based analysis also refers that, respondents who now visit hospital by different contexts (Trip Change, No Change, Hospital Switching) also visits hospitals occasionally or half yearly most. However, the little increase in monthly and weekly visitors of hospital is mainly due to the respondents who belong to "Trip Change" and "Hospital Switching" categories. Although the most increase in percentage is observed for morning time whose highest shares (5 out of 7) comes from the group of respondents who neither made change in trip pattern or changed hospital during Covid-19.

4.3 Mode Choice Preference Before and During Covid 19:

According to the data, about 30 out of 240 respondents (12.5%) used heterogenous mode for medical purposed travel before the pandemic era. This percentage drops by 8.5% during the pandemic. Those trips conducted by heterogenous travel mode were then further diverged into trip fractions.

Mode Choice Pattern by Trip Fractions

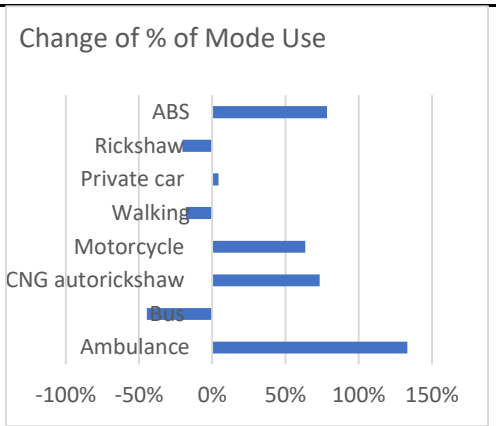
Table 3 depicts the descriptive analysis of mode choice by considering trip fractions for both before and during pandemic situation

Table 3: Mode Choice Preference of Respondents Concerning Before and During Covid 19

Mode Type	Before Covid Count (%)	During Covid Count (%)
Single	210 (87.5)	107 (91.5)
Multiple	30(12.5)	10(8.5)

Mode Choice	Before Covid (293) Count (%)	During Covid (138) Count (%)
Ambulance	1(0.3)	1(0.7)
Bus	19(6.5)	5(3.6)
CNG autorickshaw	22(7.5)	18(13)
Motorcycle	13(4.4)	10(7.2)
On foot	44(15)	17(12.3)
Private car	47(16)	23(16.7)
Rickshaw	128(43.7)	48(34.8)
ABS	19(6.5)	16(11.6)

Change of % of mode choice



*** ABS stands for App based service like UBER/Pathao etc.

The percentage of using multiple mode for commuting to hospital dropped during Covid 19. The social distance, hygiene maintenance and travel restriction made people reluctant of using multiple mode for a single trip. By trip fraction analysis, it is observed that the use of bus substantially drops during pandemic

time from 6.5% to 3.6%. In addition, respondents are also unwilling to use rickshaw for the purpose of hospital or health service visiting and so their % of use also falls by 34.8% from 43.7%. An increment is observed clearly for using private car, app-based services like UBER or Pathao or CNG autorickshaw. Private car and these type of para transits are more of personalized nature and inducive to maintain social distancing and personal hygiene than the public transits. Therefore, respondents choose these modes more during Covid 19 situation.

Mode Choice Pattern by Context:

An emergency situation like Covid-19, has made a change or not in mode choice pattern of medical purposed respondents can be better assessed by context-based analysis. However, before after analysis not be applicable for the context of "No Trip" and "No Change" as in the first case no trip was made during Covid-19 situation and rest one implies to context where no change has been imposed. Therefore, a simple mode choice analysis is shown in Figure 3 (a&b). Nevertheless, to assess the mode choice pattern for "Trip Change" and "Hospital Switch" situations, inertia analysis is perform using Sankey diagram shown in figure 4(a&b)

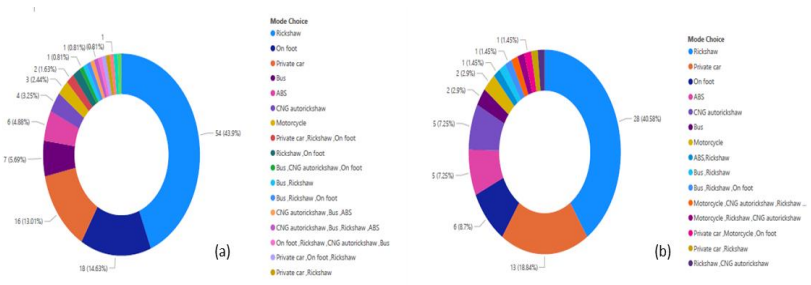
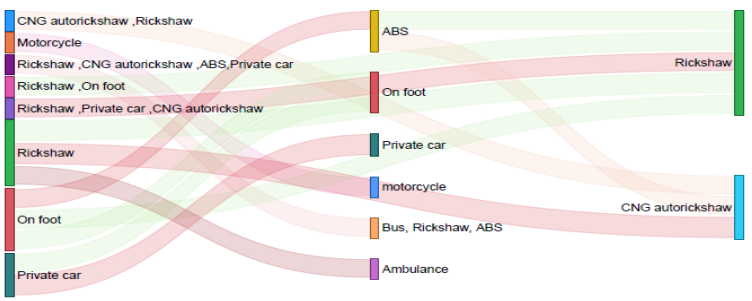


Figure 3 Mode Choice Preference of Respondents of "No Trip" group (a), Mode Choice Preference of Respondents of "No Change" group (b)

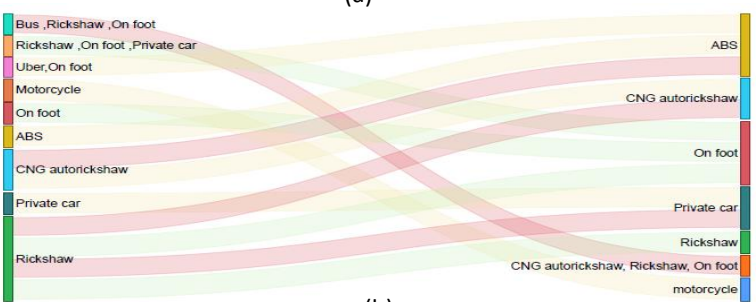
Figure 3 (a) displays that a major portion of respondents who do not make any medical purposed trip during Covid-19 situation up to the survey date used to prefer rickshaw, walking (on foot) and private cars (44%, 15% and 13% of 123 respondents approximately). Approximately 5% of total of respondents used multiple mode to make trip to hospital before Covid-19 situation and rest of them used single type of mode. "No change" context depicts both the before after mode choice pattern of 69 respondents Figure 3(b). This context also reconfirms the

predominance of rickshaw, private car and walking mode as preferable most for medical purposed travel before and during the pandemic situation comprising of 41%, 19% and 8% of 69 respondents (approx.) respectively.

Inertia analysis of mode preference using Sankey diagrams {figure 4 (a&b)} assess the tendency of respondents of "Hospital Switch" and "Trip Change" contexts to continue medical purposed travels by changing or not changing the mode pattern. Left side bars stand for mode preference of before and the right-side bars stand for mode preference during Covid 19 situation. The links between the nodes exemplifies the quantitative change of the tendency of preference and each width is proportional to its respective quantity represented. Figure 4 (a) depicts that, respondents of "Hospital Switch" context shows full inertia of travelling through motorcycle for hospital purposed travel and preferred motorcycle during the pandemic time too. Whereas, the respondents who were using rickshaw, walking or private car have shifted to other modes or interchanged among these available options. However, respondents who used to prefer multiple mode before Covid-19 situation have been shifted to single type of mode for medical purposed travel during the pandemic situation. The overall majority of respondents of "Hospital Change" context prefer to use rickshaw and autorickshaw during the Covid 19 situation. In case of "Trip Change", full inertia is observed among the respondents of Trip Change" group who preferred to travel to hospital by motorcycle, private car or ride sharing service or even preferred walking before the pandemic situation maintained their mode preference fully even during the pandemic. Respondents who used to travel by rickshaw, CNG rickshaw are more prone to shift alternate modes during pandemic times. Switching tendency from multiple modes to single modes is also prominent in "Trip Change" group



(a)



(b)

Figure 4 Sankey Diagrams explaining the mode choice change of group "Hospital Switch" (a) explaining mode choice change of group "Trip Change" (b)

Conclusion:

This study investigated the changes in the travel pattern of medical purposed trips during the Covid-19 situation comparing to the pre pandemic times. The investigation is carried out by detailed descriptive analysis based on three themes: analysis of socio-demographic information of the respondents, assessing the attributes of travel behavior and assessing the mode choice preference. The analysis also reflects three different conditions of during pandemic time: "No Change", "Trip Change" and "Hospital Switch". The respondents are mainly students or working people of medium income range. There is also a spatial cluster shown among the residence of respondents. The average value of overall travel distance, travel time increases during the pandemic whereas average travel cost drops by. The context-based analysis gives detail insights of these disparities. In addition, noteworthy contrasts are also observed in travel frequency, preferable time of visit and mode choice preference of respondents. Respondents are more eager to commute by single mode of transport rather than mode switching during the pandemic time comparing to the before pandemic situations. The findings of this study can be insightful for the policy makers and urban planners. The travel pattern concerning hospital visit particularly in pandemic situation can be transferable to other developing countries as well. Nevertheless, the study has limitations in data collection and analysis as well. Due to the online based survey performed during the pandemic time, the sample size could not be as large as expected. Since the analysis presented in this article are mainly exploratory based, future scope of this study might include advanced data modelling techniques and obtain more accurate results.

References

Anwari, N. et al. (2021) 'Exploring the travel behavior changes caused by the COVID-19 crisis: A case study for a developing country', Transportation Research Interdisciplinary Perspectives, 9(March). doi: 10.1016/j.trip.2021.100334.

Dingil, A. E. and Esztergár-Kiss, D. (2021) 'The Influence of the Covid-19 Pandemic on Mobility Patterns: The First Wave's Results', Transportation Letters, 13(5–6), pp. 434–446. doi: 10.1080/19427867.2021.1901011.

Pawar, D. S. et al. (2020) 'Impact of physical distancing due to novel coronavirus (SARS-CoV-2) on daily travel for work during transition to lockdown', Transportation Research Interdisciplinary Perspectives, 7, p. 100203. doi: 10.1016/j.trip.2020.100203.

Borkowski, P., Jażdżewska-Gutta, M. and Szmelter-Jarosz, A. (2021) 'Lockdowned: Everyday mobility changes in response to COVID-19', Journal of Transport Geography, 90(May 2020). doi: 10.1016/j.jtrangeo.2020.102906.

De Vos, J. (2020) 'The effect of COVID-19 and subsequent social distancing on travel behavior', Transportation Research Interdisciplinary Perspectives, 5, p. 100121. doi: 10.1016/j.trip.2020.100121.

Jiao, J. and Azimian, A. (2021) 'Exploring the factors affecting travel behaviors during the second phase of the COVID-19 pandemic in the United States', Transportation Letters, 13(5–6), pp. 331–343. doi: 10.1080/19427867.2021.1904736.

Politis, I. et al. (2021) 'Mapping travel behavior changes during the COVID-19 lock-down: a socioeconomic analysis in Greece', European Transport Research Review, 13(1). doi: 10.1186/s12544-021-00481-7.

Zafri, N. M. et al. (2021) 'Impacts of the Covid-19 pandemic on active travel mode choice in bangladesh: A study from the perspective of sustainability and new normal situation', Sustainability (Switzerland), 13(12). doi: 10.3390/su13126975.

Abdullah, M. et al. (2020) 'Exploring the impacts of COVID-19 on travel behavior and mode preferences', Transportation Research

Interdisciplinary Perspectives, 8(July), p. 100255. doi: 10.1016/j.trip.2020.100255.

Abdullah, M. et al. (2021) 'Measuring changes in travel behavior pattern due to COVID-19 in a developing country: A case study of Pakistan', Transport Policy, 108(May), pp. 21–33. doi: 10.1016/j.tranpol.2021.04.023.

Chen, X. et al. (2021) 'Exploring essential travel during COVID-19 quarantine: Evidence from China', Transport Policy, 111(July), pp. 90–97. doi: 10.1016/j.tranpol.2021.07.016.

Review Paper

E-waste management in Bangladesh: an overview

Umme Laiba Raha, Department of Geography and Environmental Studies, University of Chittagong, Chattogram; Bangladesh

Abstract

Electrical and electronic waste has grown expeditiously across the world over the last few decades due mainly to increased spending on electronic products. In Bangladesh, the growth of E-waste is expected to reach approximately 15% between 2020 and 2025 which is significantly high. Due to the lack of smart waste management solutions, Bangladesh recycles a tiny fraction of the total waste it produces. The massive rise of e-waste can severely degrade the environmental quality and thus put both human and marine lives at risk. As there was no explicit policy direction concerning E-waste management, the policymakers of Bangladesh have initiated fresh drives to curve the rampant increase of e-waste disposal by adopting stringent E-waste management policy. Through an extensive literature survey and content analysis, this study aims to explore the present state of E-waste management and its impact on human and marine inhabitants in Bangladesh. This study also presents an understanding of how the recently developed legal framework will contribute in controlling the rapid rise of e-waste in this country along with proposed methods for a sustainable management system comprehensively.

Keywords

E-waste, e-waste management, sustainable management, Bangladesh

Introduction

The amount of e-waste is dramatically increasing as a result of the digital revolution and easy accessibility of electronic items. The generation rate has surpassed 72 million tons, which is a 33 percent increase over the previous decade (Namias, 2013). According to a BUET study report, e-waste volumes in Bangladesh will rise to 4,62 million tonnes by 2035. (CERM, 2018). Rapid urbanization, increased purchasing power, and electronic product manufacturers' extensive use of planned obsolescence strategies are some of the factors that contribute to the massive amount of electronic waste generated. The majority of developing and under-developed countries are incapable of the management of E-waste in a way that does not adversely affects the environment or human health due to financial, technological, and political challenges. The most common

method of waste management in Bangladesh is to dump it into landfills. Instead of landfilling, e-waste should be recycled and reused properly with adequate infrastructure. Bangladesh is responsible for approximately 7% of the total E-waste dumping annually all over the world (Awasthi et al. 2016). The current waste management situation in Bangladesh is concerning. Furthermore, the management system possesses major health risks to humans and the environment and requires substantial instantaneous and sustainable solutions. Hence, this study intends to review the waste management system, as well as the existing legal framework related to waste management to ensure environmental sustainability.

Methodology

The study is based on secondary source. Scientific credibility, accuracy, and precision are all critical factors for this work. A variety of content and literature including journals, books, and other recent publications is analyzed to present a reliable conclusion. Moreover, The Government of Bangladesh's (GoB) recent legislation, The Hazardous (e-waste) Management Rules (2021), is presented concisely to represent the current state E-waste management system and the government's laws and acts on this critical issue simultaneously.

Electronic products as E-waste

E-waste generally refers to the electronic waste produced from the disposed electronic gadgets and equipment such as mobile phone sets, televisions, refrigerators, air conditioners, computers and so on that are used in household and various industries (Rode, 2012). Outdated and non-functioning electronic devices are disposed. Among many sources, televisions, computers, electric vehicles, mobile phones, CFL and mercury bulbs, and medical waste are the most common in E-waste generation of Bangladesh (Jungst, 2001; Awasthi et al., 2016).

Status of E-waste generation in Bangladesh

Bangladesh produces E-waste of different kinds from versatile sources, and among all the sources, mobile phones, televisions contribute to the primary portion of total E-waste generated. Mobile phone sets alone produced approximately 10,504 metric tonnes of E-waste in the last 21 in Bangladesh. Moreover, E-waste generation every year is around 2.81 million metric tonnes, with the majority of these wastes are subject to crude landfilling or dumped on open water bodies (Awasthi et al., 2016).

Environmental and health Impacts

E-waste components carry toxic substances representing approximately 70 percent of the hazardous waste of the total solid waste stream. Zinc, lead, cadmium, chromium etc are some of the harmful substances that come in contact with the environment through unrecycled and dumped electrical and electronic wastes of landfills. Therefore, discarded electronic materials are being mixed with soil and groundwater. Moreover, the processes used for the management of E-waste components and potential environmental hazards during management can be summarized in Fig 1. Bangladesh previously restricted the import of second-hand electronics under the Basel Convention and Import Policy Order of the Government of the People's Republic of Bangladesh. Furthermore, the recently developed E-waste management regulations 2021 prohibited the importation of old or used electronic products, with a few exceptions (for research purposes and in academic institutions with a no objection certificate from the Department of Environment).

Studies have shown that E-waste causes great damage to human body, for example, cancer, nerves breakdown, asthma, hearing and visual problem, kidney and brain disorders, liver and lung damage. Furthermore, it enhances infant mortality. According to Chowdhury et al., 36.3 percent of 1000 mothers living near informal recycling sites in the Sylhet district of Bangladesh had a baby die, and 64 percent had hearing or vision impairments. (Alam & Bahauddin, 2015).

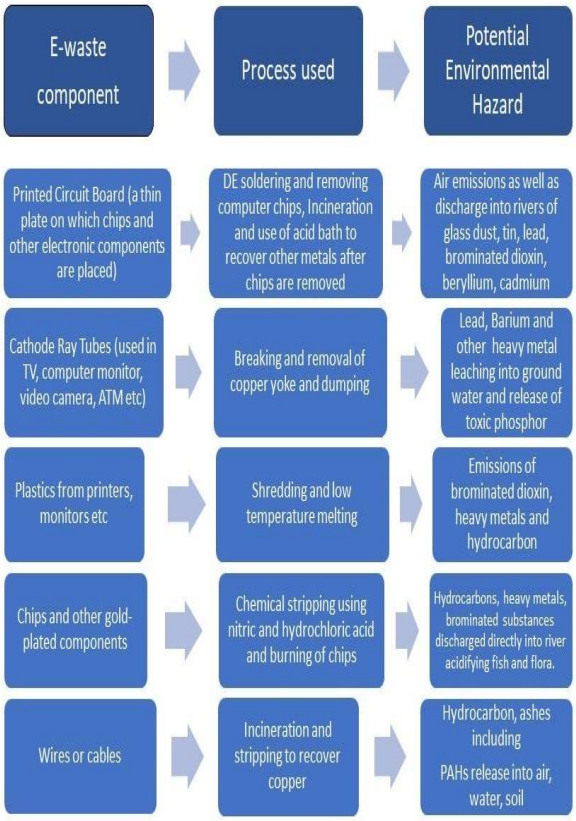


Fig 1. Effects of E-waste on environment through various processes (Pinto, 2008; Robinson, 2009; Grant et al., 2013)

E-waste management in Bangladesh

6.1 Reuse

In Bangladesh, the system of managing waste is unorganized. Among all the processes, reuse practices frequently occur in Bangladesh. In Dhaka, almost 63.37% of the total E-waste is resold after repairing old electrical and electronic products (Sudipta et al., 2017).

6.2 Recycling

Recycling of E-waste is necessary for retrieving new function-able electrical and electronic materials. The recycling process is not common across the country. Particularly in Chattogram and Dhaka, E-waste is recycled (ESDO, 2014). Moreover, only 20% to 35% of all generated e-waste is recycled in Dhaka and

Chattogram, with the remainder being thrown haphazardly here and there, posing risks to individuals' health and the environment (Islam & Emon, 2016). Different studies critically reviewed and evaluated the present E-waste recycling and reuse processes in Bangladesh concerning the vendors also with the laborers of the recycling companies (Alam & Bahauddin, 2015; Riyad et al., 2014).

6.3 Dumping and Landfilling

The majority of computers and mobile phones are disposed of in litter bins. Clinical E-waste is primarily disposed of in offices, with the rest disposed of in litter bins and accumulators. In large cities, incinerators burn medical wastes. Due to the sheer massive cost and inadequate preventive measurements, incineration technologies are not widely used. In Bangladesh, crude open dumping is common for landfilling.

E-waste management laws and acts in Bangladesh

7.1 The Hazardous (e-waste) Management Rules, 2021

This is the first formal legislation regarding the E-waste management in Bangladesh that enables large e-waste producers to store and recycle wastes in a systematic manner. Under the Bangladesh Environmental Protection Act (1995), the rule covers home appliances, monitoring and control equipment, medical equipment, IT, and communication equipment. DoE restricted the use of some specific substances in electronic devices (Table 1). In addition, obligations for manufacturers, assemblers, collectors, sellers, and consumers of the products have been established. Upon violation of the rules, the offender is liable to imprisonment or fine or to both. The e-waste management rules will aid the Department of Environment in bringing all of the country's extended producers of electrical and electronic waste under an appropriate management system. Manufacturers, large importers, dismantlers, recyclers, traders or shopkeepers, hoarders, logistics companies, repairers, collection centers, auctioneers, and exporters will be registered and this will also enable efficient monitoring of management activities across the country. Furthermore, the rules assist in determining the responsibilities of different waste manufacturers, assemblers, hoarders, and recycling companies for their storage and disposal operations. Moreover, as mentioned earlier in the paper, apart from limited exceptions (for the reasons of research use and in academic institutions with a no objection certificate (NOC) from the Department of Environment), the recent e-waste management regulations prohibit the import of old or used electrical and electronic products.

7.2 Urban Management Policy Statement, 1998

As part of the government's incentive to support the logistical as well as the economic services, municipalities were proposed to contract out the disposal of

waste, drain cleaning, etc. However, there was no framework for sorting solid wastes depending on their attributes in this regulation.

7.3 Environment Conservation Rule, 1997

According to this rule, projects that include landfilling will undergo environmental impact analysis and mandatorily need to obtain a No Objection Certificate.

7.4 Environmental Protection Act, 1995

It allows the Director General to carry out any action compulsory to protect as well as to improve the superiority of atmosphere.

7.5 The Environment Policy, 1992

According to this act, the disposal of wastes in water bodies from farming, industry, and municipal activities is illegal. It lacked adequate waste disposal plans.

Table 1. Threshold limits of restricted hazardous substances (DoE, 2021)

Substance name	Limit
Cadmium	0.01%
Lead	0.1%
Mercury	0.1%
Chromium VI	0.1%
Polybrominated biphenyls (PBB)	0.1%
Polybrominated biphenyl ethers (PBDE)	0.1%
Bis (2 -ethylhexyl) phthalate (DEHP)	0.1%
Butyl benzyl phthalate (BBP)	0.1%
Dibutyl phthalate (DBP)	0.1%
Diisobutyl phthalate (DIBP)	0.1%

Proposed E-waste management strategies

8.1 Energy generation from recycled E-waste

Bangladesh's per capita energy consumption is 344 kgoe (Kg Oil Equivalent) and per capita, electricity production is 510 kWh, both of which are lower than other South Asian countries. (2020, HCU). Electrical wastes and plastic, if treated appropriately, can be a great source of energy, providing Bangladesh with a considerable amount of power that the country currently lacks. Electronic chips,

which contain a high percentage of volatile composites (approximately 83.44 percent), can be a major energy source if used in an environmentally friendly manner (Othman et al. 2009).

8.2 Sustainable recycling and reusing

In addition to recycling, e-waste should be available for repurposing through increasing access to consumers and developing the necessary infrastructure. Figure 2 represents the proposed method for the sustainable reuse of E-waste.

A sustainable process of reusing and recycling E-waste includes collection of electronic and electrical waste and sorting the non-functioning devices into categories such as computer chips, circuits, cables, etc. The fragmented parts of various electric devices will then be forwarded to the divisional recycling factory. In the municipal recycling factory, operators and labours in the supply network of dissimilar parts will disassociate the element and afterward recycle sequentially. The recycled portions are transferred to the constructors after a proper recycling procedure. Assembling Corporation creates electric new goods in a variety of ways, such as transforming CRT televisions into low-cost TV sets and video game displays, among other things. Actions involving refurbishment bring non-functional microelectronics back to an operational state. The whole efficiency of materials arising from discarded devices spurred into new manufacturing circles.

Fig 2. Proposed framework for sustainably reusing E-waste (Sudipta et al., 2017)

Conclusion

Inadequate infrastructure and facilities, as well as insufficient funding of Bangladesh, impede the E-waste management system. Moreover, the approaches used in Bangladesh to manage E-waste are insufficiently effective. Reuse and energy generation from E-waste are sustainable management systems that have been proposed in this article, along with a discussion on laws and acts related to the management of E-waste. Implementing the mentioned model besides the recent policy can solve major problems regarding E-waste management.

References

Alam, M; Bahauddin, K M (2015) "Electronic waste in Bangladesh: evaluating the situation, legislation and policy and way forward with strategy and approach", Environment and Sustainable Development Vol. 9 No. 1.

Awasthi, A.K., Zeng, X. and Li, J (2016) "Comparative Examining and Analysis of E-waste Recycling in Typical Developing and Developed Countries," Procedia Environmental Sciences, 35 (July).

Centre for Environmental and Resource Management (CERM), Bangladesh University of Engineering and Technology (2018), "Assessment of Generation of E-Waste, Its Impacts on Environment and Resource Recovery Potential in Bangladesh," Dhaka, Bangladesh.

ESDO (2014), Magnitude of the flow of E-waste in Bangladesh, Dhaka, Bangladesh.

Grant, K; Goldizen, FC; Sly, PD; Brune, M-N; Neira, M; van den Berg, M & Norman, RE (2013) "Health consequences of exposure to E-waste: a systematic review", Lancet Glob Health, Elsevier, Vol. 1 No. 6 (December).

Hydrocarbon Unit-HU, Ministry of Power, Energy and Mineral Resources (2020), Energy Scenario, Dhaka, Bangladesh.

Islam, M. S; Emon, M. M. H (2016) Current status with facing challenges by entrepreneurs and future prospect of plastic sector in Bangladesh. Paper presented at the International Plastic Summit, Bangladesh Plastic Goods

Manufacturers and Exporters Association (BPGMEA), Dhaka, Bangladesh.

Jungst, RG (2001) "Recycling of electric vehicle batteries", Industrial chemistry library, 10:295327, Elsevier.

Namias, J (2013) "The future of electronic waste recycling in the United States: obstacles and domestic solutions", Columbia University.

Othman, N; Mohd Sidek, L; Ahmad Basri, NE; Muhd Yunus, MN & Othman NA (2009) "Electronic Plastic Waste Management in Malaysia: The Potential of Waste to Energy Conversion", Energy and Environment.

Pinto, V.N (2008), "E-Waste Hazzard: The Impending Challenge", Indian Journal of Occupational and Environmental Medicine, Vol. 12 No. 2 pp. 65-70.

Riyad, A; Mahbub Hassan, K; Jabed Iqbal, M; Rahim MABDUR & Uddin, SW (2014) "E-waste recycling practices in Bangladesh" Int J Renew Energy Environ Eng, Vol. 2 No.3.

Robinson, BH (2009) "E-waste: an assessment of global production and environmental impacts", Sci Total Environment, Vol. 408 No.2 pp. 183–191.

Rode, S (2012) "E-waste management in Mumbai metropolitan region: Constraints and opportunities", Theoretical and Empirical Researches in Urban Management, Vol.7 No.2 pp. 89-103. Retrieved from http:// um.ase.ro/no72/5.pdf.

Sudipta, C; Javed, SA; Biswa, P (2017) "Reusing and recycling practice of E-waste in Dhaka City", In International Conference on Engineering Research, Innovation and Education (ICERIE), pp.1–7.

Research Paper

3R Approach for a Sustainable Municipal Solid Waste Management System
A study of Ward No.1 of DNCC

Mehjabeen Haque Mohona, Student, Department of Urban and Regional Planning, Jahangirnagar University, Savar; Bangladesh.

Mohammad Mizanur Rahman, Assistant Professor, Department of Urban and Regional Planning, Jahangirnagar University, Savar; Bangladesh.

Abstract

Bangladesh, as a small country with a huge population, generates an enormous quantity of waste on a daily basis. Our country has a low waste collection coverage due to the lack of a specific authority responsible for waste management from collection to final treatment, leading the majority of waste to be deposited on open ground or in water bodies. Despite having a National 3R Strategy, this practice is not widely seen in our country. Besides, the strategy is solely focused on how waste should be managed once waste is collected, whereas there are ways to apply 3R long before the generation of waste. This study aims at figuring out the components behind the generation of household solid waste and finding the methods to incorporate 3R in our daily lives. The area selected for the study is ward no.1 of zone 1 DNCC. Based on study aims, data were collected from field survey through questionnaire. Multiple choice questions with a five point (1-5) Likert Scale was used for questionnaire survey and 396 household samples were collected by Simple Random Sampling (SRS) process. Statistical measures, such as correlation and Principal Component Analysis (PCA) were evaluated using SPSS statistical tools. With about 33% of the households executing at least one of the three approaches of 3R, generation of different categories of waste could be minimized. Medical waste has risen up to 12.7% and significant correlation between food waste and rooftop gardening(r=0.78); plastic waste and takeaways (r=0.9) was found. PCA showed three main components that are influencing 3R. It is expected this study exposed the degree of 3R practice in household level and recommends how these variables can be navigated for 3R application purpose to transfigure the entire MSW management system in a sustainable manner.

Keywords: *3R, Reduce, Reuse, Recycle, National 3R Strategy, MSW, Municipal Solid Waste, MSWM, Sustainable SWM, Waste Minimization, And Zero Waste.*

Introduction

1.1 Research Background

The solid waste problem in Dhaka, Bangladesh's capital is worsening in compared to cities in other developing countries, (DoE, 2013). The city's population has increased by more than 4% in the previous decade, and Dhaka is expected to rise in the rankings. After Delhi, Tokyo, and Shanghai, it will be the world's fourth biggest metropolis by 2030, with a population of approximately 28 million people (UNDESA/PD, 2018). Dhaka now faces a massive amount of environmental issues as a result of its fast population expansion, congestion, and unplanned urbanization. The current waste management system has a trash collection effectiveness of 55% on average (DoE, 2013). By 2025, however, if 100% of trash is collected and sent to the landfill, it would require about 79.35 hectares, but the current two dump sites' total land size is just 60 hectares (Kabir, 2015). National 3R Strategy for Waste Management, 2010 clearly stated its objectives and purposes in terms of managing solid waste in a solid manner but this approach is not widely seen. Dhaka Municipal Corporation estimates that 3500 tons of solid garbage are generated every day in Dhaka (The value is found higher in some recent studies). Nearly 400 tons are sent to the roadside and open space (Yasmin & Rahman, 2017). The current solid waste management method is named collect-transport-dispose and is based on the end-of-pipe concept. This strategy is both unsustainable and expensive (Enayetullah & Hashmi, 2006). The product's life cycle should lead the actions required to create and implement a comprehensive 3R effort (Srinivas, 2015).

1.2 Objective

To accomplish the research, two objectives were determined.

- Scrutinizing the current municipal solid waste management system
- Identifying means of 3R and suggesting ways of 3R incorporation into the system and residential practice in an integrated way

Methods

2.1 Context

2.1.1. 3R Concept & Guideline for Bangladesh

The famous and well-known "3R" idea relates to reduce, reuse, and recycling, especially in the context of waste generation and consumption. It demands for a greater use of recyclable materials, more reuse of raw materials and industrial waste, and a reduction in total resource and energy consumption. These concepts apply to the full lifespan of products and services, from design and raw material

extraction to transportation, manufacturing, usage, dismantling/reuse, disposal, and waste treatment (Srinivas, 2015). Emphasizing waste avoidance/reduction over recycling, and recycling above all other kinds of ecologically unsound disposal are the primary aspects of the national strategy for promoting (National 3R Strategy for Waste Management, 2010). Whenever feasible, reusing non-avoidable trash keeping the amount of hazardous trash in the garbage as low as possible ensuring environmentally sound residual waste treatment and disposal.

2.1.2. Study Area Profile

Area selected for the study is ward 1 of DNCC, (Waste Report, 2018-2019) has shown that ward 1 of DNCC zone 1 has the highest per ward waste collection amount that is 114,924 kg which is far larger than any other ward. In 2019 3R approach has been initiated by introducing source separation scheme but unfortunately it failed. Number of households in ward 1 is 42,630 which is larger than other wards of zone 1 and 2. Ward 1 consist of total 11 sectors of Uttara R/A. They are sector: 3,4,5,6,7,8,9,11,12,13,14. Which is ensures diversity in responses.

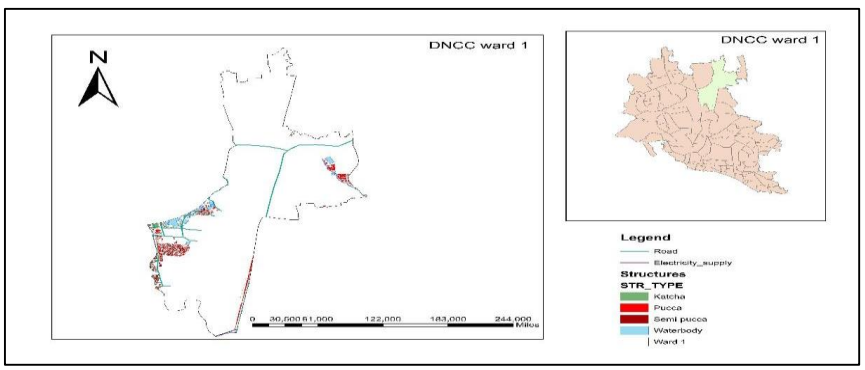


Figure 1: Study Area; Ward 1 of Dhaka North City Corporation

2.2 Data Collection Procedure

A semi - structure questionnaire survey was done to investigate the study objectives, considering the socioeconomic status of the population, national guidelines, and literatures. The questionnaire survey covered demographic variables of the households (e.g. total number of members, monthly income), composition of MSW per day (e.g estimated weight of total produced waste, approximate weight by category such as organic, paper, plastic, metal, medical waste etc.), degree of 3R application (e.g. whether or not incorporate any reduce, reuse or recycle from waste generation to disposal, if applied which category of waste had significant amount of change etc.), components behind waste

generation to disposal (e.g. Economic Factors, Environmental Concern, Information & knowledge, Moral Obligation, Subjective Norms). A five-point (1-5) Likert Scale was utilized to assess the statement descriptions, which span from strongly disagree to strongly agree, in addition to multiple choice questions. The study's sample unit was a home. Simple Random Sampling (SRS) can be used in household surveys provided a complete list of households in the survey area is available (Designing Household Survey Samples: Practical Guidelines, 2005). The Taro Yamane scientific formula can be used to compute the sample size because the population size (household number) is known. The formula is:

n= $\frac{N}{1+Ne^2}$, n = Sample size, N= Population size= 42,630 (RAJUK, 2019), e = Margin of error (MoE)= 0.05. So, n =$\frac{42,630}{1+42,630\ (.05)^2}$ =396.

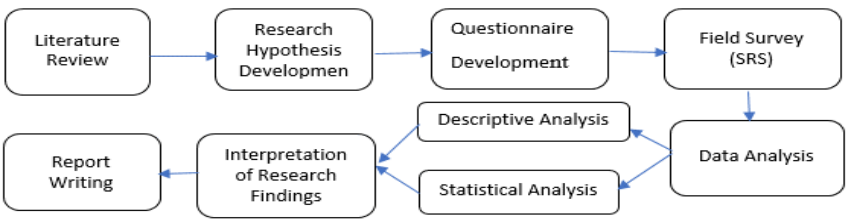


Figure 2: Methodology of the research

A total 396 households were part of the research. To ensure a diversified result, no less than 35 data was collected from each sector. In order to shed light on the current status of waste management of the study area, field observation, structured interviews of the officials and staff of City Corporation were also conducted.

2.3 Data Analysis

Data were analyzed with Microsoft Excel (2010) and Statistical Package for Social Science (SPSS) version 26.0 using a frequency, percentage, Pearson's r (correlation coefficient) and Principal Component Analysis (PCA). Pearson's r (correlation coefficient) is a test for determining the statistical link between two variables. It gives information about magnitude of association or co relation or direction of relationship. If the effect size r= +/- .9-1 it is very highly correlated, +/- .7-.9 it is highly correlated, +/- .5-.7 it is moderately correlated and +/-.3-.5 indicates low correlation. PCA was applied combined with Varimax rotation and Kaiser Normalization (Bodrud-Doza, et al., 2019). Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were employed to check the analyses' requirements before doing PCA. The KMO test result (0.781) and Bartlett's Sphericity Test result (.001) indicate the dataset is suitable for PCA. The number

of factors chosen was based on Kaiser's principle, which stipulated that only factors with Eigenvalues greater than 1.0 were considered.

Result & Discussion

3.1 MSW of DNCC Ward 1

3.1.1. Current MSW Management Procedure

Regular Dumping Process

At first the waste is collected door to door collections. Most f the houses dump the waste in waste bin then gathered in the common dumpster of most buildings. Then the waste is collected by City Corporation appointed waste collector from every sector and it is disposed at Secondary Transfer Station (STS), Ajampur. Then the whole volume of waste is loaded on heavy tractor and transported to Final dumping site which is in Aminbazar. Sometimes waste is segregated by informal activists (tokai) and they collect recyclable goods from the dumpster. And finally, the rest of the waste is incinerated and pressed in the landfill.

Source Separation

Some households separate the waste from source and repurpose the waste material in other section. Mostly the separated waste goes in recycling sector. They earn profit by selling recycled items in informal sectors. The products are being resold as long as shell life does not expire.

Illegal Dumping

Illegal dumping is done once in a while the study area. Households especially situated near open spaces, water body, dumpsters. Illegal dumping on the roads or drains is mostly seen. Because of this kind of illegal dumping blockage of drain/roads happens. Which lead to resource destruction, environmental pollution.

3.1.2. MSW Composition

In term of waste generation, the composition of the waste is a significant factor. If the composition of one's waste generation is known, then it would be possible to minimize or navigate the amount of waste in a proper manner. From the survey, the composition of waste has been collected. Waste can be divided into 8 categories.

Table 1: Composition of MSW

Category	Standard MSW Composition (%)	MSW Composition from Field Survey (%)
Food/Organic waste	68.3	48.4
Paper	10.7	6.8
Plastic	4.3	11.6
Textile and wood	2.2	5.1
Lather & rubber	1.4	2.0
Metal/ E-waste	2.0	4.3
Medical waste	-	12.7
Glass	0.7	0.9
Others	10.4	8.2

Source: Field survey, 2021; (Sahu, et al., 2017)

Among the categories medical waste is an additional category which includes gloves, masks, glass, syringe, insulin, tablets, syrup bottles etc. This category has been included in 'others' in the standard composition, but this type of waste has increased since last year for the covid-19 pandemic and with the weight of every mask 1-g gram, glove 6.5 gram on average the amount required an individual category.

3.1.3. Residential 3R Practice

The 3R practice can be incorporated into the day to day lives of the lives of the residents if they are aware of the concept. The concept is not widely known but its use is being seen quite extensively. 33% of residents execute 3R and among them the following 27% execute reduce, 29% reuse and 44% recycle. A strong prerequisite of 3R is source separation also. It ensures proper categories of waste designation and ensures sound management. 125 household out of 396 execute source separation. Among them 26.4% so it for recycling purpose, 71.2% for composting purpose, 2.4% out of environmental concern. Among the 68.4% who do not separate waste, 49.4% found it time consuming. 17.3% have lack of space in kitchen, 17.3% do not find any utility behind source separation and 7.8% do not have any motivations behind it.

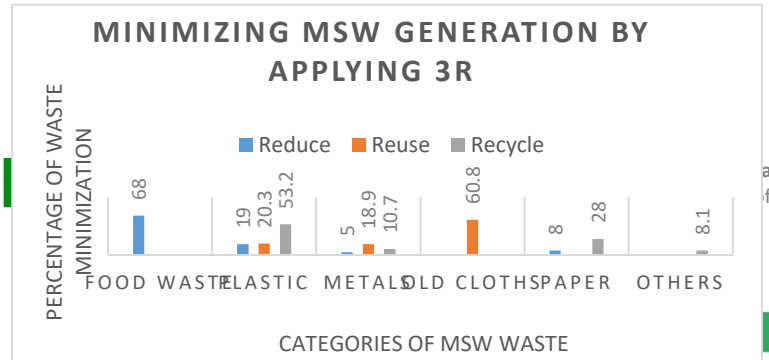


Figure 3: Reduce, reuse and recycling practice of households and categories of execution. Source: Field survey, 2021

Among the components of 3R, recycling is largely seen because of it has an instant and effortless business opportunity to work with which is profitable and with time this industry is expanding in our country.

The study came across total 27.1 kg plastic, 67 kg paper, 18 kg metal. The unit price of the materials are respectively 25tk/kg, 18tk/kg, 30tk/kg. It may vary from sector to sector, feriwala to feriwala. The reason behind recycling is popular among the three aspects is mostly because of its monetary value. So, it can be said that recycling itself can be a lucrative business sectors both for vendors and for the customers.

3.1.4. Rooftop Gardening and Organic Food Waste

Rooftop gardening has become a new trend countrywide. It is environment friendly and helps to restore the green space in concrete surrounded city life. 39.4% of the total households have rooftop gardening among them 73% use homemade compost and 27% use store bought compost. Homemade composting is a process of repurposing the organic waste of households which includes fruit and vegetable peals, eggshell, tea leaf etc.

Now from the survey, it has come to light that households which are associated with rooftop gardening produce .5-.8 kg of wastes whereas people who are not associated with rooftop gardening produce 1-3 kg of food waste every day.

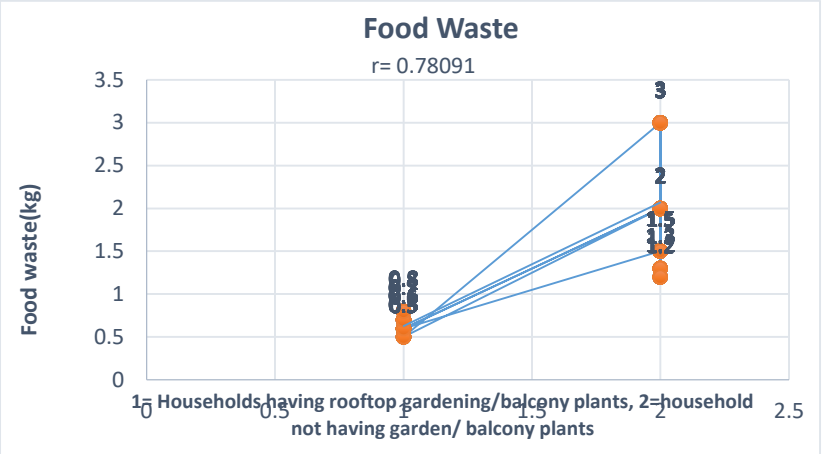


Figure 4: Correlation between rooftop gardening and organic food waste

In order to calculate the r value of the given two variables, on x axis food waste per kg and y axis codes are set then the correlation test is run. The value of r came out to be r= 0.78091 which is from the standard is very highly correlated. That means households which are associated with rooftop gardening produce less waste than the households not associated with rooftop gardening.

3.1.5. Takeaways and Plastic Waste

With 36.6% of the households ordering takeaways, it comes with a baggage full of waste. Cardboard boards wrapped with plastics, plastic utensils etc. which are entirely non-biodegradable. The order also varies from families to families. Frequency of takeaways determines the amount of generated non-biodegradable waste which comes along with it. 36.6% of the residents' order takeaways and its frequency determines how much additional plastic and packaging waste comes along with it. 44.8% of the takeaway users order once a week, 26.2% order 2-3 times, 9.7% order 4-5 times and 19.3% order everyday of a week.

Plastic generation also varies with takeaway orders. 63.4% of households who do not order takeaways produce .1-.3 kg of plastic waste each day whereas households ordering takeaways produce up to 1 kg of waste the day takeaway delivery comes.

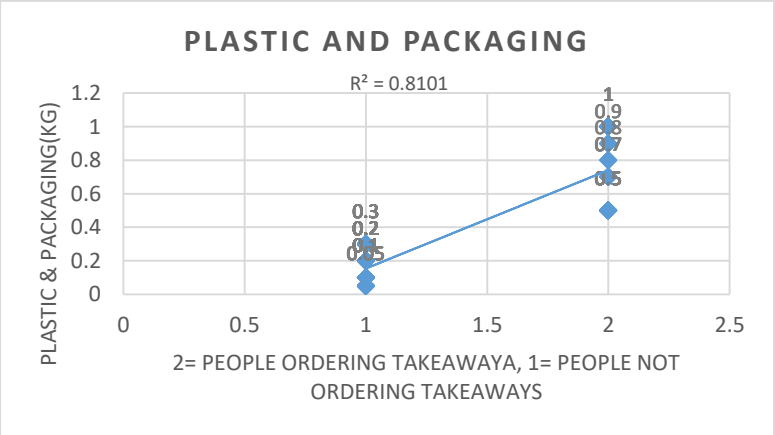


Figure 5: Correlation between takeaway orders and plastic waste

1 stands for families ordering takeaways and 2 stands for families not ordering takeaways. On x axis plastic and packaging waste per kg and y axis codes are set then the correlation test is run. The value of r came out to be r= 0.90110 which is from the standard is very highly correlated according to Pearson's Correlation. For convenience the packaging being non-biodegradable, it is not sustainable.

3.1.6. Factors Affecting 3R

There are several factors that are closely related to 3R. These factors can also be divided into indicators and the perception of 3R users regarding these indicators. A linear pattern of answers means they agreed to the statements and a reversed graph would show different opinion regarding the statement.

Table 2: Factors and indicators related to 3R.

Factors	Symbol	Indicators
Economic Factors	*EF 1*	Reduce and reuse of waste can minimize monthly cost
	EF 2	Waste recycling is profitable
Environmental Concern	*EC 1*	Protecting the environment is our responsibility
	EC2	Proper MSWM can decrease environmental pollution
	IK 1	Reduce, reuse and recycling are sustainable methods

Information & knowledge	*IK 2*	3R protects the landfills from turning into disposal sites
Moral Obligation	*MO 1*	Waste is not a waste unless we throw it
	MO 2	Waste can be turned into wealth
Subjective Norms	*SN 1*	Individual contribution can bring change in large scale
	SN 2	Reusing used materials is shameful

The interaction between the respondent's perspective and the factors related with 3R practice was investigated using Principal Component Analysis. The computed factor lodgings, as well as the cumulative percentage and percentages of variation, are shown in the table. Three variables or main components (PCs) were recovered via PCA, accounting for 56.72 percent of the total variance. The screen plot is used to determine how many PCs should be kept to put into the underlying variables, whereas the rotation matrix plot shows a substantial relationship between the study variables.

Table 3: Varimax rotated Principal Component Analysis Table

	PC1	*PC2*	*PC3*
EF2	.815	-.017	.013
EF1	.766	.164	.217
MO2	.563	.208	.463
EC2	.311	.675	-.281
IK2	.051	.674	.197
MO1	-.187	.620	.358
SN1	.256	.584	.425
EC1	.510	.565	.026
IK1	.029	.027	.699
SN2	.253	.199	.580
Eigenvalues	3.366	1.264	1.043
% of Variance	33.656	12.636	10.428
Cumulative %	33.656	46.292	56.720

In the study, *PC1, PC2, PC3* elucidates the total variance of 33.656%, 12.636%, 10.428% respectively. Based on the result PC1 elucidates 33.656% of the entire variance which includes a significant amount of positive loading with *EF2:* .0815, *EF1*: 0.766, *MO2*: 0.563, *EC1*: .051, in accordance with (Wang, et al.,

2017) classification of loading score of PCA. PC2 dataset elucidate 12.639% of the entire variance which includes a significant amount of positive loading with *EC2*: 0.674, *IK2*: 0.674, *MO1*: 0.620, *SN1*: 0.584, *EC1*: 0.565. PC3 elucidates 10.428% of the total variance loading score *IK1*: 0.699, *SN2*: 0.580. In sum, if the residents believe these factors, 3R implementation from root will increase at a significant level.

a. Screen Plot b. Component Plot in

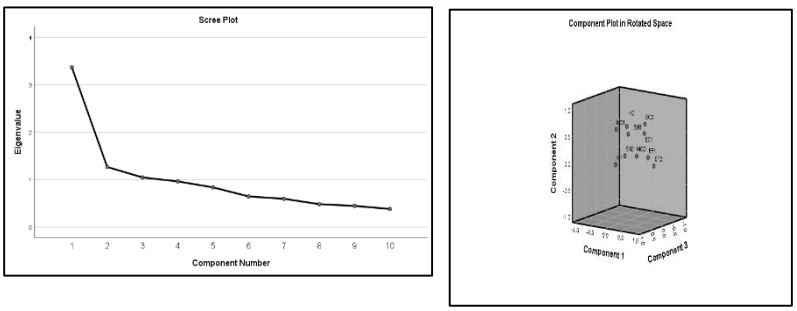


Figure 6: Principal Component Analysis by *a.* Screen Plot of the Characteristic roots and b. Component Plot in rotated space

3.2 Proposed ideas for 3R incorporation in residential waste generation practice

3R must be applied long before the generation of waste and thus the waste production can be minimized and manageable to the highest degree. Besides application of this approach can bring sustainability in social, environmental and economic aspects. It should also be applied during and after waste collection. Here is an integrated model for 3R:

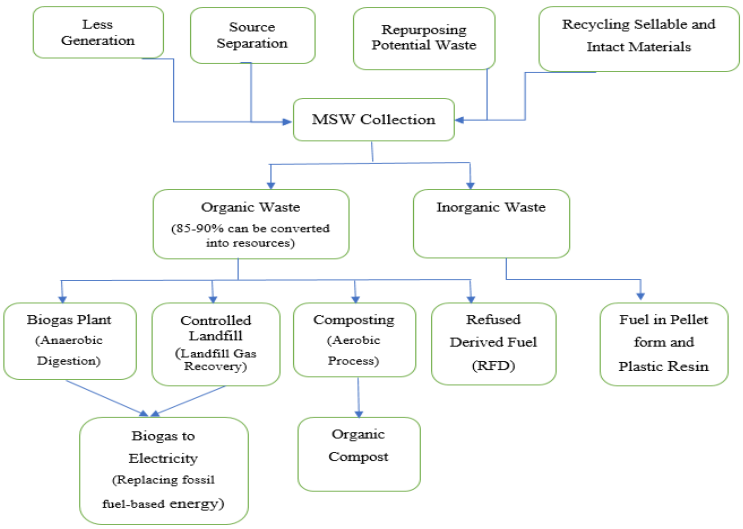


Figure 7: Integrated 3R based Waste Management Model; Source: Prepared by author, 2021

Incorporation of 3R in every level of food and production chain would be subsidiary towards the entire system of waste management. Here are some recommendations of 3R incorporation:

Manufacturing: Designing for 3Rs, indication of eco labels, reduction of byproducts, use of recyclable parts of any material etc. are helpful to ensure as little hazardous or non-biodegradable material enter our system.

Distribution: Distribution of packages are important as these end up in the waste bins of households. Simplified packaging, use of reusable boxes, using biodegradable materials for making packaging boxes, supply of echo labeled goods etc.

Consumption: In term of consumption green purchasing, carrying a bag for grocery shopping ensures extra packaging does not come along. Household waste sorting, bringing recyclables to collection etc. would contribute towards waste reduction.

Awareness: Waste is not waste unless we throw it in the bin. Increasing awareness of the residents will contribute to less generation of waste on a regular basis. Mass media, print media, familial norms etc. play roles in raising awareness.

Network between Government and 3R stakeholders: Department of Environment (DoE) has published National 3R strategy, there are action plans for the city corporations for waste and resource management. Yet this approach has not been fully adapted. A network between the government and 3R stakeholders must be created and maintained appropriately.

Conclusion

3R is a sustainable approach of waste generation and its management being applicable at social, environmental and financial aspects. It is both cost friendly and low maintenance. In spite of having an entire strategy of national 3R, Bangladesh is lagging behind to perform it extensively. By minimizing waste generation, repurposing potential waste, hence applying 3R can ensure a sustainable MSW management system at every level. The Government and the private organizations should come forward with enthusiasm to support and implement as well as modify the existing policies to make it more time worthy and eco-friendly. Incorporating 3R is the first leap towards sustainability and if the process is fully organized, our country can be of great assistance towards the world environment conservation.

References

Alamgir, M. & Ahsan, A., 2007. MUNICIPAL SOLID WASTE AND RECOVERY POTENTIAL: BANGLADESH PERSPECTIVE. Iran. J. Environ. Health. Sci. Eng , Vol. 4, No. 2, pp. 67-76.

Anon., 2018. UNDESA, New York: The World's Cities in 201; World Urbanization Prospects: The 2018 .

Bodrud-Doza, M. et al., 2019. Hydrogeochemical investigation of groundwater in Dhaka city of Bangladesh using GIS and multivariate statistical techniques. Groundwater for Sustainable Development, Volume 8, p. 226–244.

Designing Household Survey Samples: Practical Guidelines, 2005. New York: Department of Economic and Social Affairs: United Nations.

DoE, 2013. Bangladesh Environment and Climate Change. [Online].

Enayetullah, I. & Hashmi, Q. S. I., 2006. Community Based Solid Waste Management Through Public-Private-Community Partnerships. Tokyo, Japan, s.n.

Kabir, M. R., 2015. Municipal Solid Waste Management System: A Study on Dhaka North and South City Corporation. Journal of Bangladesh Institute of Planners, ISSN 2075-9363, Vol. 8, pp. 35-48.

National 3R Strategy for Waste Management, 2010. Dhaka: Department Of Environment.

Rotich, K. H., 2006. Municipal solid waste management challenges in developing coutries – Kenyan case study Waste Management. Volume 26, Issue 1, p. 92–100.

Sahu, S. S., Rahman, J. N. & Ahsan, A., 2017. Sustainable waste management policy in Bangladesh for reduction of greenhouse gases. Sustainable Cities and Society, p. 18–26.

Srinivas, H., 2015. The 3R Concept and Waste Minimization. Kobe Japan, Global Development.

UNDESA/PD, 2018. The World's Cities in 2018, New York: World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420).

Wang, J. L., G., . L. H. & Lam, K. P., 2017. . Multivariate statistical evaluation of dissolved trace elements and a water quality assessment in the middle reaches of Huaihe river, Anhui, China.. Science of the Total Environment, Volume 583, p. 421–431.

Waste Report, D., 2018-2019. Waste Report, Dhaka: Waste Management Department.

Yasmin, . S. & Rahman, M. I., 2017. A Review of Solid Waste Management Practice in Dhaka. International Journal of Environmental Protection and Policy, 5(2), pp. 19-25..

Research Paper / Case Study Paper

Rural-Urban Linkage's Effect on Rural Poverty in Bangladesh's South-West Region

Md.Be-Nozir Shah Shovon, planner and development specialist; Bangladesh
Mithila Islam Senjuti, planner and individual consultant; Bangladesh
S.M. Firoz Hossain, planner and development specialist; Bangladesh
Howlader Nazmul Huda, planner and development specialist; Bangladesh

Abstract

Poverty is not a discrete entity. There are several reasons why poverty persists, and rural-urban connectedness is a vital component of poverty eradication. Individuals with ties to metropolitan regions are in a better position than those who do not capitalize on urban prospects. The study's major purpose is to assess rural poverty's impact on rural-urban connectedness. The study studied indices of rural-urban connectivity from a range of viewpoints, including distance, commute, migration, trip duration, travel cost, and access to various services and facilities. Two unique rural regions were chosen for the study: Koyra, which is located around 100 kilometers from Khulna (the urban area), and Batiaghata. Individuals who have access to urban regions have the opportunity to commute and earn more than those who do not. Again, rural migrants have an advantage over non-migrants. The rural poor, on the other hand, choose to commute rather than reside in urban areas for a lengthy period of time due to the high expense of living in urban areas. Rural small company owners that travel significant distances to sell their wares in metropolitan markets are unable to do so because the expense of transportation exceeds the profit. Alternatively, the nearby rural small company owner capitalizes on this opportunity to profit by selling their items in the metropolitan market. Rural poverty is greatly impacted by rural-urban connectedness, although the extent to which it is impacted varies by occupation, economic status, and distance. Thus, rural-urban connectedness appears to have a good influence on rural poverty.

Keywords

Rural-urban linkage; Poverty; Impact; Accessibility; Urban Pool Factor

1. Introduction

1.1. Background

"What I may have to bestow

I never will squander away,
While many poor people I know
Around me are wretched as they."
(Taylor, 1802)

According to the World Bank, Bangladesh lowered its poverty rate from 63 million in 2000 to 47 million in 2010, despite a total population of around 160 million and a population density of 1142/sq.K.m (Khandker, 2005). Bangladesh has raised its real per capita income by more than 130 percent and reduced poverty by more than half since attaining independence in 1971. Although it is presently on track to meet the majority of its Millennium Development Goals, it remains a low-income country with significant poverty, inequality, and deprivation (Mahjabeen, 2008).

Bangladesh's population is largely rural, with about 80% of the people residing in rural areas. There is still a larger rate of poverty in rural areas than in metropolitan areas. At least 45 million people in Bangladesh, or almost one-third of the population, live in poverty, with a sizable number of them living in extreme poverty. Rural areas have the highest poverty rate, at 36%, compared to 28% in urban areas. Many people consume an insufficient diet and experience food scarcity during times of scarcity. Half of rural children are chronically malnourished, and 14% are acutely malnourished (Mondal et al., 2012). While the overall poverty rate has tended to reduce in the face of rapid economic development, such advances are barely evident in the country's south-west area, where conditions appear to be deteriorating. Numerous people live in distant places without access to basic amenities like as schooling, health clinics, and appropriate roads, particularly to markets. They face recurrent food insecurity, lack land and assets, are frequently illiterate, and may be afflicted with major illnesses or disabilities.

The purpose of this study is to examine the rural-urban relationship and its effect on rural poverty. It is one of the most contentious issues in the modern world, particularly for a developing country like Bangladesh. The 2013 Global Monitoring Report underlines the critical significance of rural-urban connections in poverty alleviation (Rakodi and Lloyd-Jones, 2002). Bangladesh's south-west area is the most vulnerable. This region is currently undergoing a period of chronic devastation, and the consequences are still being felt. The rural portions of this region are largely isolated from the metropolitan centers. Due to these unfavorable circumstances, the economy cannot grow sufficiently. Numerous programs have been undertaken to address these issues, yet the situation remains out of control. The underlying cause is a lack of coordination between rural and urban networking infrastructures. The method will operate if urban regions' concern for rural areas in need of assistance can be increased by sharing the benefits of metropolitan territory. This strategy should help enhance rural areas'

understanding and interest in those benefits. This study can serve as a useful data source for determining the most effective strategy for rural development in Bangladesh's south-west region.

1.2 Objectives

After establishing objectives, research should begin. When conducting research or conducting a study, objectives might help keep you on track. Thus, objectives serve as a means to an end, and a researcher can perform a literature review, establish a methodology, and conduct analysis based on objectives. The purpose of this research is to ascertain the impact of rural-urban links on rural poverty.
The research's core questions are as follows:

• How does rural-urban connectivity affect rural poverty?

Specific inquiries

Question 1: How does rural-urban connectivity affect income by occupation?
How are village residents, both near and far, connected to the urban area?
What are the urban draw elements that entice rural residents to commute to metropolitan areas?
Question 2: How does rural people's access to metropolitan areas (commuting, travel costs, journey duration, and agricultural land) affect rural HH income?

Assumption a. Rural people's access to metropolitan areas (commuting, travel costs, journey time, and agricultural land) has an effect on rural HH income.

Question 3: How do rural people's connections to metropolitan areas affect them?

How are product selling locations and seller satisfaction integrated?

What are the impediments to connecting with the urban market?

What is the accessibility issue in the village closest to the urban area and the village furthest from the urban area that affects poverty?

What variables influence rural residents' expenditures?

Theorem: A significant income disparity occurs between migrants from rural areas to metropolitan areas and non-migrants.

1.3 Limitation

• Time was insufficient to explore all of the rural-urban linkage's influencing variables intensively.

• The political clout of the middle man in rural entities is strong, making it difficult to reflect the true impact of linking variables. Respondents are unable to

express their opinions openly. As a result, some critical locations for investigation must be strategically avoided.

Literature review

2.1 Urban and Rural Linkage

Urban areas are defined as areas where three-fourths of the population is engaged in non-agricultural activities and when 33% of land is used for non-agricultural purposes. The population density is larger than 1,150 inhabitants per square kilometer, and the population number is greater than fifty thousand (Osman, 2009). Rural-urban links are those that span space and involve the movement of people, goods, money, information, and trash. Sectoral interactions, which include rural activities occurring in urban areas or urban activity, such as manufacturing and service provision, occurring in rural areas. Microeconomic transformations, such as structural adjustment and economic reform, have impacted both urban and rural populations (Tacoli, 1998b). The interdependence of urban and rural areas, as well as the incorporation of a regional network plan, are required to bridge the rural-urban gap. To develop policy, research on five distinct forms of rural-urban flows was conducted: people, production, commodities, capital, and information. This article proposes a regional planning framework that takes rural-urban connections into account and is adaptable to a range of local circumstances (Douglass, 1998). When examining rural-urban links, it is necessary to evaluate the pattern of various flows (goods, people, and the flow of money and information) and their combined impact on rural-urban linkages. To study the flow of commodities and identify impediments to beneficial interactions, commodity chain analysis is critical (Tacoli, 1998a).

2.2 Poverty

Commonly used for international comparisons, this poverty line adjusts for differences across countries and times in PPP. At this line, a person obtains a 'global consumption bundle' worth USD 1 per person per day (World Bank, 2012). For gaining 2122 kcal PPPD, food cost has to be at least 33 BDT for rural area and 53 BDT for urban area. Cost of a fixed food bundle (11 food items rice, wheat, pulses, milk, oil, meat, fish, potato, other vegetables, sugar and fruits) is considered in the study (Mascie, 2010).

Year	Rural Area (In BDT/PPPD)	Urban Area (In BDT/PPPD)
2010	<25.5	<41.0

2011	<27.5	<44.0
2012	<30.5	<49.0
2013	<33.0	<53.0

Table 1: Poverty Measurement

Source: Mascie, 2010

2.3 Rural urban linkage and poverty

The territorial or spatial dimension is crucial to a development plan, and regions, rather than arbitrary divisions between rural and urban areas, should serve as the unit of analysis in the development process. While macroeconomic reforms can establish a good policy framework and effective incentives, relevant interventions can be identified and executed at the regional level (Alm and Witt, 1997). Market institutions have the potential to improve the links between urban and rural communities by enhancing the market process. Five primary variables have been identified as increasing transfer costs and hence impeding market integration between rural and urban areas: information asymmetry, transaction costs, transportation and communication costs, policy-induced obstacles, and social and non-economic factors. Economic growth and development are highly dependent on the efficiency and effectiveness of markets in connecting rural and urban areas (Nagasa, 2005). Access to local market towns has an effect on household income behaviour, and improved access to local market towns benefits households (Hoddinott, 2005). Using spatial weight matrices and spatial lags, they suggested that economic development in an urban core has a complicated set of spatial effects on the surrounding regions. If the cumulative process leads in an increase in activity at the perimeter, the outcome is urban sprawl or spill over (Henry et al., 1997). Agriculture is generated through intensification tactics, and the second area of concern is a broader spectrum of mobility, accessibility, and transportation (Rigg, 2006). Non-farm activities are either supplemental (such as handcraft production and seasonal migration) or associated with farming, such as agricultural service supply, transportation, and sale of agricultural goods. It is argued that the Red River Delta's economic progress and poverty reduction will be mostly sustainable in the long run if rural-urban ties are strengthened (Tacoli, 2003).

Methodology

3.3 Stages of selecting sample

Methodology is the working procedure of a study that is followed by a researcher to achieve the targeted result. In order to achieve the objective, the first thing that

was done is to accomplish a comprehensive literature review to have knowledge about rural-urban linkages factor that have an impact on rural poverty.

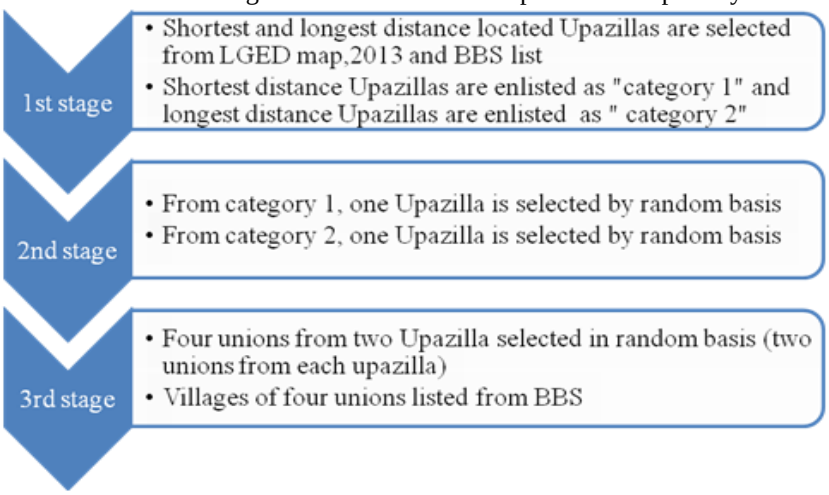


Figure:1 Stages of selecting sample

Distance from Khulna	Distance from Khulna (in K.m)	Upazilla
Long	95	Koyra
Short	16	Batiaghata

Table 2: Study Area Selection

Source: (LGED, 2013)

3.4 Sample size determination

The determination of sample size is critical in research. Two villages from two distinct unions are chosen from two Upazillas depending on their proximity to Khulna. Upazillas are classified into two types based on their distance factor. To be specific, the distance between Khulna and Upazilla is divided into two categories: a) short distance and b) long distance. Two distinct Upazilla, Batiaghata and Koyra, are chosen at random. The proportional sample method is used in this study.

Name of District	Name of Upazilla	Name of union	Name of Villages	Total HH number	Number of Sample	HH Interval
Khulna	Batiaghata	Batiaghata	Hetalbunia	866	43	20

	Gangaram pur	Boronpar a	212	11	20
Koyra	Mohessori pur	Tetultala char	776	38	20
	Koyra	4 no Koyra	1200	58	20
		Total	3054	150	

Table 3: Sample Size Determination

Source: (BBS, 2011)

Rural-Urban Linkage and Poverty Distribution

2.1. Poverty Status

According to Table 1, each person needs around 33.33 BDT per day to survive. Figure 2 depicts the poverty status of two geographical entities, Batiaghata and Koyra, using these assessment criteria.

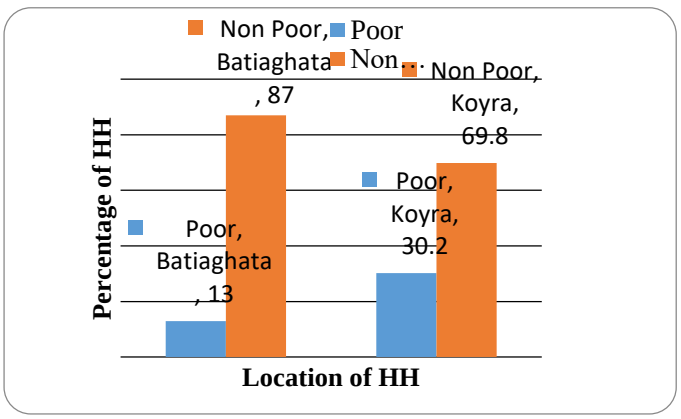


Figure 2: Poverty Status of the HH Source: Field Survey, 2014

Batiaghata has a non-poor population of approximately 87 percent, whereas Koyra has a non-poor population of approximately 70 percent. And whereas the impoverished make up about 13% of the population in Batiaghata, they make up roughly 30% in Koyra. Thus, it is obvious that more people in Koyra live below the poverty line than in Batiaghata, based on the study's measuring criteria set out in Table 1.

2.2. Linear Regression Model for Rural Households

$$E = \beta_0 + \beta_1 FC + \beta_2 TT + \beta_3 AL \quad \ldots\ldots\ldots\ldots\ldots\ldots 3$$

Dependent Variable (E) =Percentage of earnings of the rural households from the urban center

β_0 = Intercept the regression line

β_i (i=1,2,3) = Coefficient of the explanatory variables

The error components e, are assumed to be independent normal variables with mean= 0 and variance= σ^2

Variable	Sign	Coefficient	Significance
Frequency of commuting	β_1	1.29***	0.00
Travel Time	β_2	-0.10***	0.00
Agricultural land	B_3	0.11**	0.03
Constant	β_0	29.20***	0.00
Dependent Variable: Percentage of Income (BDT/Month) from Urban Center			
N = 150			**R^2 = 0.71**

Table 3: Linear Regression Model for Rural Households

N.B.: Standard errors in parentheses ***p<0.01, **p<0.05, *p<0.1

Source: Field Survey, 2014

The R2 score for the dataset reported in Table 3 is 0.71, indicating that the model accounts for more than two-thirds of the variation in the dependent value. Increase the frequency of commuting by one person and the parentage of earning from urban areas increases by 1.29 units. If travel time is increased by one hour, the percentage of income earned in urban areas decreases by 0.10 units. If agricultural land is increased by one Katha, the share of income generated by urban areas increases by 0.11 unit. Travel time has the inverse impact here, which is why the majority of day laborers and rickshaw pullers come from Batiagahta rather than Koyra.

2.3. Difference between Average Income of Migrant and Non-Migrant

All occupant kinds do not migrate to metropolitan areas. Income is impacted by migration. The average income of migrants and non-migrants is shown in Table 4.

Occupation Type	Average Income (Non-Link with UA)	Average Income (Link with UA by Migration)
Business	11062.50	

Chicken farming	6000.00	
Day labor	4684.00	5114.29
Grocery	5500.00	
Private job	11500.00	11250.00
Rickshaw/van pulling	4377.78	5500.00
Small Business	9490.91	
Tailoring	5666.67	
teacher/house tutor	12500.00	

Table 4: Effect on Income by UA Linkage

N.B.: UA = Urban Area

Source: Field Survey, 2014

Migration happens for three distinct categories of occupants: day laborers, private employees, and rickshaw/van pullers. Additionally, the average wage for these three distinct occupations varies.

2.4. Hypothesis Testing for Migrant and Non-Migrant Income

Null Hypothesis = H0: $\beta 1 = 0$. When there is no statistically significant difference in income between households that migrate to urban areas and those that do not migrate to urban areas for a particular vocation. Three vocations are chosen from Table 4.

Alternative Hypothesis = Ha: $\beta 1 \neq 0$. When there is a statistically significant difference in income between households that migrate to urban areas and those who do not migrate to urban areas for a particular vocation. Three vocations are chosen from Table 4. Significant differences between migrants and non-migrants in the occupations of Day Labor, Private Job, and Rickshaw/van Puller are evident in Table 6.2.

Variable	Observation	Mean Value	Standard Error
Income			
Migrant	13	7061	910
Non Migrant	37	5162	340
Difference	-	1899***	783

Table 5: t-test for Selected Occupation

N.B.: t Stat = 2.42; ***p<0.01, **P<0.05, *p<0.1

Source: Field Survey, 2014

2.5. Place of Product Selling

The product produced in this area are mostly sold in urban area especially Batiaghata's people take this advantage because of good connection with urban

area. The small growers of Koyra sell their product to local market because they are not able to take it in urban market because of being remote against urban area.

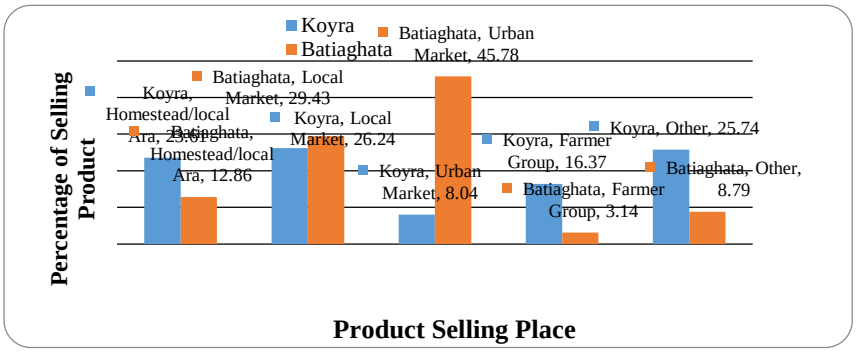


Figure 3: Place of Product Selling (*Source: Field Survey, 2014)*

From the Figure 3 it is clear that the Koyra's people get less opportunity and advantage of linkage with urban area. Only 8 percent people sell their product in urban area of Koyra. On the contrary about 46 percent people of Batiaghata people sell their product in urban market.

2.6. Satisfaction of the Seller

Most of the people of Koyra are not satisfied to sell their product and do not get the actual benefit. On the contrary the people of Batiaghata are satisfied largely. From the figure 4 it is clear that the seller of Batiaghata is satisfy about 55 percent on the contrary seller of Koyra are satisfy only 16 percent.

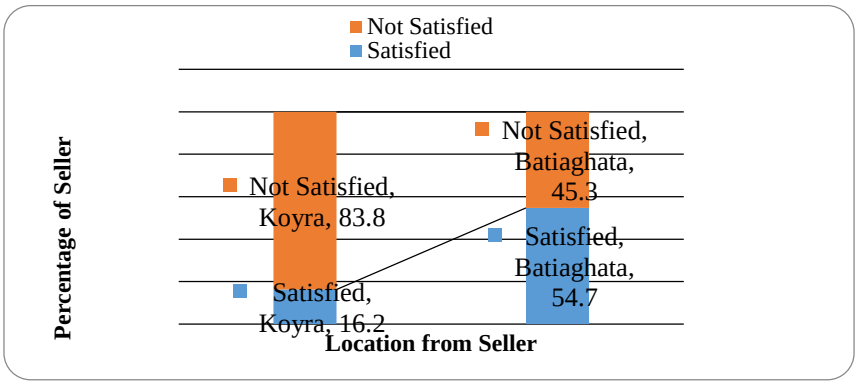


Figure 4: Satisfaction of Seller
Source: Field Survey, 2014

When sellers are not satisfied then why they are not heading forward is a prime question. With a view to answer the question figure 4 are portrayed from the field survey. In precise, the barriers to linkage with urban market are denoted here.

Zahir Uddin of Koyra stated, "I have been in Koyra since my boyhood and have been involved in fish harvesting." I sold my merchandise in a neighborhood market because the urban area is too far from my home. My stuff is taken by a middle man, and I am aware that the price I am offered is really cheap. If I had the opportunity to visit a metropolitan market, I wished I could earn more."

Akkas Ali of Koyra stated, "The people of my area have been harmed by tragedy, and as a result, their economic situations are poor. Agriculture, livestock, health, and education are all detrimental to the majority of people, while banking is a pipe dream for the poor. When a government officer is assigned, he or she is not interested in staying for an extended period of time. Koyra currently lacks a government medical officer. Many people are unable to go to urban areas for treatment and other essential purposes since Khulna's residential facilities are unviable for them."

Joy Devnath of Batiaghata stated, "Agricultural, livestock, health, and education services are largely dependent on the economic and educational standing of the population." What the rank of government officials is irrelevant to me. However, Khulna, the district town, is nearby. Numerous residents of my village visit. Individuals with family in Khulna have an advantage, although those without relations can obtain service because night hold is not required here."

Ronjon from Koyra stated, "I am a day worker and used to travel to Sundarban, but I am out of employment during the rainy season." I usually travel to Khulna to pull rickshaws/vans. I took my family there last year to settle down. We began living in a Rupsha slum. I had to pay a large fee to the owner, and other fees are also substantial. We were unable to afford!"

In a nutshell, the following observations pertain to the chapter number:

• Due to insufficient transportation, the product is unable to be sold in metropolitan markets. The situation is most dire in the remote rural district of Koyra.

• In Koyra, products are primarily sold in farmstead and local markets, and as a result, they are not priced competitively.

• Due to the tiny quantity of merchandise, the residents of Koyra cannot afford to sell it in urban markets.

• Some migrants are unable to afford the high expense of metropolitan living, and as a result, rural poverty becomes urban poverty.

• In both Koyra and Batiaghata, the rate of access to agriculture, livestock, health, education, and banking is higher for non-poor than for poor. However, rural poor living in close proximity to metropolitan areas have greater access to agriculture, livestock, health, education, and banking than Koyra peoples have.

Conclusion

Growth ties between rural and urban areas have been found to be important for both. In the study village and with Khulna city, the nature of rural-urban linkage is depicted in terms of migration and commute, spatial distribution such as distances, travel costs, and travel times. Access to service is also depicted in rural areas that are closer and further away from the urban entity in terms of economic classification. Rural poverty can only be eradicated if rural-urban linkages are developed and strengthened. The study concluded that rural-urban connectivity in Bangladesh's south-west region is in a transitional stage. The majority of potentials have not been acknowledged yet. Additional research is needed to determine how to provide a favorable environment for rural poverty without jeopardizing urban growth control.

References

Abdullah, H.J. and Fofana-Ibrahim, A. (2010). The Meaning and Practice of Women's Empowerment in Post-conflict Sierra Leone, Development, 53(2), pp. 259-266.

Alm, L.R. and Witt, S.L. (1997). The Rural-Urban Linkage to Environmental Policy Making in the American West: a Focus on Idaho, The Social Science Journal, 34(3), pp. 271-284.

BBS (2011). 'Statistical Year Book of Bangladesh 2011', Bangladesh Bureau of Statistics (BBS), Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Douglass, M. (1998). A Regional Network Strategy for Reciprocal Rural-Urban Linkages: An Agenda for Policy Research with Reference to Indonesia, Third World Planning Review, 20(1), p. 1.

Elmelech, Y. and Lu, H.-H. (2004). Race, Ethnicity, and the Gender Poverty Gap, Social Science Research, 33(1), pp. 158-182.

Goto, R., Mascie-Taylor, C. and Lunn, P.G. (2009). Impact of Intestinal Permeability, Inflammation Status and Parasitic Infections on Infant Growth Faltering in Rural Bangladesh, British Journal of Nutrition, 101(10), pp. 1509-1516.

Handinott, J.T. (2005). Motivations for Commuting: an Assessment and a Value-Expectancy Research Model. Journal of Regional Science, 35(2), pp. 200-205.

Henry, M.S., Barkley, D.L. and Bao, S. (1997). The Hinterland's Stake in Metropolitan Growth: Evidence from Selected Southern Regions, Journal of Regional Science, 37(3), pp. 479-501.

Islam, R. (2004). The Nexus of Economic Growth, Employment and Poverty Reduction:an Empirical Analysis, Recovery and Reconstruction Department, International Labour Office.

Khandker, S.R. (2005). Microfinance and Poverty: Evidence Using Panel Data from Bangladesh, The World Bank Economic Review, 19(2), pp. 263-286.

LGED (2013). 'Zilla/Upazilla Map of Bangladesh 2013', Local Government and Engineering Department (LGED), Ministry of Local Government, Rural Development & Cooperatives, Government of the People's Republic of Bangladesh,Dhaka.

Mahjabeen, R. (2008). Microfinancing in Bangladesh: Impact on Households, Consumption and Welfare, Journal of policy modeling, 30(6), pp. 1083-1092.

Mascie,T.C.(2010). Association between Socio-Economic Status and Childhood Undernutrition in Bangladesh; a Comparison of Possession Score and Poverty Index, Public Health Nutrition, 13(10), pp. 1498-1504.

Mondal, D., Minak, J., Alam, M., Liu, Y., Dai, J., Korpe, P., Liu, L., Haque, R. and Petri, W.A. (2012). Contribution of Enteric Infection, Altered Intestinal Barrier Function, and Maternal Malnutrition to Infant Malnutrition in Bangladesh, Clinical Infectious Diseases, 54(2), pp. 185-192.

Nagasa, A. (2005). Market Institutions: Enhancing the Value of Rural-Urban Links, MTID, (89).

Osman, F.A. (2009). Public Health, Urban Governance and the Poor in Bangladesh: Policy and Practice, Asia-Pacific Development Journal, 16(1), pp. 27-58.

Rakodi, C. and Lloyd-Jones, T. (2002). Urban Livelihoods: a People-Centred Approach to Reducing Poverty, Routledge.

Rigg, J. (2006). Evolving Rural-Urban Relations and Livelihoods in Southeast Asia.

Tacoli, C. (1998a). Rural-Urban Interactions: a Guide to the Literature, Environment and Urbanization, 1.

Tacoli, C. (1998b). Rural-Urban Interactions; a Guide to the Literature, Environment and Urbanization, 10, pp. 147-166.

Tacoli, C. (2003). The Links between Urban and Rural Development, Environment and Urbanization, 15, pp. 4-12.

Taylor, J. (1802). Poverty [online], Available at: http://www.poetryfoundation.org/poem/182540 (Accessed on 18th November,14).

An integrated rural planning of climate resilient infrastructures for sustainable livelihood at Teesta-Brahmaputra Basin of Bangladesh

1. Md. Anisul Wahab Khan, Project Director, PROVATi[3], LGED, Dhaka, Bangladesh.
2. Mohammed Maksudur Rahman, Market Design and Planner, PROVATi[3], LGED, Dhaka, Bangladesh.

Abstract

The study will take an integrated approach including technical and participatory methods to make the recommendations resilient and popular targeting to the scope of replication by national project framework. Focus will be on achieving sustainable livelihood of the rural people with laying a plan for constructing resilience infrastructures including rural roads, markets and flood shelters and advising proper management and maintenance for sustained services. The study will be undertaken within an ongoing government project setup of Local Government Engineering Department (LGED) financed by government of Bangladesh and International Fund for Agricultural Development (IFAD). The results of the study intend to improve project approach and implementation process with the scope to modify the project plan – as necessary, particularly in context of COVID-19 pandemic. It will advise project for better engagement towards the goal of achieving sustainable livelihoods of the rural community ensuring resilient services of the infrastructures. The study results will recommend good practices for the project as well as other projects of LGED to adapt with climate changes. The study results will have enormous scope to be adopted by national development planning in line with the needs of Government Perspective Plan (2021-41), Comprehensive Delta Plan 2100 (BDP 2021), and Sustainable Development Goals (SDGs) for climate resilience development and poverty reduction, and thereby will contribute to an adaptable infrastructural building plan in a changing environment induced by climate changes.

Key words

Resilient infrastructures, Sustainable livelihoods, Integrated technical and participatory planning, Adaptation to climate changes.

1. Introduction

Achieving sustainable development (SD) is an outcry of SDGs when that has now been plunged into a deep crisis impacted by COVID-19. It is now an urgency to plan something different that can expedite the process to achieve the goals of SD in a stipulated time with targets. Efforts are need to be integrated with multiply inputs under proper planning. This study is an effort to suggest plan towards that for an area where people's suffering is too hard and poverty is counted the highest in the country[1]. The lives there are highly exposed to adverse weathers, like extreme recurring floods and river erosions resulted by climate changes. When infrastructural improvement, such as building road, market is a must necessity for improving the livelihoods, it is too difficult to build those due to unstable land setup.

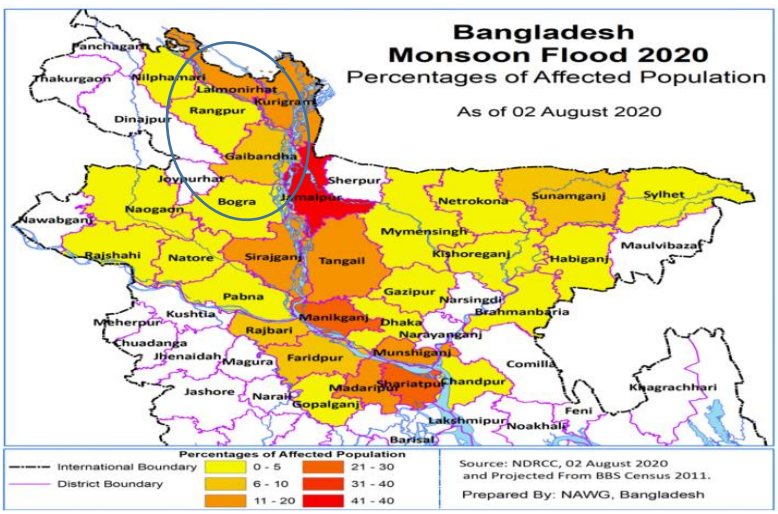


Figure 1: Flood affected population, 2020 & Study areas (*Source: NDRCC*)
Household Income and Expenditure Survey, 2016, BBS

Sustainable Livelihoods for rural people assumed to grow primarily based on the improved infrastructural communication and marketing scopes. The study will include three infrastructural interventions of the project namely Promoting Resilience of Vulnerable through Access to Infrastructure, Improved Skills and Information (PROVATi[3]) Project[2] of LGED implemented at Teesta-Brahmaputra basin in Bangladesh and will suggest for three categories of infrastructures, i) rural roads ii) rural markets and iii) flood shelters to enhance the resilience against possible damages by flood and river erosion.

2. Objective and Theory of Change

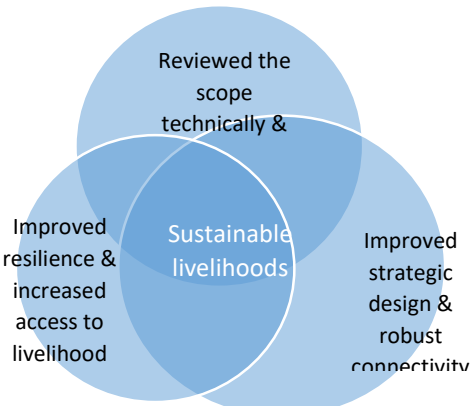


Figure 2: The schema to strengthen the project to realize the goal

Resilient road infrastructure and improved connectivity of it with market will enhance the economy of the rural community impacting on both ends - backward and forwards services to the rural production system. Further, the resilient connectivity of the road with the well-planned flood shelter will work as to timely refuge of the community at flooding time. The pathway to realise the goal is to

PROVATi[3] is a IFAD and GOB funded project is being implement by LGED under Local Government Division of Ministry of Local Government, Rural Development and Cooperative with a development objective of strengthen resilient connectivity and infrastructures

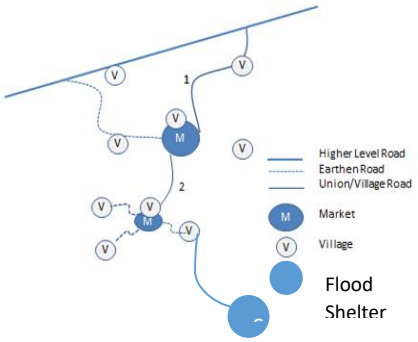


Figure 3: Road connectivity with market and Flood shelter in the Project

Source: Project Design Report, PROVATi[3]

3. Methodologies and Approach

From project areas, twenty roads, ten markets and five flood-shelters will be included for the study those will be representative for the included infrastructural works of the project for all areas based on a checklist. Following table shows the distribution of the infrastructures:

Table 1: Distribution of the infrastructures taken under study

Sl.	District	Project Upazilas	Infrastructure		
			Road	Market	Shelter
1	Jamalpur	5	4	2	1
2	Gaibandha	5	4	2	1
3	Kurigram	9	6	3	1
4	Rangpur	2	2	1	0
5	Nilphamari	2	2	1	1
6	Lalmonirhat	2	2	1	1
Total	6	25	20	10	5

The study will consult with all possible recognized research papers particularly covering those areas considering three issues to understand the locational vulnerability. The issues will be:

- Assessment of climate change on Teesta-Brahmaputra River system;
- Assessment of erosion and accretion of land/char due to maundering of rivers in study areas; and
- Determination of flood risk zones in study areas

Along with that, the study will review the causes and state of poverty and nutrition in the area based on the poverty and nutrition map (2016) conducted by World Food Programme (WFP) in partnership with PROVATi[3]-IFAD and the project baseline survey findings that has recently been conducted.

A comprehensive participatory reflection will be undertaken using various tools and tested checklist and questionnaire in participation of the project beneficiaries of the infrastructures at all areas comprising diverse sectors including different categories of farmers, fishers, traders, teachers, household women etc. to understand their views and suggestions towards building resilience infrastructures.

All views of the community will be reviewed technically by engineers and disaster experts and project people. Later a validation workshop will be undertaken in participation of experts, project officials and community people and the recommendations of the workshop will be forwarded to the project to apply for. The following framework highlights the flow of the study

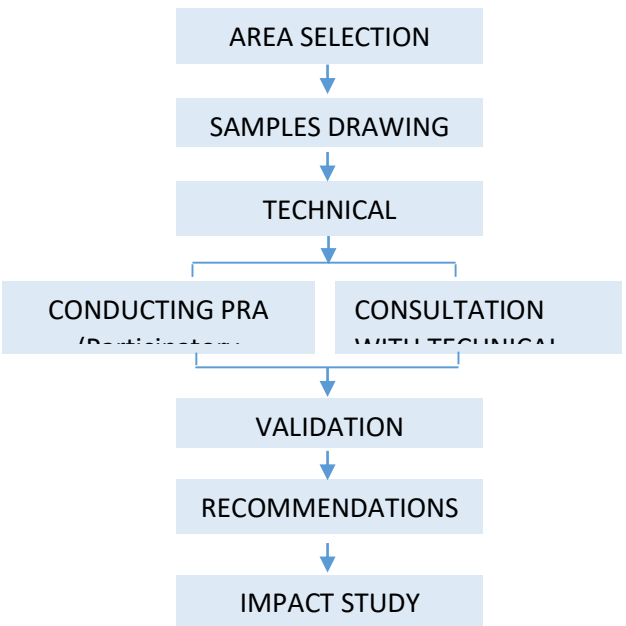


Figure 4: The framework of the study

Project will take an integrated strategic planning to materialize the recommendations. It will include three elements in its planning,

First, will raise 'awareness to action' among the staff and stakeholders;

secondly will initiate 'systematic collective project effort'; and

finally, will give efforts focusing on 'transforming and strengthening the process by innovation of ideas' to refine actions and consolidate the purpose of reaching the project goal (Rob Brodnic, 2016).

Besides the above, an impact study will be conducted to understand the scope and benefit of the community counting the sustainability of their livelihoods attributed to resilient construction of the infrastructure built on the recommendations of the study.

4. Outcome of the study in peoples live and livelihoods

The outcome benefit of the study would be diverse. It would be suggestive guidelines for integration of road, market and flood shelter building at the basin with a resilient integrated planning.

The benefits from the study through integrated planning of resilient infrastructures are expected enormous including:

(i) increase all season access to market through improved connectivity generating improved rural production;
(ii) marginal shifts in cropping diversity and patterns in response to market improvement and road communication;
(iii) an increase in the cropping intensity resulting in enhanced production;
(iv) overall reduction in transport costs due to smooth roads and also significant time-saving
(v) increase all time mobility of the community, particularly the women, in accessing to public and other basic services;
(vi) safe shelter in flooding time to safe life and essential belongings; and
(vii) influence policy for building resilient infrastructure targeting to improve livelihoods of the vulnerable community in post-COVID-19 era by integrated planning.

PROVATi[3] Project covers some 356,000 households from 25 Upazilas of Kurigram, Gaibandha, Jamalpur, Rangpur, Nilpharmari and Lalmonirhat districts of Bangladesh. These households would be targeted for livelihoods enhancement and social development by this study. All households will be directly benefited by a few interventions of the project. However, by road, market and Flood shelter the number of beneficiary households are shown in the table below.

Road improvement benefits households	53,250
Market improvement benefits households	272,700
Flood-shelter benefits households	2,250

Table 2: Benefited direct outreach by road, market and flood shelter

Sources: Project Working Paper – Detailed Design Report, 2017

5. Conclusion

The study will be undertaken from November 2021, and the results will be incorporated in the project work with immediate effect. The impact of the study would be significant for the project design in rural areas, in general, and in specific for the river basin zones. As it will benefit the project, similarly it will benefit the development partners, government departments engaged in project design in a composite format for sustainable livelihood development of the rural poor live in the high-risk areas resulted by climate changes. The study will support PROVATi[3] to attin its development objective and thereby benefit its targeted people, and further through project's scope of practical policy initiative it may advocate the better approach in planning and designing resilient integrated structures within LGED and beyond that.

6. References

(2017), Final Project Design Report, Promoting Resilience of Vulnerable through Access to Infrastructure, Improved Skills and Information (PROVATi[3]), IFAD, Asia and the Pacific Division, Rome.

(2017), Working Papers, Detailed Design Report, Promoting Resilience of Vulnerable through Access to Infrastructure, Improved Skills and Information (PROVATi[3]), IFAD, Asia and the Pacific Division, Rome.

(2018), Development Project Proposal Proforma, Promoting Resilience of Vulnerable through Access to Infrastructure, Improved Skills and Information (PROVATi[3]), LGED, Bangladesh.

(2019) Household Income and Expenditure Survey 2016; Bangladesh Bureau of Statistics (BBS) Statistics and Informatics Division, Ministry of Planning, Government of The People's Republic of Bangladesh.

(2020) Poverty Maps of Bangladesh, 2016, WFP -UN, Bangladesh Bureau of Statistics (BBS) Statistics and Informatics Division, Ministry of Planning, Government of The People's Republic of Bangladesh: and IFAD, https://bbs.portal.gov.bd/sites/default/files/files/bbs.portal.gov.bd/page/5695ab85_1403_483a_afb4_26dfd767df18/2021-02-22-16-57-c64fb3d272175e7efea0b02de6a23eaa.pdf

(2020), Perspective Plan of Bangladesh 2021-2041, General Economics Division (GED), Bangladesh Planning Commission, Ministry of Planning, Government of the People's Republic of Bangladesh.

(2018), Bangladesh Delta Plan 2100, General Economics Division (GED), Bangladesh Planning Commission, Ministry of Planning, Government of the People's Republic of Bangladesh.

(2015), Transforming our world: the 2030 Agenda for Sustainable Development with its 17 SDGs was adopted at the UN Sustainable Development Summit in New York in September 2015, https://sdgs.un.org/goals

National Disaster Response Coordination Center (NDRCC) under the Ministry of Disaster Management and Relief, 2020, https://modmr.gov.bd

Brodnick, Rob (2016) '' What is Integrated Planning?'' Sierra Learning Solution. Sep 19, 2016.

Hossain, Mohammad Imran (2021) "COVID-19 Impacts on Employment and Livelihood of Marginal People in Bangladesh: Lesson Learned and Way Forward", South Asia Survey 28 (1) 57-7, 2021. SAGE.

PPRC BIGD. (2020, May). Livelihoods, coping and support during covid-19 crisis. PPRC-BIGD Rapid Response Research. https://bigd.bracu.ac.bd/wp-content/ uploads/2020/05/PPRC-BIGD-Final-April-Survey-Report.pdf

Case Study Paper

Building Community Resilience to Fire Hazard:

A Case Study of Ward 33 in Old Dhaka

Zakia Akter, Knowledge Management and Documentation Officer; Proyash-II, SEEP, Bangladesh
Dr. Adil Mohammed Khan, Professor, Department of URP, Jahangirnagar University, Bangladesh

Abstract

Fire incidents are a very common phenomenon in Dhaka city, especially in densely populated Old Dhaka which is very compact in terms of residential, commercial, industrial and institutional use. Whether a hazard is major or minor, the local people suffer its adverse effects significantly. The study is an attempt to explore the resilient characteristics of the local community. Respondents are interviewed by purposive sampling technique. Though every year the local people face fire incidents, there is no formalized coping strategy to reduce vulnerability at individual or community level. Unplanned and haphazard development, lack of community awareness about fire hazard, greediness among landlord, control of influential industrial owner etc. are found as major threat to building resilience among the community. But there is a strong community network and collaboration which underpins the resilience of the community of the area. Fire Service and Civil Defense, existing panchayet system and social club, educational and religious institution, prevalent real estate companies, NGOs can play a positive role to make people aware and prepare to encounter fire hazard. The formation and proper functioning of Ward Disaster Management Committee according to Standing Orders on Disaster is necessary. Ward wise urban community volunteer formation can be an effective and sustainable solution in disaster preparedness and response. Finally, a fire disaster management plan considering mitigation, preparedness, response and recovery phase is proposed for building community resilience of the study area.

Keywords

Hazard, Resilience, Ward Disaster Management Committee, Urban Community Volunteers

Introduction

1.1 Background of the Study

A blend of human and natural factors results in various urban hazards with serious impacts on local community who face the immediate impact of damage or loss and also acts as the first responders to withstand the situation before arrival of rescue and relief. Community resilience is the ability of communities to withstand, recover and learn from disasters to strengthen future response and recovery effort. So, community level is an important scale for building resilience both for individual and household.

Old Dhaka, distinct for its unique socio-cultural characteristics, is one of the densest areas of Dhaka City. High population density, mix use of buildings, enormous chemical factories, blighted structures, inadequate transportation facilities and utility services together with uncontrolled and unguided development creates congestion, environmental pollution and insecure tenure living. The old city presents a spectacle of complete chaos that keeps the people here hostages to a devastating fire incident. In 3rd June 2010, a devastating fire broke out at Nimtoli of Old Dhaka city which killed at least 117 people and caused injury to nearly 188 people (Imam, 2010). Old Dhaka is categorized into different fire hazard zones according to the frequency of fire incidents (Alam and Baroi, 2004). 80% of residential houses in old Dhaka have some kind of factory or warehouse on the ground floors and residential flats on other floors (Rahman, 2016). Though the city hasn't faced any massive earthquake in recent years, it is in great risk. If it happens, fire hazard will be one of the outcomes of earthquake. Fires cause emotional distress as well as physical damage. Whether a hazard is major or minor, the local people suffer its adverse effects significantly. So, it necessitates the community to prepare themselves with greater awareness on fire hazard and capacity to respond and manage it rather than expecting institutional intervention alone.

Considering this issue, the study aims to explore the resilient characteristics of the community people of selected Ward and to give recommendations for making the community resilient to fire hazard.

Methodology

In this research, both quantitative and qualitative method has been used. Quantitative method is used to analyze the demographic, infrastructural, institutional and social indicators. Qualitative research method is used to explore the power actors in the study area, their roles in building resilience of community and to find out the knowledge and preparedness among community. A total of 110 respondents from household level are interviewed from the study area. Purposive sampling technique was adopted for sampling to gain a diverse range of respondents for face to face interviews with a questionnaire survey. Snowball sampling technique was adopted to conduct key informants interviews with arranged with Ward councilor, local government officials, NGO officials, fire experts to know existing provisions to mitigate risks and limitations. Focus Group Discussion was conducted where participants talked about their

experience, knowledge, risk, preparedness in the context of fire hazard and gave valuable suggestions from their perspective. The study area is observed to explore the spatial features such as building use, accessibility, road width, condition of existing open spaces, existence of fire fighting equipment in the study area to understand fire risk and community resilience in the study area. The required map has been prepared through Arch GIS.

Literature Review

The concept of 'Community Resilience' is viewed as being associated with increasing local capacity, social support and resources and decreasing risks, miscommunication and trauma (Patel et al, 2017). A resilient community can respond to crisis in ways that strengthen community bonds, resources, and the community's capacity to cope.

Kafle and Murshed (2006) said that government in coordination with NGOs may initiate and implement community level programs before and after any hazard. But such initiatives often discontinue once the organizational support is ended. Unless the hazard risk management efforts are sustainable at individual and community level, it would be difficult to reduce the vulnerability and losses. However, experience of past disasters, knowledge of disaster or hazard warning signs, identifying locally safe and vulnerable areas, methods of survival and social relations are important in coping with crisis. Islam and Hossain (2018) conducted a study to assess the existing realities of city dwellers of Dhaka city in understanding of fire hazards, the possible fire mitigation measures at household level and commercial area. He suggested arranging mock drills at community level for preparedness and response, raising awareness through information, education and communication on disaster risk reduction, arranging regular camping and training by local government etc. Twigg et al (2017) revealed the lack of data on fire hazards, impacts, and vulnerabilities, together with inconsistent and incompatible data collection frameworks for compilation of relevant fire data as a limitation in Low Middle Income Countries in their research. They suggested that community-based risk and vulnerability assessment methods could be adapted to urban fire risk assessment. Aziz (2016) in his research tackles disaster prevention problems in dense urban areas, concentrating on the urban fire challenge in Historic Cairo district, Egypt, through a disaster risk management approach. Therefore, the study investigates the significance of hazard management and how urban strategies can improve the city resilience. It is found that the absence of the mitigation and preparedness phases is the main problem in the risk management cycle in the case study. The study concludes with recommendations which invoke incorporating hazard management stages (pre disaster, during disaster and post disaster) into the process of evolving development planning. Islam (2016) in his research highlighted that after the incidence of massive fire hazard in Nimtoli, a part of Ward 33, local residents still live with fear, and some families left the area for their safety. Yet, no progress has been made to reallocate risky economic

activities from the study area. He urged for strict implementation of legal provision for fire safety and strengthened capacity at community and institutional level to reduce fire hazard risk.

3.1. Disaster Risk Management - Policy Structure

Standing Orders on Disaster (SOD) 2019 is prepared to make the concerned persons understand their duties and responsibilities regarding disaster risk management at all levels and accomplish them. All the Ministries, Divisions/Departments and Agencies of Bangladesh shall prepare their own Action Plans with respect to their responsibilities under the Standing Orders for efficient implementation (MoDMR, 2019). According to SOD, Disaster Management Act 2012 was enacted with a view to making disaster-related activities coordinated, target-oriented and strong; and making rules for an effective disaster risk management framework for all types of disasters. National Disaster Management Policy 2015 was formulated to ensure good governance for disaster risk management ensuring participation and accountability of all concerned stakeholders. The main purpose of this policy is to formulate and implement hazard-specific strategies based on assessments of major disaster risks in Bangladesh National Plan for Disaster Management (2016-2020) was formulated considering the achievements of the previous plan's implementation, learning and challenges to ensure disaster risk management through the coordinated and effective efforts of relevant stakeholders. The action plan has indicated the intent to identify the areas of investment for disaster risk management through a Risk Informed Development Plan and emphasized its implementation with the participation of all concerned.

The Fire Protection Act 2003 mentioned the provisions for all the buildings, including high rises and commercial establishments, to have sufficient fire fighting equipment and confirm the measures of public security. It is mentioned that buildings of six storied and above, must have an emergency exit, elevator and emergency electricity supply. Also, each of the high rises must have an individual control room and gas and heat detection system. The Building Construction Rule 1996 provides some measures for fire safety such as provision of setback for safe distance between residential and commercial site, emergency exit for safety etc.

According to this Dhaka Metropolitan Building Construction Act 2008, fire safety provisions in the applicable buildings shall be considered along with lifesaving mechanism in fire hazard situation. Therefore, the dwellers of building will get more fire safety options in a hazard situation (Nasir, 2014).Bangladesh National Building Code is used to establish minimum standards for design, quality of materials, use and occupancy, location and maintenance of all buildings within Bangladesh. BNBC has the clear provision of fire safety rules for buildings (Shafi, 2010).

In the Draft Dhaka Structure Plan (2016-35), the title "Create highly responsive and resilient community in a safe and protected built and natural environment" emerges as one of the goals of RAJUK.

3.2. Disaster Risk Management Coordination at the Local Level

The success of disaster risk management at the local level largely depends on the proper initiative and coordination of local agencies. At City Corporation, there is City Corporation Disaster Management Committee which has risk reduction and emergency response functions. Ward Disaster Management Committee (WDMC) is the lowest tier for disaster management in urban areas. The structure of the committee consists of total of 35 members in 27 posts and the members would be selected such that they represent every stakeholder group in respective Wards. The Ward councilor is the chairperson of the committee. The responsibilities of the committee are clearly described in SOD 2019. The main role of WDMC is to act as a supporting body and ensure that every project, development initiatives are disaster risk reduction (DRR) inclusive. There would be activities such as arranging bimonthly meetings, disaster risk reduction training programs, awareness program, formation of community volunteers and performing social works and emergency response.

Description of Study Area

Description of Study Area

Ward 33 is in the jurisdiction of zone 4 of DSCC and a part of Old Dhaka. It is one of the most densely populated areas in Dhaka city. The total area of Ward 33 is 90 acres. As indicated by Population and Housing Census 2011, more than 65 thousand individuals live in 12,891 family units. The land use pattern of the area is characterized by intensive commercial, industrial and residential uses. Almost areas are built up. The Ward faced several fire incidents in every year. Among those the fire incident at Agamasi Lane in November, 2002 due to an electric short circuit led to a huge damage of resources. The fire incident of Nimtoli in 2010 at Ward 33 was the deadliest ever fire disaster in the country where least 117 people found dead. From July, 2018- June 2019, 23 fire incidents occurred at different areas of Ward 33 (Siddik Bazar Fire Station, 2019).

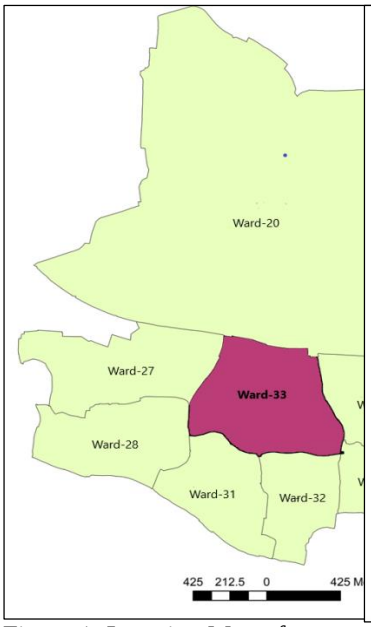


Figure 1: Location Map of Ward 33

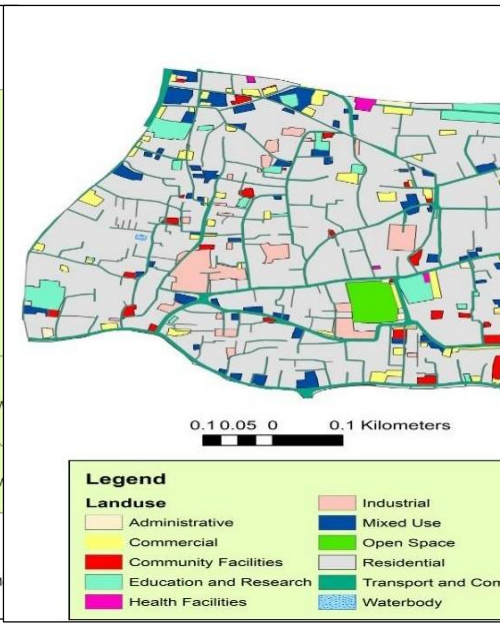


Figure 2: Land use of Ward 33

Open space and water body are considered as important features in fire response. A pond is found at the study area which is well managed. Khaleq Sardar Park is the most prominent feature of the study area, located at Sikkatuli Lane. There is another open space known as Bangladesh Field, located near Majed Sarder Road. There is sufficient water supply, gas supply and electricity supply in the study area. Waste generation is highest in this Ward in comparison with other areas. Six mahallahs among eleven are fully under coverage of waste collection. The waste collection in Ali Naki Deure, Sikkatuli and Uttar Bangshal is partial. Drainage condition of the study area is not good. Most of the cases, drains are open which is risky for people.

Figure 3: Sikkatuli Pond

Figure 4: Khaleq Sardar Park

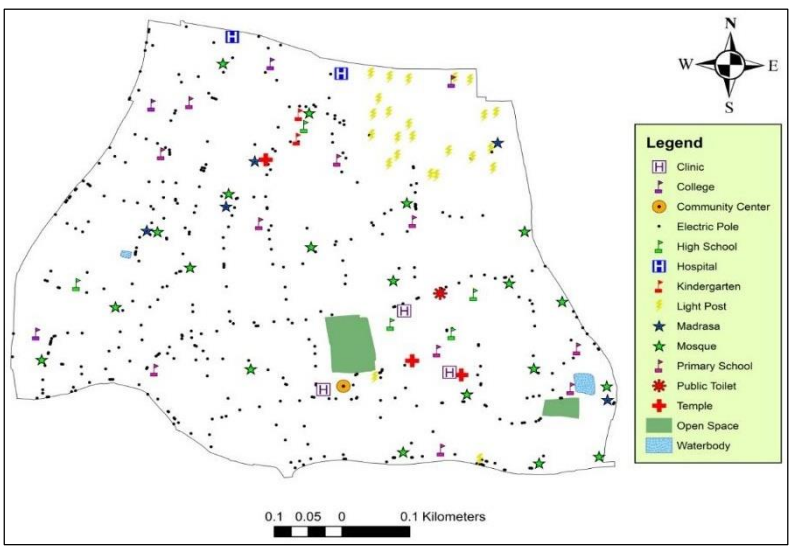
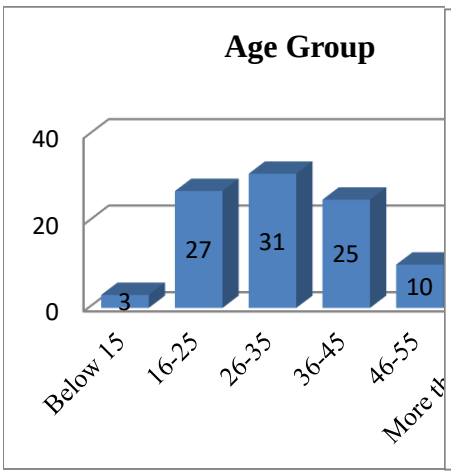


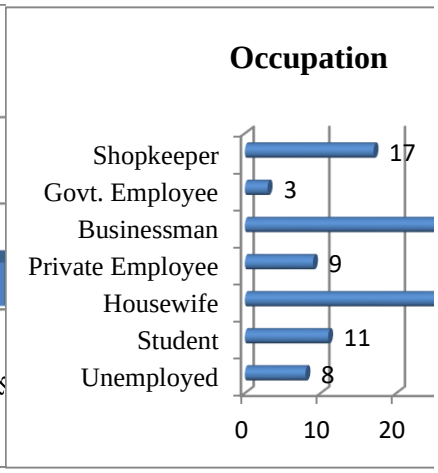
Figure 5: Community Facility at Ward 33

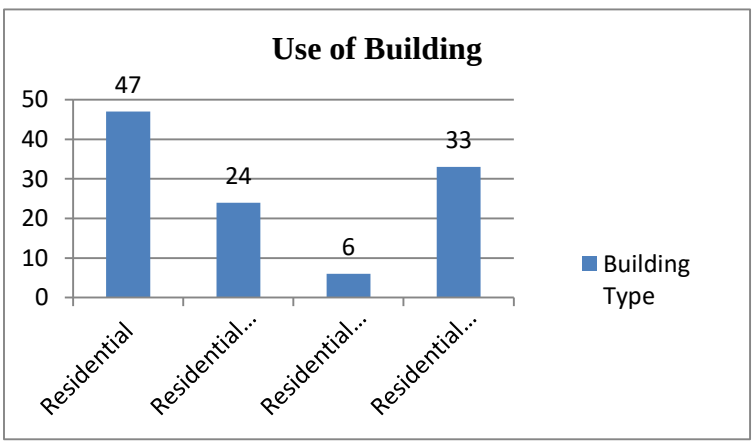
Analysis and Major Findings

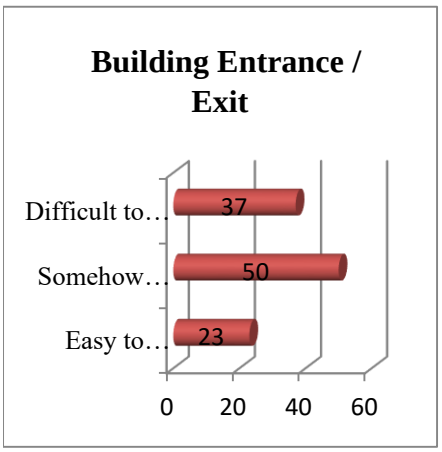
Among 110 respondents, 61 were female and 49 were male. Most of the respondents were of 26 to 35 age groups. Respondents were of various occupations, mostly are businessmen, housewives, shopkeepers, private employees etc. Among them, 47 respondents live in residential buildings and rests live in buildings of mixed use which is risky for fire hazard. The size of the average family size unit is 4.9.

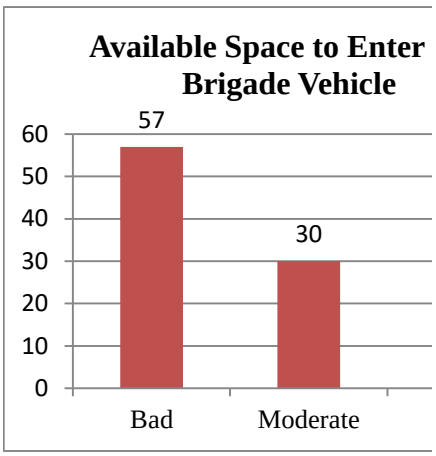
41 respondents know that they can seek help in emergency situation by dialing 999 and they learnt this number from family members, neighbors, friends, school, television, SMS, posters, police week and mock drill. Among 110 buildings from where household survey was conducted, entrance of 37 buildings were found which is difficult to enter or exit at emergency and 23 buildings were found where anyone can easily enter or exit. 57 respondents said that there is no available space to enter fire brigade vehicle in emergency as internal roads are very narrow where 35 respondents said that fire brigade vehicles can anyhow manage to enter as space is limited.











Most of the fire events at Old Dhaka originate from electric short circuit, transformer blast and gas leakage. Residents of residential cum industrial buildings are considered as highly vulnerable to fire events. In addition, no setback rule is followed which adds to the fire risks as fire spreads rapidly in congested areas. Again fire hazards occur for some unconscious activities like drying clothes above stove, putting cigarettes ablaze and also from conspiracy. Among 110 respondents, 18 respondents faced the fire hazard directly and among them 5 respondents lost their family members and relatives due to fire hazard. Those who saw their family members, relatives or close person's died due to fire hazard, it undermines their sense of safety, lead to depression and financial crisis. Living at the same house which was damaged due to fire hazard or death of family members in that house sometimes leads to post traumatic stress disorder. Those who are victims of the Nimtoli tragedy received financial aid from the government and they suggested that providing a formal job would be more sustainable for their livelihood. It is a common tendency of old people, not to escape from their owned house in an emergency by being emotional, feeling the attachment with home. On the other hand, children become nervous in the disastrous event; pregnant and persons with disabilities cannot escape or move easily. Those households who have children, old members and pregnant women can fall in risk, if they are not prepared both mentally and physically to encounter fire hazard. Though critical facilities such as fire station, medical are located near to the study area, it will take time to get services as access roads are very narrow. There is no formalized coping strategy to reduce residents' vulnerability to fire accidents at either the individual or the community level. Some local residents keep bucket of sand at buildings, very few fire extinguishers have been found in mixed used buildings. As the study area lacks sufficient wide road network and adjacent buildings have no gap or very low gap, some inhabitants consider rooftop linkage between buildings as a way to escape. BFSCD has conducted

some awareness raising programs at some schools. Besides, the Ward Disaster Management Committee of Ward 33 is not active. The City Corporation Disaster Management Committee is working on DRR in collaboration with Non-Government Organizations and Fire Service and Civil Defense. The Ward is not considered as any project area of DRR. No Ward based community volunteer has formed in the Ward.

5.1 Existing Factors Enhancing Resilience within the Community

There are some factors that underpin the resilience of community of the study area. The local community knows some of the causes of fire hazard learned from previous fire hazards and from mass awareness programme. They know the traditional approach to put off fire. The community assistance and collaboration is a useful intervention during fire outbreak in the study area.

5.2 Existing Factors Threatening Resilience in the Community

These are mixed use of land, enormous chemical factories, blighted structures, narrow streets and huge pressure on utility services to support dense population. Due to some narrow roads, the waste collection van cannot reach every house. Improper waste collection may act as a threat as industrial waste is an agent for fire hazard. As fire hazard occurs frequently, it seems that local people get accustomed with minor fire incidents and do not take this issue seriously. Owners of some buildings live outside the Ward. They are not concern about the structural and tenants safety of their own building, rather concern for profit making by renting ground floors as chemical godowns or industry. Though local authority or many residents are concerned about the risk of fire hazard, formal steps cannot execute successfully in the mixed use area to remove or reallocate risky industrial activities from the residential area due to intrusion of some influential and political industrial owner.

Recommendation and Conclusion

6.1 Role of Various Actors in Building Community Resilience

The headquarter of Bangladesh Fire Service and Civil Defense and the Siddik Bazar Fire Station, situated at Ward 34 is very near to the study area. BFSCD should promote their hotline number and the emergency number 999 regularly through door to door campaign, leaflet, using a mike, attaching emergency number contained template with the front gate of every building emergency, etc. Recently 'Fire Hazard Week' has been observed in many cities of Bangladesh and undoubtedly such initiatives are the great sources of generating awareness among the people. Real estate companies can play a vital role in making the residents resilient by involving the apartment buyers and the tenants of their buildings in risk reduction program. BFSCD must check the provision of fire control room and a trained operator in high rise buildings. The religious leaders

should be engaged in awareness programmes who can play an active role by sensitizing local people on fire safety.

As Old Dhaka is in great risk of fire hazard and the Ward faced a devastating fire tragedy in 2010, the Ward Disaster Management Committee (WDMC) should play a vigorous role to implement disaster risk reduction and emergency response functions according to SOD 2019. At present, the WDMC of Ward 33 is not properly active. In reality, most of the time,the committee faces administrative and political hindrance in case of functioning and formulation. Proper monitoring is needed from City Corporation and Ministry of Disaster Management and Relief for proper formation and functioning. The City Corporation authority should provide enough budget which would able the WDMCs to accomplish tasks and avail necessary resources.

Urban Community Volunteer (UCV) is an effective and sustainable solution for community awareness and preparedness. A good number of community volunteers have been formed in some Wards in Old Dhaka under some DRR projects. But in reality, most of them have been dropped out during and after the project phased out. BFSCD can arrange monthly meeting, refresher training to make UCV regular. The UCV of the study area should be formed immediately as the study area faces several fire hazards.

6.2 Proposed Fire Disaster Management Plan

A fire disaster management plan has been proposed which can help to make the study area as well as community resilient to fire hazard.

Mitigation Phase

Illegal and unplanned electricity connection should be disconnected and proper maintenance of transformers in a regular interval is needed. Industrial waste should be removed regularly as combustible material is important factor of fire hazard. Besides, solid waste collection should be improved, especially in Ali Naki Deuri, Sikkatuli and Uttar Bangshal area of Ward 33. Most risky buildings should be identified by technical team and should be reallocated from residential use in short period. In long term, the industrial activities should be segregated from residential use. It will help to decrease the population density as well as pressure on urban basic services. DSCC and RAJUK should make sure that all new constructions on the site must follow building code and necessary building construction rules. The entry log of fire incidents of Bangladesh Fire Service and Civil Defence follow analog method and data are recorded zone wise. All data should be digitally recorded and Ward wise fire incidents data is required to put consideration of most vulnerable Wards in upcoming risk reduction projects. A risk reduction action plan should be developed in coordination of WDMC, BFSCD, City Corporation and concerned authorities and local community representatives. Community people must be aware of the potential sources of fire hazard through mass awareness and behavioural change programme.

Preparedness Phase

In order to encounter fire hazard, urban community volunteers must be formed with basic training from BFSCD. The community people must know different methods of fire fighting based on the source of incidents. BFSCD can play an active role by arranging mock drill in community and schools. Early warning systems in coordination of religious leaders should be designed. Fire hazard preparedness training sessions for at least one member of each household must be arranged in cooperation with BFSCD which includes emergency number dissemination, first aid courses, household risk management approach etc. Thus, community people will be sensitized to store sand water, keep first aid box and necessary equipment at household level. Water reservoir tank of buildings to be filled up by water must be monitored. Community people must be oriented on safe evacuation, designated escape routes and informative signage by community volunteers. The routes for fire-fighting vehicles in these areas should be earmarked. Suitable vehicles may also be arranged for the area. Access roads should be widened by covering open drainage and sufficient street lights should be provided to avoid risk at night. A contingency fund can be prepared from community people to help fire victims.

Response phase

WDMC members and community volunteers will respond immediately to search and rescue victims. They must respond to situation such as assisting victims with first aid, taking injured to hospitals, providing temporary shelter, food, sanitation, safety etc. A post-disaster assessment such as listing the information of the victim may help in the recover stage.

Recover phase

Proper counseling, economic support, repairing infrastructure by relevant organizations is needed to help fire victims to return back in normal life. A fund can be raised by WDMC from local people to provide immediate support. Relevant local stakeholders can prepare documentation for lesson learnt and arrange programs to raise awareness for post-disaster recovery.

Appropriate coordination and cooperation among the government organizations, city development authority, NGOs and local organizations is needed to build awareness among community and make them prepare to encounter any minor or major fire hazard. The electronic media as well as newspapers could be an effective source to make people aware of fire hazards. Besides, an appropriate scale of physical planning is necessary to provide a safe living environment.

References

Alam, J. & Baroi, G. (2004) 'Fire Hazard Categorization and Risk Assessment for Dhaka City using GIS'. Journal of Civil Engineering (IEB), 32 (1), 35-45.

Aziz, N. A. A. E. (2016) 'Urban strategies to promote resilient cities: The case of enhancing Historic Cairo response to urban fire'. International Journal of Engineering Science Invention, Volume 5 52-59. Available at http://www.ijesi.org/papers/Vol(5)8/I0508052059.pdf

Imam, H. (2010) 'Nimtoli tragedy: The worst nightmare', The Daily Star, June 12. Available at https://www.thedailystar.net/news-detail-142316

Islam, M. (2016) 'An Assessment of Fire Hazard Risk in Old Dhaka: A Case Study of Nimtoli Area'. Available at: https://www.researchgate.net/publication/305724182_An_Assessment_of_Fire_Hazard_Risk_in_Old_Dhaka_A_Case_Study_of_Nimtoli_Area

Islam, M. & Hossain, M. K. (2018) 'Fire Hazards in Dhaka City: An Exploratory Study on Mitigation Measures'. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), [online] 1(Issue 5), pp.46-56. Available at: https://www.iosrjournals.org/iosr-jestft/papers/Vol12-%20Issue%205/Version-1/G1205014656.pdf

Nasir, K. G. (2014) 'Protecting the living environment of Dhaka metropolis', The Daily Star, October 17. Available at https://www.thedailystar.net/protecting-the-living-environment-of-dhaka-metropolis-15964

Patel, S. et al. (2017). What do we mean by 'community resilience'? A systematic literature review of how it is defined in the literature

Shafi, S.A. (2010). Round Table Discussion on Implementation of National Building Code. Available at https://www.blast.org.bd/content/key-note/national-building-code-29June.pdf

Standing Orders on Disaster (2019). Ministry of Disaster Management and Relief. Available at https://modmr.portal.gov.bd/sites/default/files/files/modmr.portal.gov.

bd/policies/7a9f5844_76c0_46f6_9d8a_5e176d2510b9/SOD%202019%20_English_FINAL.pdf

Twigg, J. et al. (2017) 'Improved methods for fire risk assessment in low-income and informal settlements', International journal of environmental research and public health. 14(2), 139.Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5334693/

Kafle, S.K., & Murshed, Z. (2006) Community-based disaster risk management for local authorities. Bangkok, Asian Disaster Preparedness Center.

Research Paper

Assessing Spatial Flood Vulnerability of Greater Rangpur Region in Bangladesh Using GIS: A Tool for Resilience Planning at Regional Scale

Tasin Islam Himel[1], Rifat Hossain Talukder[1], Md. Zakir Hossain[1], Sumya Naz[1], Sumaya Arfin[1], Jannatun Nahar Fariha[1]

1. Urban and Rural Planning Discipline, Khulna University, Khulna-9208, Bangladesh
Corresponding Email: 180435@ku.ac.bd

Abstract

This study has used a geospatial technique to assess spatial extent of flood vulnerability of Greater Rangpur Region. A spatial vulnerability mapping has been used for deriving spatial level and extent of flood vulnerability of the northern districts Gaibandha, Kurigram, Lalmonirhat, Nilphamari, and Rangpur that contribute to disaster resilience planning for the Greater Rangpur Region. In the most recent year in 2020, one-third of Bangladesh was inundated, where this region shared a larger part; around 6.9 million people of northern Bangladesh were affected in the August 2017 flood which resulted in numerous deaths and significant economic damage. The rationale for choosing this region is that the districts of this region have co-existence of poverty and flood vulnerability and therefore frequent flooding events have an influence on high levels of poverty. This research uses a quantitative approach and secondary data has been analyzed to reveal the flood vulnerability of the Greater Rangpur Region. Upazila is considered as the unit of analysis and different socioeconomic and physical information has been collected from census data 2011 and remote sensed images of 2021. A total of 18 indicators from two major dimensions are taken into account: thirteen for socioeconomic vulnerability and five for physical vulnerability. Indicators within a major dimension are equally weighted. The final integrated vulnerability map is classified into five categories of intensity level such as very low, low, moderate, high, and very high. The maximum integrated flood vulnerability score we observed is 0.67 in Gaibandha's Sadullapur Upazila, while the minimum is 0.41 in Patgram Upazila of Lalmonirhat district. Eleven Upazilas have a 'high', while four have a 'very high' level of vulnerability. Interestingly, compared to the poverty level of Bangladesh with vulnerability level, the poverty estimation at Upazila level says these fifteen Upazilas also have a 'very high' level of poverty. Socioeconomic factors like a

higher reliance on agriculture, a low level of work opportunities in the service and industry sector, limited access to basic services like sanitation and electricity are responsible for the higher vulnerability of these Upazilas. Additionally, several physical factors have influenced the high level of vulnerability of the aforementioned Upazilas including closeness to the rivers, lower elevation. This paper will offer background or a basis for different stakeholders, community, local government, central government organizations to make regional level disaster resilience planning effective, including evacuation planning, preparedness, emergency responses resource allocation for rehabilitation.

Keywords
Flood Vulnerability, Spatial level and extent, Greater Rangpur Region, Geo-spatial techniques, Resilience Planning

Introduction

In the recent time flood has become a very common and serious issue in a low-lying country like Bangladesh. This paper aimed to state a spatial comparison between flood vulnerability and national poverty, where the flood vulnerability is assessed considering socioeconomic vulnerability and physical vulnerability. Bangladesh is experiencing an extreme level of climate change problem, resulting in a number of natural disasters (i.e., flood, cyclone, river erosion, tidal surge, salinity, intrusion, earthquake, drought), which considered the country as the world sixth most disaster-prone countries (Kreft et al., 2015; Smith and Frankenberger, 2018).

It is enumerated that floods covered 29% of the natural disaster in Bangladesh from 1971 to 2018 which resulted in a huge economic loss, property damages, causalities, and homelessness, 1974 about 38 million people were affected where 28,700 died and economic losses were $579.2 million, in 1998 the economic losses were at recorded amount $4.3 billion, in 2017 6.9 million people were affected and 134 people died (Philip et al., 2019; Mondal, Murayama and Nishikizawa, 2020). This information indicates that in the previous the loss of life was more but now it is less although the economic losses have increased.

The selection of criteria for each element of vulnerability (socioeconomic, physical) is correlated to the precession and dependency of vulnerability information. So comprehensive and precise data of vulnerability is inevitable to make plans for flood mitigation. Physical or natural factors like land use, distance to the active channel, slope, elevation, and precipitation intensity also affect and control vulnerability (Birkmann, 2007; M. A.-A. Hoque et al., 2019). Human

efforts and proper policy implementation can diminish the vulnerability created by society. Hence researchers are highly involved in this sector. Socioeconomic vulnerability can provide location-specific information which facilitates in acquiring micro-level data for policymaking have considered income, health status, education level, number of disabled populations, family structure type, and occupation indicators are required to assess the vulnerability and these are also crucial for the implementation of any risk mitigation process (Ahsan and Warner, 2014; Sahana et al., 2021).

Flood exposure and poverty vary spatially with differences in socioeconomic and physical variables. Most of the poor households consider themselves more vulnerable to flood and the reasons include living in the flood-affected area, the poor structural condition of the houses, and receiving inadequate support from any organization to cope with (Bangalore, Smith and Veldkamp, 2019).

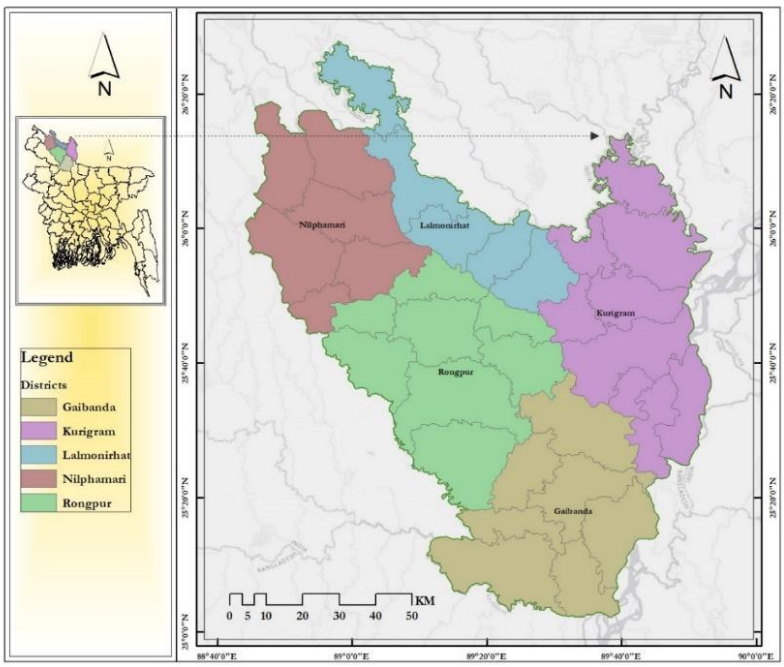
In order to address the flood vulnerability, this study aims to develop a flood vulnerability map by using geospatial techniques. The geospatial technique is the combination of a Geographic information system (GIS) and Remote Sensing (RS) and these are highly effective tools for multi-criteria decision analysis (MCDA) (Rahman et al., 2019). Remote sensing technique is used for land use land cover (LULC) mapping which gives us the substantive data of the earth surface and the details of human activities and this LULC classification is done by the supervised classification (Islam and Sado, 2000). GIS provides a framework for integrating, analyzing, and reclassifying data and finally prepared the comparative map of the different regions (Feloni, Mousadis, and Baltas, 2020).

Here, our study aims to assess the spatial flood vulnerability of the greater Rangpur region in Bangladesh. The specific objectives are as follows: (i) developing GIS-RS based multi-criteria analytical framework to assess flood vulnerability at a regional scale; (ii) measuring the spatial extent of flood vulnerability considering social, economic, and physical factors; (iii) identifying whether any co-existence of flood vulnerability and poverty level existed at Upazila level.

Material and Method

1.1 Study Area

Country's poverty report and geographic setting of the northern part of Bangladesh evident the existence of flood vulnerability in this region. From the above figure (Figure 1) our study area is previously known as greater Rangpur contained five districts of present Gaibandha, Kurigram, Lalmonirhat, Nilphamari, and Rangpur occupies approximately 9554.33 sq. km land area. The area lies between 25°02' and 26°33' north latitudes and between 88°44' and 89°56' east longitudes (Bangladesh Bureau of Statistics, 2021). The study area is basically known as the Tista River Floodplain in Bangladesh (TRFB). The river Tista originates from the Himalayan range in Sikkim and continues through to India and Bangladesh. Importantly, our considered five districts are the areas of Bangladesh part where this Tista runs through (Islam, 2016; Mondal and Islam, 2017).



○ **Figure 3: Study Area**

Table 1: An overview on study area

District	Upazilla	Area (sq. km)	River
Gaibandha	Gaibandha Sadar, Gobindaganj, Palashbari, Phulchhari, Sadullapur, Saghatta, Sundarganj	2179.27	Bhramhaputra, Kartoa, and Ghagot
Kurigram	Bhurungamari, Char Rajibpur, Chilmari, Kurigram Sadar, Nageshwari, Phulbari, Rajarhat, Raumari, Ulipur	2245.04	Bhramhaputra, Dharla
Lalmonirhat	Aditmari, Hatibandha, Kaliganj, Lalmonirhat Sadar, Patgram, Dimla, Domar, Jaldhaka, Kishoreganj, Nilphamari Sadar, Saidpur	1247.37	Tista, Dharla, Saniajan, Sarnamati, Trimohoni, Ratnai and Sati
Nilphamari	Dimla, Domar, Jaldhaka, Kishoreganj, Nilphamari Sadar, Saidpur	1546.59	Isamoti, Jamuneshwari, Dhum, Kumlai, Charalkata, Sorbomongola, Salki, Chikli and Deonai
Rangpur	Badarganj, Gangachara, Kaunia, Mitha Pukur, Pirgachha, Pirganj, Rangpur Sadar, Taraganj	2400.56	Jamuneshwari, Ghaghat, kartoa, Chikali and Akhira

○

1.2 Data Collection and Data Preparation

Eighteen indicators under two major dimensions-socioeconomic vulnerability and physical vulnerability have been considered. These indicators are considered based on literature review which is widely used in different scholarly literature. Socioeconomic vulnerability assessment in different parts of Bangladesh we commonly see is conducted, using these indicators (Ha-Mim, Hossain and Moniruzzaman, 2019; Moniruzzaman, Hossain and Ha-Mim, 2019; Ha-Mim and Hossain, 2020; Mudasser et al., 2020). These indicators are correlated with flood vulnerability.

Under socioeconomic vulnerability, the area with a higher population density has a higher chance of being affected by the floods. Senior citizens who are above 65 years of age are dependent and not seen earning. So, a place with a higher percentage of senior citizens is more vulnerable. Similarly, disabled people are

affected both physically and psychologically by any form of disaster. The illiterate people are more vulnerable compared to literate people (M. Hoque et al., 2019; Ha-Mim et al., 2020). These are basically, demographic aspects. From an economic aspect, agricultural land is more susceptible to climatic disasters. Thus, higher dependency on agricultural activities is an indication of higher vulnerability. The vulnerability has also close relation with infrastructural factors like katcha or jhupri which is the dominant household structure of our study area is more vulnerable to floods. Sanitation and drinking water are also the dominant factors for measuring vulnerability. Inadequate source of drinking and absence of hygienic sanitation can cause many waterborne diseases (Ha-Mim et al., 2020).

Among the parameters under the physical vulnerability, land use and land cover has an impact on the flood. Vegetation area has a negative correlation with the flood events. On the contrary, when it is a settlement, the surface is less permeable for water penetration. Thus, a settlement has vulnerability relative to vegetation area (Mojaddadi et al., 2017; Rahman et al., 2019). Elevation and slope have a negative correlation with flood vulnerability as the plain and lower areas are more vulnerable (M. Hoque et al., 2019). The higher order of line density is nearer to the river means higher-order lays in the downstream areas. People who live in the lower stream are more vulnerable to floods. Similarly, with the decrease of distance from a river, the vulnerability increases (Zzaman et al., 2021).

Indicators under the socioeconomic vulnerability are collected from community-level population and housing census data from the Bangladesh Bureau of Statistics and indicators under physical vulnerability are from USGS (mentioned in Table 2).

Table 2: Data type and the sources of Data collection

Data Type and Used for	Sources	Period (Year)
Indicators under socioeconomic vulnerability dimension	Bangladesh Bureau of Statistics (BBS)	Population and Housing Census of 2011
SRTM-DEM (30m resolution)	United States Geological Survey (USGS) Earth Explorer	2000

Sentinel-2 for LULC	United States Geological Survey (USGS) Earth Explorer	2021
Upazila level poverty Data	Bangladesh Bureau of Statistics (BBS)	Poverty Maps of Bangladesh 2016

Table 3: Criteria and ranking for the considered indicators for Flood Vulnerability Assessment

Major Dimension	**Indicators** (Unit of measurement)	**Criteria and Ranking Based on Vulnerability**				
		Very Low (1)	**Low (2)**	**Moderate (3)**	**High (4)**	**Very High (5)**
Socioeconomic Vulnerability	Population density (person/km)	<855.6	855.6-1185.2	1185.2 - 1514.8	1514.8 - 1844.4	>1844.4
	Percentage of senior citizen (above 65 years) (%)	<4.16	4.16-4.62	4.62-5.08	5.08-5.54	>5.54
	Illiterate persons (%)	<44.96	44.96-50.92	50.92-56.88	56.88-62.84	>62.84
	Households live in rented house (%)	<3.18	3.18-5.86	5.86-8.54	8.54-11.22	>11.22
	Population with disability (%)	<1.3	1.3-1.6	1.6-1.9	1.9-2.2	>2.2
	Employment in agriculture (%)	<12.26	12.26-15.05	15.05-17.85	17.85-20.65	>20.65
	Working age population (%)	>62.58	60.96-62.58	59.34-60.96	57.72-59.34	<57.72
	Unemployment rate (%)	<18.53	18.53-20.1	20.1-21.66	21.66-23.23	>23.23
	Service & industry employment (%)	>17.57	14.4-17.57	11.22-14.4	8.04-11.22	<8.04

	Households with tube-well as water source (%)	>97.46	95.92-97.46	94.38-95.92	92.84-94.38	<92.84
	Households with non-sanitary toilet (%)	<22.12	22.12-38.54	38.54-54.96	54.96-7138	>71.38
	Households without electricity connection (%)	<47.12	47.12-57.44	57.44-67.76	67.76-78.08	>78.08
	Katcha/Jhupri Housing Structure (%)	<36.76	36.76-52.02	52.02-67.28	67.28-82.54	>82.54
Physical Vulnerability	Distance from River (meter)	>6800	5100-8500	3400-5100	1700-3400	<1700
	Land Use and Land Cover	Water-bodies	Bare soil	Vegetation	Cropland	Settlement
	Elevation (Meter)	>43.58	36.67-43.58	27.93-32.67	26.66-27.925	<23.66
	Slope (Degree)	>8.71	6.51-8.71	4.31-6.51	2.11-4.31	<2.11
	Drainage Density (line density of natural stream order) (km/sq.km)	0-0.5	0.5-1	1-1.5	1.5-2	2-2.5

○

1.2.1 Socioeconomic Vulnerability Score

All thirteen indicators for socioeconomic vulnerability score have been collected from BBS, 2011. The desired data haven extracted at the Upazila level. Using equal interval from minimum to maximum five classes has been made. Thus, all the indicators have been ranked from 1 to 5. After that, following equation (i), standardization has been conducted.

$$Sd_x = \frac{Rx - min}{max - min} \quad \text{.....(i)}$$

Here, Sd_x is the standardized score of an Upazila in the indicator x where max and min are the maximum and minimum rank value of x indicator and Rx is the rank of that Upazila in the same indicator x.

Once, standardization is completed for all the indicators, it is ready to proceed in the next step. Using equation (ii), socioeconomic vulnerability has been assessed.

$$SeVs = \frac{\sum_{i=1}^{n} Sdx^{i}}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Later, this SeVs has been imported in ArcGIS and a socioeconomic vulnerability map has been produced with five categories of level of intensity.

1.2.2 Physical Vulnerability Score

As shown in table 1, We have considered five indicators- distance from the river, elevation, slope, LULC, and drainage density for assessing physical vulnerability. Five different layers for the five indicators were generated at 30m resolution using ArcGIS. Giving equal weight, the weighted overlay technique is applied here with these five indicators and we got a map with the score from 1 to 5. As here we used satellite image mention in the data source table and all the layer are raster file, within a certain Upazila different pixel gets different value. Thus, it is not possible at this stage to represent each Upazila with a single physical vulnerability score. Based on zonal statistics, we take these different pixel values within each of the Upazila to a single value which is the ultimate representative of the physical vulnerability of that particular Upazila. The value is a fraction as the zonal statistics work with the central tendency of all the pixels within a particular layer and its range is the same as previous as 1 to 5. Now, the stage is ready for the standardization using the same equation (equation ii) adapted for the socioeconomic vulnerability score.

1.2.3 Integrated Flood Vulnerability Score

The standardized physical vulnerability score has been exported to excel from ArcGIS. Now all the eighteen indicators under two major dimensions have been weighted equally using the equation (iii).

FVs = (SeVs × Wi) + (PVs × Wii) ……..……(iii)

Where, for Equation (iii), FVs= Flood vulnerability score, SeVs = Socioeconomic Vulnerability score, PVs= Physical Vulnerability Score. W refers to the weight that has been assigned as per equal weighting to each major dimension where Wi = 0.72 Wii = 0.28. Subsequently, the FVs has been imported in ArcGIS and a necessary map of socioeconomic vulnerability is produced with five categories of level of intensity.

Result

2.1 Socioeconomic Vulnerability and Physical Vulnerability

The produced socioeconomic vulnerability score is categorized into five levels of intensity. Thus, a socioeconomic vulnerability map (Figure 2) has been generated. The maximum score we find is 0.67 in Sadullapur Upazila of Gaibandha where the minimum is 0.38 in Patgram of Lalmonirhat district. Among 35 Upazilas maximum of ten belong to the 'high' vulnerable class and three are found to be 'very high' vulnerable to flood. The district Gaibandha consists highest five of its Upazilas as 'high' to 'very high' level of intensity where the number is three for Kurigram and two for each of the districts Nilphamari and Rangpur. In this aspect, the district found to be most comfortable is Lalmonirhat where it's all five of the Upazilas are in 'low' to 'very low' level of socioeconomic vulnerability.

This highly vulnerable zone is due to the economic components and the physical and infrastructural components. The higher dependency on agriculture, as well as lower work rate in service and industry sector; sanitation issue; households not having electricity; higher number of households with katcha or jhupri tenure condition, are responsible for having a higher SeVs score.

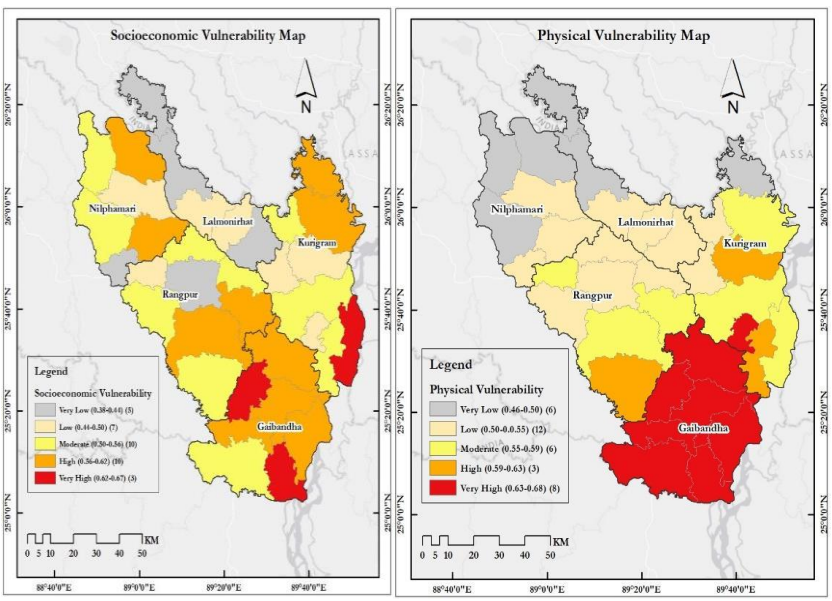


Figure 2: Socioeconomic Vulnerability (left) and Physical Vulnerability Intensity Map (right)

The physical vulnerability map (Figure 2) has also been generated with five categories considering five factors. The map illustrates the district Nilphamari and Lalmonirhat are in a similar condition in terms of comfort or carrying lower physical vulnerability whereas the districts Gaibandha are in a situation that describes it as the most physically vulnerable district in this region. After Gaibandha it is Kurigram which is observed to have three of its Upazilas are carrying high to very high level of vulnerability. This higher physical vulnerability is caused by the closeness to the rivers, lower slope, lower elevation as well as higher stream order or higher line density or natural drainage density nearer by the riverside. Compared to Gaibandha and Kurigram, the scenario for Rangpur is quite better.

2.2 Integrated Flood Vulnerability

The integrated flood vulnerability analysis shows that eleven of thirty-five Upazilas are having a 'high' and four are 'very high' level of intensity of flood vulnerability. The share of these fifteen Upazilas is among four districts. Gaibandha occupies all seven where Rangpur and Nilphamari have two to each and four of the Upazilas of Kurigram are exposed this high to very level of intensity. We see from the figure (Figure 3) the maximum-colored areas are occupied by the districts Kurigram or Gaibandha. Upazila where the maximum score of 0.67 is found is Sadullapur in Gaibandha on the contrary, the minimum score of 0.41 is observed in Patgram of Lalmonirhat. The district Nilphamari does not have a single Upazila that is moderately or highly vulnerable to flood events.

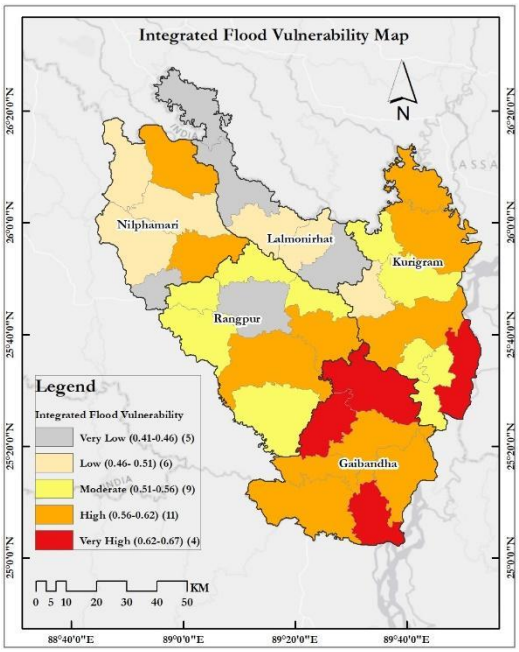


Figure 3: Integrated Flood Vulnerability Map of Greater Rangpur Region of Bangladesh

Discussion

Among the accounted thirty-five Upazilas we have found earlier that fifteen of the Upazilas are in an either high or very high level of intensity of flood vulnerability. Noticeably, Gaibandha is the only district where all the Upazilas within it are in high to a very high level of vulnerability. The average vulnerability score of each socioeconomic indicator (Table 4) shows, five of the total thirteen are contributing most to the socioeconomic vulnerability as well as the flood vulnerability. It indicates that the higher percentage of agricultural employment, lower percentage of service and industrial employment impact on higher vulnerability score. Besides, inadequate hygienic sanitation, a larger number of Katcha or Jhupri household structure, and a lack of electrification also have a higher impact to the overall vulnerability. In the physical context, the same district Gaibandha is in the most vulnerable zone because of the lower elevation as well as lower slope, and shorter distance from the major active water channel.

From the key findings of the Poverty Maps of Bangladesh 2016, Upazila level poverty estimation says the severity of poverty of all fifteen Upazilas is very high as well (Bangladesh Bureau of Statistics, 2021). Agricultural damages due to the frequent floods, the income level of the people of this higher flood vulnerable districts: Gaibandha and Kurigram let them not to progress out of poverty. Thus, they are unable to function the desirable things like electricity, well-functioned housing, sanitation. And, when they are unable to meet the minimum and fundamental needs it indicates their inability to turn their income into well-being and this scenario demonstrates them as absolute poor. Likely the vulnerability, these parameters: household structure, sanitation, electricity connection, employment sector can also describe the poverty condition of a certain people in a certain area. Ultimately, we can say that existence of flood vulnerability is an indication of the existence of poverty.

Table 4: Average Vulnerability Score of each Indicator

Average Vulnerability index of each indicator					
Socioeconomic Indicator	**Gaibandha**	**Kurigram**	**Lalmonirhat**	**Rangpur**	**Nilphamari**
Population density (person/km)	0.36	0.19	0.25	0.41	0.42
Percentage of senior citizen (above 65 years) (%)	0.57	0.61	0.45	0.56	0.13
Illiterate persons (%)	0.68	0.67	0.50	0.50	0.58
Households live in rented house (%)	0.04	0.08	0.05	0.16	0.17
Population with disability (%)	0.68	0.31	0.45	0.41	0.33
Employment in agriculture (%)	**0.82**	**0.78**	**0.85**	**0.78**	**0.79**
Working age population (%)	0.64	0.69	0.75	0.38	0.63
Unemployment rate (%)	0.18	0.31	0.25	0.38	0.42
Service & industry employment (%)	**0.86**	**0.89**	**0.85**	**0.81**	**0.79**
Households with tube-well as water source (%)	0.54	0.22	0.25	0.28	0.29
Households with non-sanitary toilet (%)	**0.86**	**0.44**	**0.00**	**0.72**	**0.75**
Households without electricity connection (%)	**0.71**	**0.89**	**0.95**	**0.59**	**0.54**
Katcha/Jhupri housing structure (%)	**0.89**	**1.00**	**0.10**	**0.88**	**0.92**

Conclusion

This paper has followed geospatial techniques to assess the spatial extent of flood vulnerability of the greater Rangpur region: Gaibandha, Kurigram, Lalmonirhat, Nilphamari, and Rangpur districts based on the socioeconomic and physical aspects. Later, it has compared the national poverty to the higher flood vulnerable zone and revealed that the higher flood vulnerable zone has also a higher magnitude of poverty. Subsequently, this paper also shows what are indicators affecting this vulnerability.

We see the more of the areas with higher flood vulnerability are firstly in the Gaibandha District and some are in the Kurigram. It is also seen that the region has a huge dependency on agriculture as industrialization has not been seen yet. Here, tenure conditions, lack of electricity, sanitation issues enhance the degree of vulnerability when a natural calamity took place. Establishing training programs to increase the skill of industrial and service activities, water flood resistance crops for agricultural activities, and monetary support can be encouraged at an affordable price at policy intervention. Besides, taking Rangpur into account maintain scale and order, territorial development, urban-rural linkage, technology transfer can be promoted. However, this paper will offer different stakeholders including responsible authorities to take a course of action to overcome the described situation.

Data from BBS 2011 is quite older and it struggles to describe the current scenario of 2020. Further research of this paper suggests working with the upcoming BBS 2021 census to achieve better accuracy. This paper has worked with some predetermined indicators as the scale is quite large and object-focused. Conducting open interviews and subject-focused small scale (i.e., Union level) research can make a qualitative judgment and help in indicator selection.

References

Ahsan, Md.N. and Warner, J. (2014) 'The socioeconomic vulnerability index: A pragmatic approach for assessing climate change led risks–A case study in the south-western coastal Bangladesh', International Journal of Disaster Risk Reduction, 8, pp. 32–49. doi:10.1016/j.ijdrr.2013.12.009.

Bangalore, M., Smith, A. and Veldkamp, T. (2019) 'Exposure to Floods, Climate Change, and Poverty in Vietnam', Economics of Disasters and Climate Change, 3(1), pp. 79–99. doi:10.1007/s41885-018-0035-4.

Birkmann, J. (2007) 'Risk and vulnerability indicators at different scales: Applicability, usefulness and policy implications', Environmental Hazards, 7(1), pp. 20–31. doi:10.1016/j.envhaz.2007.04.002.

Feloni, E., Mousadis, I. and Baltas, E. (2020) 'Flood vulnerability assessment using a GIS-based multi-criteria approach—The case of Attica region', Journal of Flood Risk Management, 13(S1), p. e12563. doi:10.1111/jfr3.12563.

Ha-Mim, N.M. et al. (2020) 'Exploring Vulnerability–Resilience–Livelihood Nexus in the Face of Climate Change: A Multi-Criteria Analysis for Mongla, Bangladesh', Sustainability, 12(17), p. 7054. doi:10.3390/su12177054.

Ha-Mim, N.M. and Hossain, M.Z. (2020) 'Differential climate change vulnerability among different poverty groups in southwestern Bangladesh: lessons for adaptation planning', Recent Research in Science and Technology, pp. 6–10. doi:10.25081/rrst.2020.12.6084.

Ha-Mim, N.M., Hossain, M.Z. and Moniruzzaman, S.M. (2019) 'ASSET BASED PROFILE APPROACH FOR UNDERSTANDING DIFFERENTIATED VULNERABILITY AND RESILIENCE OF COASTAL HOUSEHOLDS IN THE CONTEXT OF CLIMATE CHANGE', p. 7.

Hoque, M. et al. (2019) 'Assessing Spatial Flood Vulnerability at Kalapara Upazila in Bangladesh Using an Analytic Hierarchy Process', Sensors, 19(6), p. 1302. doi:10.3390/s19061302.

Hoque, M.A.-A. et al. (2019) 'Tropical cyclone risk assessment using geospatial techniques for the eastern coastal region of Bangladesh', Science of The Total Environment, 692, pp. 10–22. doi:10.1016/j.scitotenv.2019.07.132.

Islam, Md.F. (2016) Water Use and Poverty Reduction. Tokyo: Springer Japan (New Frontiers in Regional Science: Asian Perspectives). doi:10.1007/978-4-431-55172-0.

Islam, M.M. and Sado, K. (2000) 'Flood hazard assessment in Bangladesh using NOAA AVHRR data with geographical information system', Hydrological Processes, 14(3), pp. 605–620. doi:10.1002/(SICI)1099-1085(20000228)14:3<605::AID-HYP957>3.0.CO;2-L.

Kreft, S. et al. (2015) Global Climate Risk Index 2016 Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2014 and 1995 to 2014.

Mojaddadi, H. et al. (2017) 'Ensemble machine-learning-based geospatial approach for flood risk assessment using multi-sensor remote-sensing data and GIS', Geomatics, Natural Hazards and Risk, 8(2), pp. 1080–1102. doi:10.1080/19475705.2017.1294113.

Mondal, Md.S.H., Murayama, T. and Nishikizawa, S. (2020) 'Assessing the flood risk of riverine households: A case study from the right bank of the Teesta River, Bangladesh', International Journal of Disaster Risk Reduction, 51, p. 101758. doi:10.1016/j.ijdrr.2020.101758.

Mondal, M.S. and Islam, M. (2017) 'Chronological trends in maximum and minimum water flows of the Teesta River, Bangladesh, and its implications', Jàmbá Journal of Disaster Risk Studies, 9. doi:10.4102/jamba.v9i1.373.

Moniruzzaman, S.M., Hossain, D.M.Z. and Ha-Mim, N.M. (2019) 'ASSESSING PHYSICAL VULNERABILITY IN COASTAL BANGLADESH TOWARDS NATURAL DISASTERS: A COMPOSITE INDEX APPROACH', p. 7.

Mudasser, M. et al. (2020) 'Investigating the Climate-Induced Livelihood Vulnerability Index in Coastal Areas of Bangladesh', World, 1(2), pp. 149–170. doi:10.3390/world1020012.

Philip, S. et al. (2019) 'Attributing the 2017 Bangladesh floods from meteorological and hydrological perspectives', Hydrology and Earth System Sciences, 23(3), pp. 1409–1429. doi:10.5194/hess-23-1409-2019.

Rahman, M. et al. (2019) 'Flood Susceptibility Assessment in Bangladesh Using Machine Learning and Multi-criteria Decision Analysis', Earth Systems and Environment, 3(3), pp. 585–601. doi:10.1007/s41748-019-00123-y.

Sahana, M. et al. (2021) 'Assessing socio-economic vulnerability to climate change-induced disasters: evidence from Sundarban Biosphere Reserve, India', Geology, Ecology, and Landscapes, 5(1), pp. 40–52. doi:10.1080/24749508.2019.1700670.

Smith, L.C. and Frankenberger, T.R. (2018) 'Does Resilience Capacity Reduce the Negative Impact of Shocks on Household Food Security? Evidence from the 2014 Floods in Northern Bangladesh', World Development, 102, pp. 358–376. doi:10.1016/j.worlddev.2017.07.003.

Zzaman, R.U. et al. (2021) 'Flood hazard mapping of Sangu River basin in Bangladesh using multi-criteria analysis of hydro-geomorphological factors', Journal of Flood Risk Management, 14(3), p. e12715. doi:10.1111/jfr3.12715.

Bangladesh Bureau of Statistics (2021) Population and Housing Census. Available at: http://www.bbs.gov.bd/site/page/47856ad0-7e1c-4aab-bd78-892733bc06eb/Population-and-Housing-Census (Accessed: 10 October 2021).

Bangladesh Bureau of Statistics (2021) Income, Expenditure and Poverty. Available at: http://www.bbs.gov.bd/site/page/648dd9f5-067b-4bcc-ba38-45bfb9b12394/Income,-Expenditure-&-Poverty (Accessed: 10 October 2021).

Research Paper

ASSESSMENT OF VULNERABILITY TO FIRE HAZARD OF RDA MARKET IN RAJSHAHI CITY

Md. Abu Sadath, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh

Farhana Afroz, Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi-6204; Bangladesh

Fahim Shahriar Sakib, Department of Chemical Engineering, Bangladesh University of Engineering and Technology, Dhaka-1000; Bangladesh

Abstract

A fire hazard has been a very frequent occurrence in an urban area, nowadays. When urban areas are built without following any guidelines it becomes unmanageable. In Rajshahi city, the RDA market is established, in violation of BNBC (Bangladesh National Building Code) rules and regulations and without proper fire safety measures. Recently, a massive fire was caught at the factory of Kemiko Pharmaceuticals Limited in Rajshahi city. The study attempted to analyze the vulnerability level in the RDA market. Also, 40 individual shops are surveyed to check individual assessments. Analysis based on this indicator was performed and indicators were selected for analysis. To calculate the vulnerability, the indicators were weighted (depending on importance) and graded (based on condition). The findings show that the market building is highly vulnerable with practically no fire safety measures. To reduce vulnerability, there needs to be some proper fire safety planning, market design and modification with the assistance of expert personnel, following appropriate rules and policies.

Keywords

Fire hazard, BNBC, Vulnerability, Fire safety, Expert personnel.

1. Introduction

Fire hazard risk has become a major concern in Bangladesh, as several major fires have occurred in recent years (Rahman, 2014). With the growing population

and rapid urbanization, unplanned housing and congestion in both residential and commercial areas are increasing with accelerates the risk of fire hazard (Opie et al., 2014). Given the various measures, rules and regulations that have been introduced in recent decades, there are still several fire outbreak accidents that result in significant losses of lives, livelihoods, equipment and property (Uddin & Hossain, 2009). From the beginning of 1997 to end of 2018, around 250,000 fire incidents occurred in Bangladesh (Sakib et al., 2020). Although the Rajshahi region is not much developed economically and industrially, due to unplanned commercial structure or other aspects there are also some fire hazard scenarios (Poddar & Shanta, 2017). Rajshahi Development Authority market (RDA) has recently been identified by Fire Service & Self Defense as being the most vulnerable to fire risk (Daily Star, 2019). But the market authority has not taken any steps to improve its condition.

Fire hazard is one such phenomenon that currently frequently causes enormous economic loss as well as the tragedy of human death. If there look into the examples, we can see that the reported incidences of fire in Bangladesh between 2004 and 2006 were 7140, 7135 and 9642, respectively. In addition to human death and injury, property damage in Dhaka city was reported to be more than Tk. 6 Crore on average each year due to fire incidents (Sayeeduzzaman, 1990). Also, this number could be applicable anytime in Rajshahi city if effective measures are not taken. RDA market, Rajshahi City's most popular shopping mall, is situated in Shaheb Bazar (Rajshahi Central Business District) in Rajshahi. A three-story building together with a newly built building covers an area of 2.18 acres. The area is a commercial area and a lot of restaurants, shopping malls and many other shops are surrounded by the market. The narrow access road, the insufficient body of water, and neglect of rules and regulation during building construction exacerbate the vulnerability of fire hazard on the market. If any fire hazard happens at this shopping mall, it will also affect the surrounding area. That's why the study was conducted for its improvement to attain the existing condition of this fire risk area. From the city planning perspective in Bangladesh, the fire safety issue in large urban areas, including Rajshahi, is not strongly emphasized. In most cases, the issue of community protection is widely debated by local newspapers immediately after any large-scale fire devastation but over time, the issue eventually falls away from people's minds. Currently, this metropolitan city's authority has no contingency plan and adequate preparedness to prevent large-scale fire disorders. Unfortunately, very little research has been conducted on fire protection in city markets in Bangladesh. So, the current research focuses on the assessment of fire risk of the RDA market in Rajshahi and analyzes the vulnerable level of the fire hazard of this building. After risk assessment, there take some safety precautions. If fire prevention or mitigation is more feasible for the RDA market may be debatable,

but there is no question the matter should be considered in the RDA market's planning.

2. Methodology

The primary data was collected in this study from a field survey & physical survey conducted on the RDA sector, and the secondary data was collected from Rajshahi Development Authority, newspapers, journals and various websites. Possible vulnerable zones had been selected by following different factors of BNBC-2006 guideline considerations like emergency departure matters, fire prevention and extinguishing systems, electrical systems etc.

2.1. Fire Risk Assessment Methods

Risk indexing is a way to evaluate various attributes into a single value, and the number and types of parameters (attributes) considered and the numerical functions used to summarize these parameters vary mainly in different risk indexes. The most famous among different types of fire risk ratings are Gretener's index, FRAME index, Dow's fire and explosion index, fire system assessment system index and hierarchical approach (Šakenaite & Vaidogas, 2010). In most of these indexes, the criteria are grouped into different categories describing different aspects of fire safety, such as fire prevention, egress, compartmentalization, detection and warning, emergency response etc.

To evaluate the FRI for the soft parameters, we adopted a linear additive model of the form below for the current work:

$$FRI = \frac{\sum_{i=1}^{n} ■ Wi Xi}{\sum_{i=1}^{n} ■ Wi} \qquad (1)$$

Where x_i was a dimensionless score or grade points for parameter i, w_i was the importance of parameter i and n was the number of total parameters. The weight w_i was used to integrate the differences in the value of the parameters relative to each other and was usually calculated, if available, by expert opinion and/or from past data. The grade points or scores x_i indicate the 'measurement' of the danger, outcome or protection given by a parameter i. Since the units of measurement were different for different parameters, x_i was expressed as a standardized dimensionless number, so that they could be added together (Watts & Kaplan, 2001). This FRI could be easily included in developing a much broader FRI involving other categories of 'hard' parameters as long as the relative importance of soft and hard parameters could be established.

2.2. Development of the Parameters and Weights

In general, the shop will follow the fire safety legislation set by BNBC-93 as well as the BFSCDA regulations for the 'strong' parameters. Although there are some soft criteria in the BFSCDA checklist, they're not

detailed. There is also no other standard set by any regulatory authority to ensure operating protection and fire management practices in the market (although in some cases, additional rules and checks are set by the purchasing foreign firm). The soft parameters were initially selected using BFSCDA's checklist, literature review and discussion with two fire safety experts. A pilot survey was then carried out at the market to ensure that the identified parameters are 'measurable' during inspections and the parameters are fine-tuned to produce the final list of 20 (i.e. n = 20) soft parameters. The weight, W_i of equation 1 may represent a variety of factors that explain 'importance', but the comparison of these important factors may be more difficult. The weight represents the significance of the parameters in terms of potential impacts for this study. This is if an expert determines that deficiencies in this parameter will cause high harm to both life and products, while the weight is minimum-1, if the predicted damage is small, a soft parameter will be given the maximum weight, 5. To prevent a disparity in interpretation among the experts about the 'measure' of value (Dodd & Donegan, 1994) experts were presented with a weighting scheme to direct their ranking, see Table 1.

Ten experts were then presented with the list of the soft parameters and the weighting scheme. These specialists were selected from the researchers and the practitioners directly involved in the management of fire safety or disasters. These include four academics involved in the design of buildings for disaster management and fire safety, three BFSCDA officers, one Bangladesh Army official responsible for fire protection, a National Housing Authority engineer and an urban risk reduction specialist from the Comprehensive Disaster Management Programme. Using their judgment of the parameters and their importance, the experts provided their grades for the selected soft parameters as per Table 1.

Advanced techniques such as analytical hierarchy, fuzzy theory, reliability interval system, grey relational model or simulation approaches have been applied in the literature to generate

Table 1: Definition of Weights for Each Parameter

Weight	Description of Consequences
5	Most important (if not present, very high damage to both life and properties may occur.)
4	Important (if not present, considerable damage to both life and properties may occur.)
3	Essential (loss of life may not occur but other losses and injuries are high)

2	Essential (loss of properties and injuries are considerable)
1	Not essential but preferable.

Source: Assessment of Fire Risk in the Readymade Garment Industry (Industry, 2014)

accurate parameter weights Judgments from experts (Ming Lo, 1999; Lo et al., 2005; Zhao, 2004). Nonetheless, given the lack of resources to produce these tests, and remembering Watt's 1991 third fire risk axiom — there is no purely objective or empirical way to measure fire risk — we follow the simple procedure of averaging the weights for each parameter. To ensure that the weights are not significantly influenced by the extreme values provided by one or two experts, the maximum and minimum weights for each parameter are omitted and the remaining eight experts average the weights. Table 2 describes the list of expert opinions on the soft parameters and their corresponding weights.

Table 2: Weight of the Parameters

Rank	Parameters short name	Parameters description	Weight average
1	Exit door	Locked/unlocked condition of the exit door	5.00
2	Chemicals	Existence of chemical material inside	4.75
3	Block furniture	Blockade of exit corridor by furniture/other material	4.75
4	Fire drill	The practice of fire drill	4.63
5	Extinguisher workability	Serviceability of fire extinguisher	4.63
6	Water in tank	Presence of adequate water in the tank	4.50
7	Extinguisher operator	Performance of fire extinguisher operator	4.38
8	Exposed utility inside	Exposed electric or gas line inside the factory floor	4.25
9	Fire pump access	Accessibility to the fire hydrant	4.25
10	Switchboard	Location of main electric switchboard	4.13
11	Communication	Communication between command centre to floor	4.13

12	Fire pump protection	Protection of fire pump against mechanical damage	4.00
13	Occupant load	Number of workers/occupants per unit floor area	3.88
14	Roof access	Unobstructed access to the roof	3.88
15	On roof obstruction	Presence of obstruction on the roof	3.75
16	Emergency light	Serviceability/working condition of emergency lights	3.75
17	Electric overhead	Existence of electric overhead line in front of the building	3.63
18	Alternate power	Presence of alternative power system	3.63
19	First aid	Availability of first aid kits on the shop floor	3.50
20	Gas mask	Availability of gas mask for emergencies	3.38

Source: Assessment of Fire Risk in the Readymade Garment Industry (Industry, 2014)

3. Results and Discussion

3.1. Existing Condition

In front of the RDA market, the road was approximately 20 feet wide. There was a 10-foot wide road to the east, west and south portion of the market. But there was not enough wide road in front of the market for fire truck parking.

There were two three-storied buildings on the RDA market. The old one with a wide entrance was unplanned and built to have two stories but additional floors had been added later (Daily Star, 2019). There was no such fire extinguishing device listed in 'Ogni Nirbapon Bidhi O Nitimala 2014' (Auto Fire Extinguisher, Sprinkler System, Water Reservoir, Fire Hydrant, Emergency Exit etc.) on the RDA market except some manual fire extinguishers. This research there surveyed 40 shops in the RDA market to ensure whether these shops were capable enough to protect themselves from any fire hazards or not. It was quite unfortunate that only 7 shops had a fire license from Bangladesh Fire Service and Civil Defense. i.e. these 7 shops were capable to protect their shop from any vulnerable situation of fire hazard.

3.2. Causes for Fire Vulnerability

In the RDA market, there were many dangerous things which were the causes of any fire hazard in the market. Some major causes of these were- electric short, loose wiring, overheating of used electric shorts, electric kettle, smoking unconsciously. Also, sometimes unplanned smoke and heat could be spread to the market and the main causes were the service duct (electric and other cables such as- Network telephones etc). If any unwanted flames were created in the market, the existing interior decoration had a large amount of flammable material and would quickly spread. In the market, there was the possibility of people being trapped inside and not having any emergency power supply.

Table 3: Existing fire prevention and extinguishing systems

No.	Indicator	Existence
1	Exit door	To exit the market- at the bottom of the market, there were 3 roads to the east, 9 roads to the west and the main road to the north. There was a total of 7 stairs to the second and third floors of the market, these were 4 feet wide.
2	Block furniture	Yes
3	Fire drill	No
4	Extinguisher workability	Yes
5	Water reservoir	There was no water reserve anywhere in the market
6	Extinguisher operator	Yes
7	Exposed utility inside	Yes
8	Fire pump access	No
9	Switchboard	Danger
10	Communication	No
11	Fire pump protection	No
12	Occupant load	Medium
13	Roof access	No
14	Emergency light	No
15	Electric overhead	Yes
16	Alternate power	Yes
17	First aid	No

Source: Authors Survey, 2021

There used the FRI tool to calculate whether the RDA market shops were safe or not. As chemical, gas mask and on roof obstruction is not applicable for the market, those three parameters were omitted from the calculation. For the calculation there uses the existence of different indicators. Here the safe parameter was assumed to be 1.00 value and the risk parameter was assumed to be 5.00 value. Then the value obtained by the calculation had been verified in numbers between 1-5, where value 1 counted as the safest position and value 5 counted as the riskiest zone. There got a value by calculation 3.36 which was more than 3. Therefore from the calculation, it was clear that all these shops of RDA markets were at High risk. The loss of life may not occur there but other losses and injuries will be high.

4. Conclusion

This research shows the very weak fire prevention system of the RDA market. There was no fire safety plan in favor of the market. A fire safety plan needs to be prepared for the market on an emergency basis and subjects to the approval of the Fire Service and Civil Defense Directorate, the next step must be implemented. Fire service and civil defense department numbers had not been placed in any market place. The national Help Desk number, 999 and the telephone number of the Rajshahi Sadar fire station, nearest to the building, should be kept in large and clear form, with visible and multiple locations in the building. There was no training from the manpower fire service and civil defense working in the market. Training in firefighting, rescue and first aid should receive by the Fire Service and Civil Defense Department. The public address system should be established in the market. Smoking inside the building should be banned. Formed a Fire Safety Cell for the market, a trained fire extinguisher, rescue and first aid, with 20 members, working in the market under the supervision of 01 responsible officers trained in the cell. The task of this group will be assisting people in safety evacuating from the market by disaster, to rescue people who are trapped or unable to evacuate, and to engage in rapid-fire extinguishers with fire extinguishers on the market. The staff of this team should be trained in firefighting and rescue. The staff of this team will ensure proper maintenance and effectiveness of the fire protection system installed in the market. The auto-shutdown switch should be kept on every floor so that the power line can be switched off in the event of a fire or any emergency. After all, the RDA market is very risky, so it was recommended to break the market and re-establish the modern firefighting system.

Acknowledgement

We want to thank Inspector Faruk Ahmed, Fire Service & Civil Defense Rajshahi, who helped us a great deal to conduct this study by providing us with an understanding of the risk indicator and a report on the RDA sector.

5. References

Watts, J.M. and Kaplan, M.E., 2001. Fire risk index for historic buildings. *Fire technology*, *37*(2), pp.167-180.

Ming Lo, S. (1999). System for. *Fire Technology*, *35*(2), pp.602–607.

Šakėnaitė, J. and Vaidogas, E.R., 2010. Fire risk indexing and fire risk analysis: a comparison of pros and cons.

PODDAR, S. and SHANTA, S., Community Based Risk Reduction Strategies of Fire Hazards: A Case Study of Rajshahi City.

Dodd, F.J. and Donegan, H.A., 1994. Some considerations in the combination and use of expert opinions in fire safety evaluation. *Fire safety journal*, *22*(4), pp.315-327.

Ahmed, J.U. and Hossain, T., 2009. Industrial safety in the readymade garment sector: A developing country perspective. *Sri Lankan Journal of Management*, *14*(1), pp.1-13.

Lo, S.M., Hu, B.Q., Liu, M. and Yuen, K.K., 2005. On the use of reliability interval method and grey relational model for fire safety ranking of existing buildings. *Fire technology*, *41*(4), pp.255-270.

Watts, J.M., 1991. Axioms of fire risk. *Fire technology*, *27*(1), pp.1-2.

Zhao, C.M., Lo, S.M., Lu, J.A. and Fang, Z., 2004. A simulation approach for ranking of fire safety attributes of existing buildings. *Fire Safety Journal*, *39*(7), pp.557-579.

Rahman, N., 2014. Vulnerability assessment of earthquake and fire hazard and formulating risk reduction strategies at community level.

Opie, K., March, A., Leonard, J. and Newnham, G., 2014. Indicators of fire vulnerability: risk factors in Victorian settlements.

Sakib, F.S., Ahmed, R. and Khan, E.A., 2020. Study of Fire Growth Behavior in a Residential Apartment using Fire Dynamic Simulator. *Chemical Engineering Research Bulletin*, pp.99-105.

Sayeeduzzaman, M. and Islam, M.A., 1992. A Fire Hazard Assessment Model and Fire Hazard Zones in Dhaka SMA. *Oriental Geographer*, *36*, pp.3-23.

Wadud, Z., Huda, F.Y. and Ahmed, N.U., 2014. Assessment of fire risk in the readymade garment industry in Dhaka, Bangladesh. *Fire Technology*, *50*(5),pp.1127-1145.

Research Paper

Delineation of Flooded Areas using Remote Sensing Technology
A Case Study on Subarnarekha River Basin, Odisha, India

Zakaria Salim, Associate GIS Analyst, Tiller Easing Spatial Solution; Bangladesh

Abstract

Floods in India are extremely frequent owing to their geographical position. Recently, the formation of Cyclone Yaas over the Bay of Bengal struck the Indian state of Odisha, causing severe devastation to a larger extent. This study aimed at developing a methodology for rapid mapping of potential flood-affected areas exploiting Sentinel-1 synthetic aperture radar data through the usage of ground range detected images to mitigate the extent of flood damage and make a quick response. Sentinel-1 images from Pre-flood date: May 17, 2021 (The Archive Image) and post-flood date: May 29, 2021 (The crisis Image) were used from pre-processed products made available by the European Space Agency (ESA), which can be quickly treated for information extraction through different algorithms. Flooded areas appeared in red as there was a high response in the red channel but a low response in both the green and blue channels. Uniformly dark return given that will have a low backscatter return both in the archive and crisis image for which in red, green, and blue have a lower response. Finally, flood maps could be distributed to the local community to expedite aid in flood-prone areas. The data and methodology of the study could be replicated from time to time for flood mapping with high precision of flood-affected areas as the European Space Agency (ESA) offers free products i.e., systematically archived data for 24h with a high repetition rate (six days) to the public for flood analysis.

Keywords

Flood Mapping, Remote Sensing, Disaster Management, SAR, Sentinel-1, Cyclone Yaas

INTRODUCTION

Floods are one of the most severe natural hazards that cost maximum damage in contrast to other natural calamities (Dhar & Nandargi, 2003). In terms of damage to economies, infrastructure, and lives, it stunned people worldwide several times in the past decade (Amitrano, et al., 2018). During the period 1995-2015, it cost about $662 billion with catastrophic destruction in the lives of about 2.3 billion

people (UNISDR & CRED, 2015). The consequence of this natural phenomenon has been exacerbated in Asia in comparison with other continents which is struck by 70% of all floods occurring over the world and the average annual cost is approximately $15 billion including the immense loss in infrastructure facilities (Hansson, et al., 2008). Currently, India upholds the 18th rank in terms of coastal length and these densely populated coastal areas are extremely vulnerable due to sea-level rise, storm surges, and tropical cyclones (Ravinder Dhiman, et al., 2019). On May 26, 2021 "cyclone Yaas" which is formed over the Bay of Bengal hit Odisha, India which is the 96th tropical cyclone to strike Odisha in 130 years (Mohanty, 2021). Many areas have been flooded with serious landfall leaving roadblocks and local inhabitants isolated (Davies, 2021). It is cumbersome to protest a natural phenomenon like floods but an effective assessment of flood hazard and vulnerability to delineate flooded areas can mitigate its exposure as a crucial output for decision-makers and authorities for exigency response (Buehler, et al., 2006) (Rosser, et al., 2017). During the flood period, it is difficult to get higher accuracy from optical images for dense cloud coverage which is needless to say, a sturdy impediment for mapping (Uddin, et al., 2019). Therefore, the use of synthetic aperture radar (SAR) is getting popular nowadays for its creation of major opportunities for flood extent monitoring in all weather conditions due to the availability of the acquisition independently from solar illumination (Greifeneder, et al., 2014). This computational method provides reliable results especially for the areas with simple flood situations and homogenous topographical characteristics (Amitrano, et al., 2018). Detection of abrupt changes to land surfaces due to flood events is of utmost importance for rapid monitoring which can be efficiently performed based on multi-temporal SAR images by masking out some permanent water bodies (Mason, et al., 2012) (Zhao, et al., 2019). The Sentinel-1 mission includes two satellites (S-1A and S-1B, each carrying an imaging C-band SAR instrument providing data continuity of ERS and ENVISAT SAR types of mission) operated by the European Space Agency (ESA) which offers free products especially GMES Ocean, Land and Emergency services within 3h of acquisition for near-real-time (NRT) emergency response and 24 h for systematically archived data with a high repetition rate (six days) to the public for flood analysis (Uddin, et al., 2019) (Torres, et al., 2012) (Zhang, et al., 2020). The purpose of the study is to delineate the flooded areas of Odisha along Subarnarekha River Basin due to the recent natural event "Cyclone Yaas".

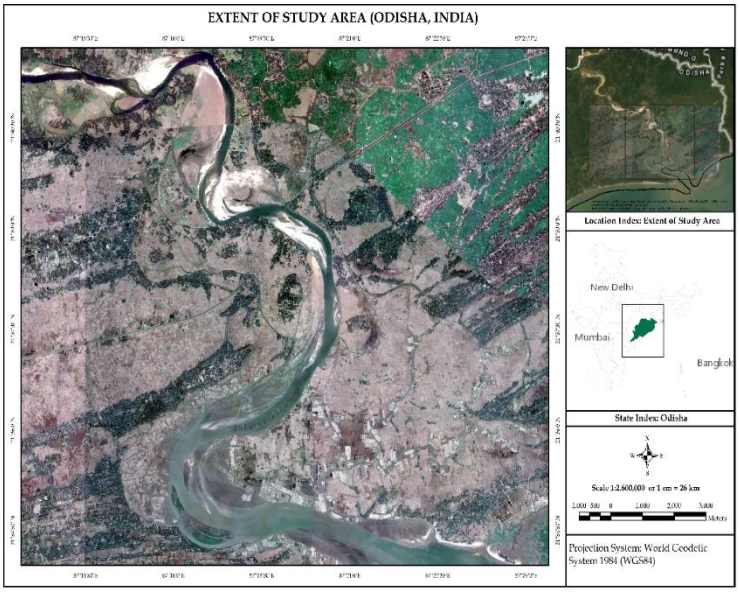
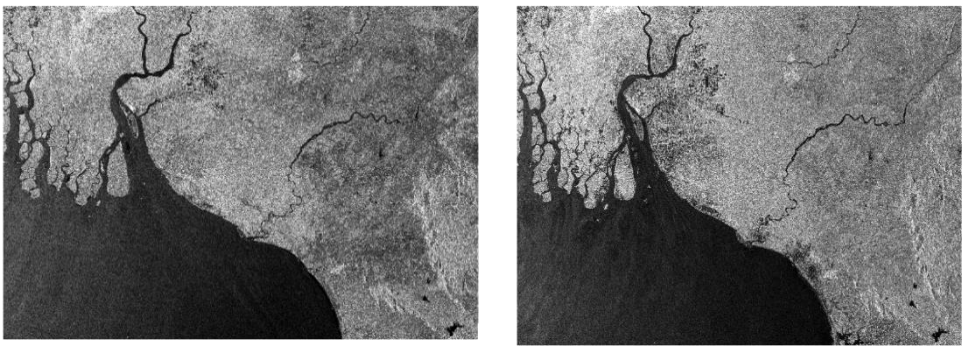


Figure 1 EXTENT OF STUDY AREA (SUBARNAREKHA RIVER BASIN, ODISHA, INDIA)

METHODOLOGY

For delineation of flooded areas, Sentinel-1 level-1 Ground Range Detected (GRD) products were used from both the archive image (pre-flood date -17 May 2021) and the crisis image (post-flood date- 29 May 2021) which were downloaded from the Copernicus open access hub data portal of the European Space Agency (ESA) (www.scihub.copernicus.eu). The GRD products consist of focused SAR data that was detected, multi-looked, and projected to the ground range using the WGS-84 Earth ellipsoid model (Uddin, et al., 2019) through some pre-processing steps including data import, radiometric calibration, speckle filtering, radiometric terrain correction, linear-to-backscattering coefficient decibel scaling (dB) transformation, and data export using ESA's Sentinel Application Platform (SNAP) (Small, 2011) (Ajadi, et al., 2016).



(A) **(B)**

Figure 2 SENTINEL-1 LEVEL-1 GROUND RANGE DETECTED (GRD) PRODUCTS WITH 10M RESOLUTION. (A) ARCHIVE IMAGE (PRE-FLOOD DATE -17 MAY 2021) AND (B) THE CRISIS IMAGE (POST-FLOOD DATE- 29 MAY 2021). DOWNLOADED FROM THE COPERNICUS OPEN ACCESS HUB DATA PORTAL OF THE EUROPEAN SPACE AGENCY (ESA)

Firstly, two products from different dates were first imported into "SNAP Desktop" tool and therefore cropped into the particular extent of Odisha, India by creating a raster subset for two images. Secondly, the radiometric correction was performed by applying calibration on both Sentinel-1 images to for making a comparison between the two images. Most of the pixels were found out with a very low backscatter value and few pixels were with a very high backscatter value for which a radiometric conversion from a linear scale to a dB scale was conducted for better visualization and easier to manipulate histogram (where one peak corresponds to the pixels over land and the smaller peak corresponds to the pixels over water) using the following expressions:

$$\sigma^0_{dB} = 10.\ log_{10}\ \sigma^0$$

Here,

σ^0_{dB} = backscattering image in dB

σ^0 =Sigma nought image

After that, geometrical terrain collection was performed for projecting the pixels onto a map system inlining with correction for distortion over the areas of terrain using the Range-Doppler Terrain correction process. Then, the overlay of one image into another was done by

coregistration (Stack tool) using product geolocation. Finally, an RGB image was produced from the stacked image for a clear distinction between permanent water bodies and the flooded areas by selecting archive image as Red band and crisis image as Green and Blue band in RGB Image Channels.

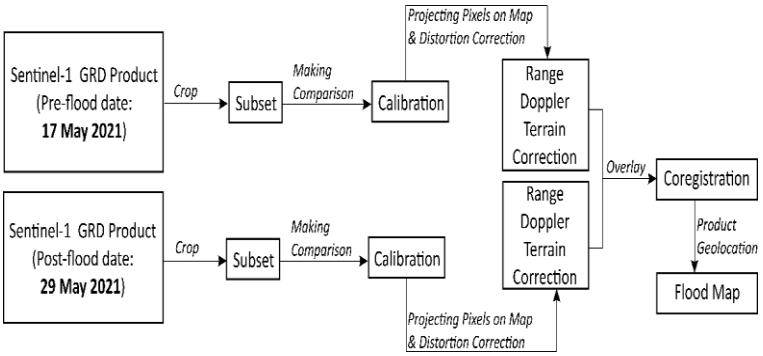


Figure 3 GENERAL WORKFLOW. THE INPUT IS TWO SENTINEL-1 GRD PRODUCTS WITH 10 METERS SPATIAL RESOLUTION (PRE AND POST-FLOOD EVENT IMAGES) WHICH ARE PROCESSED WITH CROSS-CALIBRATED USING THE VARIABLE AMPLITUDE LEVEL EQUALIZATION METHOD. A CHANGE INDEX IS DEFINED TO DELINEATE THE FLOODED AREAS BY OVERLAYING TWO IMAGES.

RESULT & DISCUSSION

2.7. Result

A high radar response was found over the flooded areas in red cannel as these areas would be land but it was not expected to see flooded areas in the archive image for which a high backscatter return was found out. However, over the flooded areas will have a low backscatter return in crisis image. Flooded areas appeared in red as there was a high response in the red channel but a low response in both the green and blue channels. Uniformly dark return given that will have a low backscatter return both in archive and crisis image for which in red, green and blue have a lower response. There were found some areas in cyan color

which was ground cover but not related to flooded areas. The river was appeared very dark and its surrounding areas were symbolized as different tones of grey.

Figure 4 FLOOD HAZARD MAP FOR THE STUDY AREA (SUBARNAREKHA RIVER BASIN, ODISHA, INDIA). DERIVED FLOOD MAP FOR 29 MAY, 2021 FROM SENTINEL-1 SATELLITE IMAGE.

2.8. Discussion

The method applied for delineation of flooded areas in this research from SAR data can perform well in other regions with high sustainability (Zhang, et al., 2020). The accuracy of obtained results can be enhanced by field observations. The concern over the increase of flood hazards with the growth of flood events is getting high nowadays globally (Zadeh, et al., 2020). So, it is of utmost importance to shape flood risk management policy due to the high exposure of people living in riverain and coastal areas with the rise of flood risk with the implication of proper flood hazard assessment (Golnaraghi, et al., 2020) for mitigation of aftermath of a flood.

References

Ajadi, O. A., Meyer, F. J. & Webley, P. W., 2016. Change Detection in Synthetic Aperture Radar Images Using a Multiscale-Driven Approach. Remote Sensing, 8(6).

Amitrano, D. et al., 2018. Unsupervised Rapid Flood Mapping Using Sentinel-1 GRD SAR Images. IEEE Transactions on Geoscience and Remote Sensing, 56(6), pp. 3290-3299.

Buehler, Y. A., Kellenberger, T. W., Small, D. & Itten, K. I., 2006. Mapping With Remote Sensing Data During Flooding 2005 In Switzerland By Object-based Methods: A Case Study. WIT Transactions on Ecology and the Environment, Volume 89, pp. 391-400.

Burton, I., 2006. The Canadian Encyclopedia. [Online] Available at: https://www.thecanadianencyclopedia.ca/en/article/floods-and-flood-control

Davies, R., 2021. Flood List. [Online] Available at: http://floodlist.com/asia/india-cyclone-yaas-may-2021

Dhar, O. N. & Nandargi, S., 2003. Hydrometeorological Aspects of Floods in India. Natural Hazards, p. 1–33.

Golnaraghi, M., Thistlethwaite, J., Henstra, D. & Stewart, C., 2020. Flood Risk Management in Canada, s.l.: The Geneva Association.

Greifeneder, F., Wagner, W., Sabel, D. & Naeimi, V., 2014. Suitability of SAR imagery for automatic flood mapping in the Lower Mekong Basin. International Journal of Remote Sensing, pp. 2857-2874.

Hansson, K., Danielson, M. & Ekenberg, L., 2008. A framework for evaluation of flood management strategies. Journal of Environmental Management, pp. 465-480.

Mason, D. C. et al., 2012. Near Real-Time Flood Detection in Urban and Rural Areas Using High-Resolution Synthetic Aperture Radar Images. IEEE Transactions on Geoscience and Remote Sensing, 50(8), pp. 3041-3052.

Mohanty, H., 2021. Down to Earth. [Online] Available at: https://www.downtoearth.org.in/news/environment/cyclone-yaas-is-the-96th-tropical-cyclone-to-strike-odisha-in-130-years-77116

Ravinder Dhiman, Renjith VishnuRadhan, T. I. Eldho & Arun Inamdar, 2019. Flood risk and adaptation in Indian coastal cities: recent scenarios. Applied Water Science.

Rosser, J. F., Leibovici, D. G. & Jackson, M. J., 2017. Rapid flood inundation mapping using social media, remote sensing, and topographic data. Natural Hazards, 87(1), pp. 103-120.

Small, D., 2011. Flattening Gamma: Radiometric Terrain Correction for SAR Imagery. IEEE Transactions on Geoscience and Remote Sensing, 49(8), pp. 3081-3093.

Torres, R. et al., 2012. The Sentinel-1 mission and its application capabilities. IEEE International Geoscience and Remote Sensing Symposium, pp. 1703-1706.

Uddin, K., Matin, M. A. & Meyer, F. J., 2019. Operational Flood Mapping Using Multi-Temporal Sentinel-1 SAR Images: A Case Study from Bangladesh. Remote Sensing.

UNISDR & CRED, 2015. The Human Cost of Weather-Related Disasters 1995–2015. In: s.l.:United Nations Office for Disaster Risk Reduction and Centre for Research on the Epidemiology of Disasters.

Zadeh, S. M., Burn, D. H. & O'Brien, N., 2020. Detection of trends in flood magnitude and frequency in Canada. Journal of Hydrology: Regional Studies.

Zhang, M. et al., 2020. Use of Sentinel-1 GRD SAR Images to Delineate Flood Extent in Pakistan. Sustainability, 12(14).

Zhao, M., Ling, Q. & Li, F., 2019. An Iterative Feedback-Based Change Detection Algorithm for Flood Mapping in SAR Images. IEEE Geoscience and Remote Sensing, 16(2), pp. 231-235.

Analyzing the Causes of Frequent Waterlogging and the Subsequent Socio-Economic Impacts in Developing Countries: A Case Study of Teligati, Khulna

Md. Sabbir Hossain, Department of Urban and Regional Planning, Khulna University of Engineering & Technology, Khulna, Bangladesh.
Md. Lutfor Rohman, Department of Urban and Regional Planning, Khulna University of Engineering & Technology, Khulna, Bangladesh.
Mahbub Hasan Medul, Department of Urban and Regional Planning, Khulna University of Engineering & Technology, Khulna, Bangladesh.

Abstract:

From the last few decades Bangladesh, the largest delta in the world, is facing frequent water logging in every year especially in the monsoon season. As a low-lying developing country water logging has become one of the greatest impediments to development which causes a huge impact on the overall economy and social life as well. Khulna is the 3rd largest city of Bangladesh and just like the other major cities the problem of water logging is also increasing here day by day. Due to unplanned urbanization and improper drainage system along with the impact of climate change in this southern part of Bangladesh, the roads are becoming overflowed even if there is a very little amount of rain. The aim of the study is to find out the causes of frequent water logging in Khulna city and analyzing the socio-economic impact. Both primary and secondary data are considered for analysis. Primary data is backed by sufficient amount of direct field survey, questioner survey, focus group discussions, and key informant interviews. For preparing the map ARC GIS 10.3 was used. According to this research the excessive rainfall, dumping solid waste in the drainage area, filling up pond and ditches, pressure of urbanization & unplanned development, low lying road, poor drainage management system, lack of public awareness, disappearance of natural drainage, encroachment natural water bodies and the lack of proper policy guidelines and implementation are the main cause of water logging in Khulna city. And according the research findings, frequent water logging has a huge impact of overall economy as well as social life.

Keyword:

Waterlogging, Slop map, waste disposal, drainage system, socio-economic impact.

1. Introduction

Currently around 5% of total land of Bangladesh is affected by waterlogging (M. M. Rahman, 2009). According to department of forestry of Bangladesh, it will increase to 14% by 2100 (Department of Forest, 2016.). Most of the time during the monsoon, the water level of the river is high comparatively other season, for this reason river water enter the city through drain and rain fall water do not pass. Eventually create a serious water logging inside the city. Rive siltation and climate change is one of the reasons behind this. It has been noticed that improvement of the drainage system and standard draining by gravity is one of the highest priorities needs of the urban authority for living environment of its urban population. The water logging and drainage congestion sufferer of urban area people especially during rainy season. It creates an unhygienic environmental condition, and causes trouble to the city dwellers and damages of the urban infrastructure, loss of business potentiality and spreading of diseases.

The long-time water-logging situation has caused significant displacement presenting humanitarian challenges in safe water supply, sanitation, shelter, food security, and employment opportunity (Awal, 2014). Social demoralization, diseases, unemployment and migration have been increasing in the locality where the places protracted by water-logging (M. Salauddin, 2011). Socio-economic and agricultural activities have also largely been hampered due to water logging (N. Adri, 2010). Further in many urban area roads are sink due to this severe problem. South-western region of Bangladesh is greatly affected by water logging problem. About 8000 hectares of waterlogged land occurs in Khulna- Jessore region (Awal, 2014). The daily news Dainik Pourbanchal on July 22, 2005, screened that 1 million people of Khulna city fell in trouble due to water logging (Pourbanchal, 2005).

The aim of the study to find out the main causes of water logging and develop some policy and strategy the solving the problem. And recommend some mitigation measure for sustainable urban growth. Khulna has been selected as a study area. This study mainly focuses to overcome the water logging problem of Khulna City, it is necessary to find out the prime causes of this problem by considering its associated impacts on human life. Thus, the study focuses to find out the causes of water logging and same times analyze its effects of water

logging due to storm water, and provide possible mitigation measure to solve water logging problem.

There has various cause behind water logging such as Disappearance of natural drainage system, unplanned and inadequate drainage system, poor operational performance and maintenance of drainage systems are the other prime reason for water logging in Khulna. Normally, Storm water of Khulna city had been drained out through some natural drains (e.g. creek and canals). During the last three decades, most of these natural drains are either filled up or were encroached by political leader or powerful influential people. Some of these are converted by narrow surface drains, which decrease the capacity of drainage system continuously and it increase the water logging problem in the city (M. M. Rahman, 2009). This problem is now become very challenging to control and minimize. This research is focused on trying to highlight the main cause of the water logging, the influence of undertaken projects and people's perspective about the effects of water logging in their urban areas and recommend possible mitigation measure for solve water logging problem.

2. Methodology

This work mainly based on several collections of data. Two main types of data collection are primary and secondary. Primary data collected from field like Primary survey, household survey and market survey of Khulna city. Secondary data sources of drainage network and with its canal system and identify of waterlogging area by the KCC (Khulna City Corporation) authority provided their recent maps and frameworks of recent KCC maps. The previous research reviews provide the clear idea of this type of work. Some statistical method has applied to analysis the project, like scatter diagram with regression analysis and time series analysis. Conceptual mapping (like choropleth, isopleth) has been drawn for showing population density, road density, depth of water level, during waterlogging period. Some diagram like pi-chart, proportional circle, bar diagram, ternary diagram, square diagram, flow diagram, etc. have been made for showing the impact of waterlogging on diseases, the waterlogged area, waterlogged affected road, the flow of water through the canal and also the year wise rainfall variation. The work is completed through the application Google Earth and some software like Arc GIS10.2

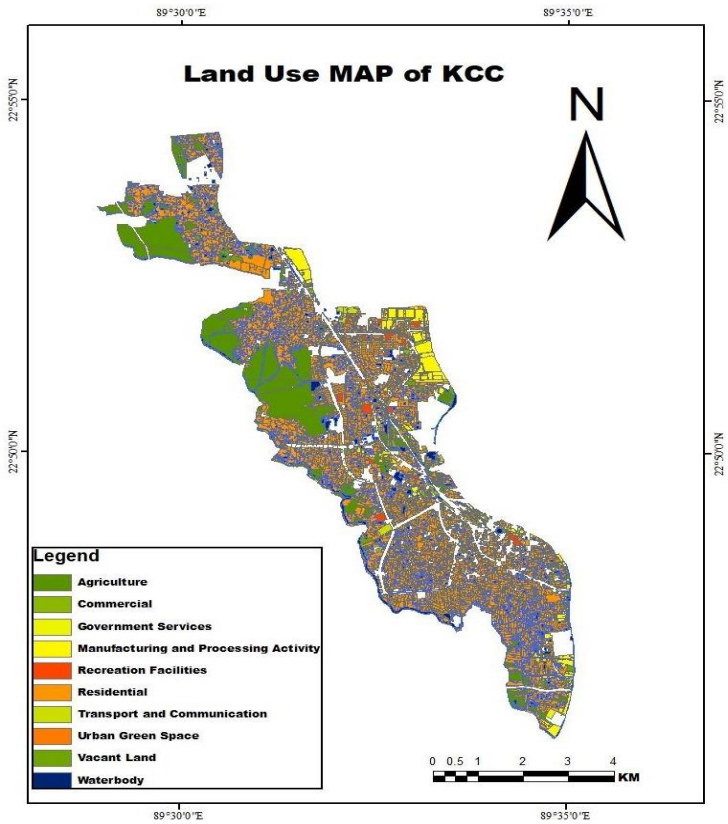


Figure 1: Land use map of the study area **Source:** Author, 2019

For conducting surveys appropriate questionnaire and checklists have been prepared based on the reconnaissance survey and indicators discussed in literature review and study area section Questionnaire and Checklist covered questions about impact analysis on the socio-economic condition of the people (e.g education, income, occupation), loss of utility services, major economic activities, growth centers, connection disruption with growth centers due to water logging.

First of all, focus discussion is a part of data collection which was done to get descriptive data of our study area. For this a group of people was selected who

are related to this study and have influence on the city development, or those people who are handling to solve this type of city problem. And those who could provide different information, statistics and over all view of our study area and also key information of the area related to our study.

Table 1. Secondary data source used in this research.

Secondary Data		
Data	Data type	Data Source
Study area map, Land use map	.img, .mxd	GIS, Google map, Google earth
Books, Journal	.pdf, .txt	Qader Ali, Gurucharan Singh
Charts, Graphs	.xlsx	Excel, SPSS

So, to verify the information from different focus groups, key information interview was taken from the head of the planning department of KCC and head of the KDA. Secondary data is collected from case studies, journals, thesis, reports websites etc.

The collected data have been analyzed and related interpretations have been provided. After conducting the field survey all the data has been compiled. Necessary software like GIS, Excel, and SPSS have been used for this purpose. According to questionnaire survey to analyze the data and find out what are the main cause of water logging and loss analysis. Due to water logging how much impact on local people and city dweller life and their livelihood, loss of income loss of road and infrastructure. According to their perception how to solve this type problem for immediate and permanent basis. They provide their perception for solving the problem.

3. Data analysis:

To find out inherent causes of water logging in Khulna City, a field survey as a questionnaire survey, informal interviews and open discussion has been conducted with the authorities of different concerned organizations, experts and people living in different parts of Khulna City. The total numbers of respondent were 120 in total**.**

3.1 Causes of Water Logging:

Khulna city is the third largest city in Bangladesh. It is known as a port city, in recent years this city facing extensive water logging during the monsoon (May to October) as a common problem. Unplanned spatial development activities and growth of habitation due to rapid population growth are causing encroachment on retention areas and natural drainage paths with little or no care of natural drainage system.

Table 2 Seasonal calendar Drainage impact during water logging

Months / Extents of water	January	February	March	April	May	June	July	August	September	October	November	December
No Impact of Drainage	■	■										■
Less Impact of Drainage			■	■							■	
Moderate Impact of Drainage					■					■		
Service Impact of Drainage						■	■	■	■			
Extremely Service Impact of Drainage							■	■	■			

Source: Field Survey, 2019

Excessive rainfall, inadequate drainage facility, conventional drainage system with low capacity and gravity, natural siltation, absence of inlets and outlets, indefinite drainage outlets, lack of proper maintenance of existing drainage system, and over and above disposal of solid waste into the drains and drainage paths are indicated for the main causes of blockage in drainage system and water logging.

Table 3. Causes of Water Logging in Khulna City (Weight given by author after field survey)

Cause	Percentage (Weight)
Excessive rainfall	14.06
Dumping solid waste	20.16
Filling up pond and ditches	6.37
population growth & unplanned development	4.24
Low lying road	5.31
Tidal effect	2.12
Drainage management System	21.22
Lack of public awareness	8.49
Disappearance of natural drainage	4.24
Encroachment natural water bodies	9.55
Lack of policy guidelines and implementation	4.24

Source: Author, 2019

3.2 Excessive rainfall:

As the Khulna city is located beside the Bay of Bengal so it faces a huge amount of rainfall especially in the monsoon period. Average amount of rainfall in this month for last 30 years is 164mm (BSS, 2019). Generally, the city faces prolonged precipitation in the period of monsoon with low intensity which creates water logging problem in city especially, those areas where the drainage system is congested and becomes inefficient due to lack of maintenance. According to 74% responds, excessive rainfall is one of the major reasons for water logging in Khulna city.

3.3 Population growth and unplanned development:

Khulna is city is facing rapid urbanization with an urbanization level of 28.49% (M. A. Rouf, 2004). During 2001 to 2011 population of Khulna increased by 37%. (M. A. Rouf, 2004). This high amount of population growth and shortage of land, lead to the increase of hard scape soft scape ratio. As the area of hard scape is becoming high, so the rain water cannot infiltrate to groundwater and it increases the surface runoff. 45% respondents said that the existing drainage

system cannot carry this huge amount of runoff and they identified that population growth and unplanned development is one of the major causes of water logging in Khulna.

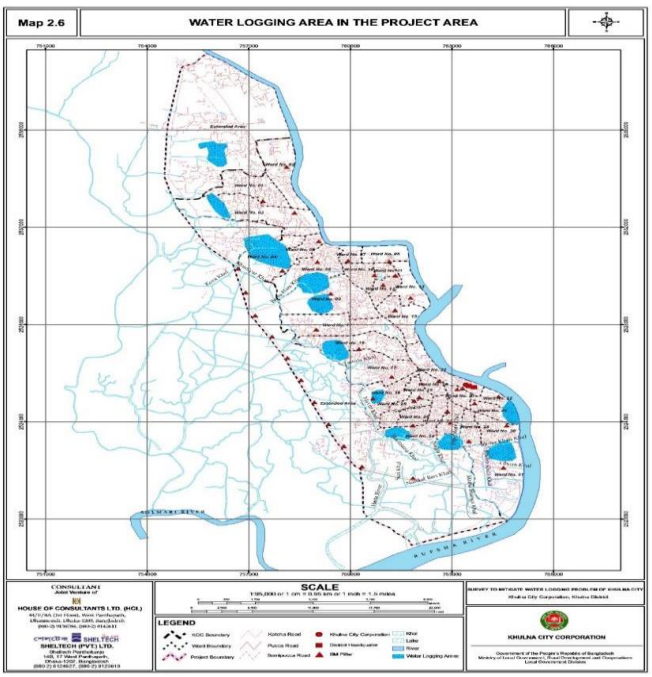


Figure 2: Water logging Point in Khulna City. Source: KCC, 2011

This low capacity of drainage system creates water logging. At present, many areas (i.e. Natun Bazar, Rupsha, Tutpara, Shipyard areas, East Bania Khamar, Boyra, RayerMohal, Kan-A-Sabur road, Nodal Point of Khan Jahan Ali and KDA Avenue.) are suffering from water logging problem due to drainage congestion during moderate to heavy rainfall. 59% responder said that Unplanned and inadequate drainage system is one of the main causes for water logging.

3.4 Disappearance of Natural Drainage System

Khulna city is surrounded by 15 canals and 3 rivers. Since long these canals were used to drain out the storm water. But last three decades most of these natural drains are either filled up or were encroached by human intervention like construction of road or development of residential areas. Some of these are

replaced by narrow surface drains (M. M. Rahman, 2009)**.** The disappearance of the natural drainage system is one of main causes for water logging. Natural drains are now filling up for building residential area, uncontrolled and haphazard disposal of solid wastes and garbage. 65.83% of the respondents said that filling up the ponds and ditches are responsible for water logging in many areas of Khulna.

3.5 Disposal of solid waste into drain

Development work during the rainy season is the cause of water logging in Khulna city. In rainy season construction work running beside the road, for this reason, the construction material store on the roads and drain so the rainwater does not reach the inlet and create waterlogging on the road. The massive drain with 4 ft height and 70-inch width in front of Laboratory School intersection, Teligati, Khulna was found 100% clogged in that area because of huge amount of solid waste disposal.

Figure 03**:** Waste disposal into the drain in front Laboratory School, Teligati, Khulna

3.6 Unplanned and inadequate drainage system:

The existing drainage lines are not in a condition to serve well. Only 45%of the drains are well served where, 52% of drains are poorly served and 3% are in vulnerable condition (KCC, 2016). Existing drains have a capacity of draining out 10 to 15 mm of rain water per hour (M. M. Rahman, 2009) which is not sufficient to drain water in rainy season.

Table 4. Length of existing drain in Khulna city

Total length(km)	Packa(km)	Cover Drain(km)	Kutcha(km)
547.27	466.81	38.2	42.71

Source: KDA, 2016

According to the drainage map of Teligati area, it was clear that, the drainage path was not properly completed to the discharge points. In several areas the drain lines were ended into some local pond or water bodies, which later connected the Dakatia Beel though narrow canals.

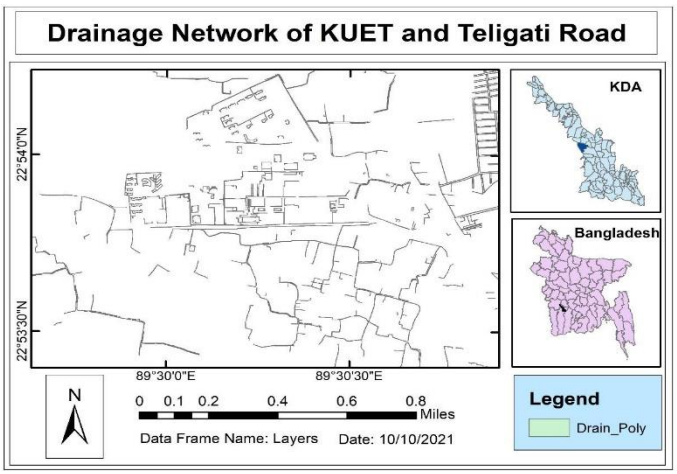


Figure 4: Drainage network of Teligati, Khulna area

3.7 Elevation of drainage system:

Water always tends to move higher place to lower place. To check the causes of waterlogging in the study area necessary slop map and contour map of the study area was also analyzed.

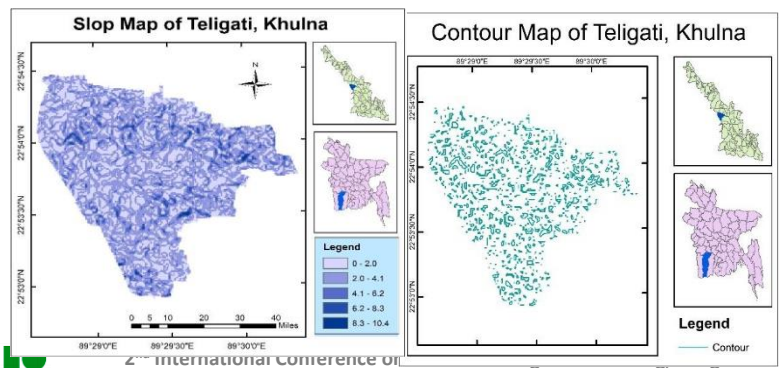


Figure 5: Slop map and contour map of the study area.

While building a drainage network in area, the terrain of that area must be taken into consideration. This slop map and contour map were prepared using hi-resolution terrain data provided by NASA EARTHDATA (2009). These maps clearly show the presence of difference in elevation in the study area that showed the south-west area were comparatively lower in elevation than other area. It means the natural path of drainage water also will be in that direction.

To check the leveling of the drainage line the elevation of the first 420m road was plotted using the Google earth data (2021) in the figure 06. According to the figure 06 the starting point of the Road has the height elevation which was 19 ft and the lowest elevation was recorded only 10 ft which is only 240 m away from the starting point. And this is the point where the drainage line was started in this road. Here the height and width of was 1m by 1m. But only 160 m from the starting the of the drain the elevation of the road was found 15 ft where the depth of drain was found 1.3 ft only. The inconsistency in the drainage elevation depth can cause the waterlogging situation in rainy season.

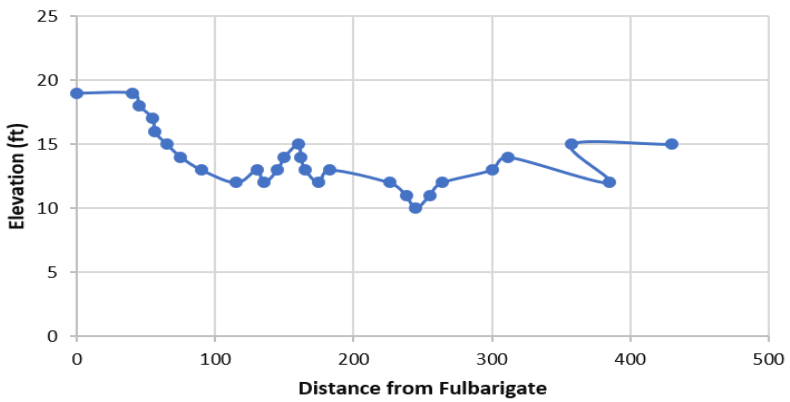


Figure 06: Elevation difference of first 430 m road in the study area.

3.8 Filling up the ponds and ditches

Along the side of Rupsha and Bhairab River, there exist a lot of water bodies. Most of these water bodies served as catchments of rain water and places of fish

cultivation. But due to rapid urbanization, these water bodies are converted into build up area with a significant rate. Around 4.75% pond and ditches areas are filled up during last 20-year (K. Haldar, 2008).As a result, there exists a shortage of storm water discharge place and this creates water logging in many areas of Khulna.

(1) Image date: 23-06-2009

(2) Image Date: 11-02-2012

(3) Image Date: 11-01-2016

(4) Image Date: 05-03-2021

Figure 07: Satellite imagery of KUET road at different dates showing gradual shrinking of waterbodies and construction activities

3.9 Encroachment

Encroachment of natural water bodies is a normal practice in Bangladesh.

Bangladesh
of Planners

Figure: Dakatia Beel area, where the drained water is finally disposed
(Source: Field survey, 2021)

Most of the natural drainages of Khulna City disappeared or are in way to lose their existence due to illegal encroachment. Once upon a time Khulna city was blessed with the flowing waters of over 50 canals. More than half of those water bodies are gone now. And the remaining 22 are under threat for survival, due to encroachment, mindless dumping of waste and sheer negligence of the authorities concerned.

3.10 Operational Performance and Maintenance of Drainage Systems

Inadequate maintenance of existing natural drains due to lack of comprehensive and planned maintenance program, equipment's, adequate budget, staffing, proper monitoring program and institutional set up to effectively operate and maintain the drainage network. Poor solid waste management is the main problem to maintain the storm water drainage. According to the chief planner of KCC, he said that they have not enough manpower to manage the daily household waste and it is one of the most common problems behind the waterlogging.

3.11 Lack of Public Awareness and Education

In general, most people of Bangladesh has a serious lacking of public awareness about the necessity of natural drainage. People don't understand the effect of drainage blocking and filling of natural drainage, low lands, wetlands etc. Therefore, they don't hesitate to throw solid waste on to the roads and drains and their poverty encourage them to fill the natural water bodies as well as destroy the ecological habitats.

3.12 Lack of Policy Guidelines and its Implementation

Lack of regulation; weakness in the existing regulations for development control, waste disposal, encroachment; negligence of the authorities for its implementation; and poor motivation and communal awareness to make the users responsible against clogging of the drains and encroachment of low lands, wetlands, khals and rivers by individuals are the major reasons for failure of urban authority to preserve the right of way over the existing natural drainage

channels. On the other hand, the laws and regulations for planning and development of Khulna cities not up to date and it is not suitable to present development, control, and needs.

3.13 Effects of Water Logging

There have many effects for waterlogging. Urban runoff creates problems. These problems very serious when an existing drainage system fails. Rapid Urbanization disrupts natural drainage patterns; natural basin is destroyed; natural reservation of rain water by plants and soil is destroyed and then create the impervious layer of surfaces and increases the amount of runoff. This runoff water washes out the road and polluted water body through mix with solid waste and become silt and contamination of water. The siltation and erosion rate are increased because volume and rate of runoff increased. Therefore, its impact on the inhabitants of the city, leading to water logging and creating the major effect on social, physical, economical as well as environmental aspect.

Table 05 Types of Problems Faced due to Water Logging in Khulna City

Problem	No of Respondent	Percentage
Disruption of traffic movement	78	65.00
Disruption of normal life	110	91.67
Damage of household goods	20	16.67
Damage of underground service lines	40	33.33
Increase mosquito	70	58.33
Damage of trees and vegetation	30	25.00
Increase of construction and maintenance cost	67	55.83
Damage of roads	87	72.50
Dirty road for household sewage	56	46.67
Building salinity problem	75	62.50

Source: Field survey, 2019

3.14 Disruption of Traffic Movement

Disruption of traffic movement is an important impact identified during waterlogging period. According to 65% of interviewers, traditional water logging

problem create disruption of traffic movement. Normal traffic movement is hampered during rainfall over 194mm, creating traffic jam in the city area and people lose their valuable time. Where the storm water stagnant on the road cannot drain out due drainage congestion, muddy will form. This is not just discomfort for pedestrians but also dangerous for road users.

Figure 08 Disruption of Traffic Movement due to Water Logging KDA Avenue, Khulna

Source: The Daily observer, 2015

3.15 Disruption of Normal Life

Waterlogging seriously disrupts normal life and it has direct impacts on the poor, as they often live on unsuitable, low-lying and flood prone or steep, and unstable sites, have high-density housing. According to field survey 91.67% of inhabitants mentioned that waterlogging hamper daily life of the city dwellers and especially the daily wage earners. The frequent waterlogging causes pollution of water supplies and the aquatic environment, the breeding of mosquito and soil erosion.

Figure 09 Stagnant Water due to poor drainage and Disrupt the Normal Life of Khulna City

Source: Daily Sun, 2017

3.16 Damage of Road and Infrastructure

Waterlogging of the ground contributes to ground heave, subsidence, dampness and other damage of property. Every year at the time of monsoon season damage leading to the movement problem and interrupts the journey. According to field survey 87% of respondents noticed such a problem. On the other hand, 33.36% mentioned that metalloid pipes of various underground utility services such as water, telephone, sewerage etc. are damaged and they lose their longevity due to waterlogging.

Figure 10 Damage of road due to waterlogging.

Source: Author, 2019

3.17 Damage of Structures

The substructure of the pucca houses in the low laying areas remains underwater due to water logging. The brick foundations losses its longevity by being affected with corrosive effect of salinity and damping is the aftereffect, said 62 per cent respondents.

In slums and low-income areas, most of the people are used to live in vulnerable houses. These houses become badly damaged during the period of water logging. Water enters into houses and the floor and walls remain damped for a long period

Figure 11 Waterlogging damage houses and structure different point in Khulna City

Source: Author, 2019

3.18 Increase of Construction and Maintenance Cost

Water logging increases the construction and maintenance cost. According to field survey, 55.83% of the respondents claimed that urban drainage system is decreasing day by day due to uncontrolled rapid urbanization and water logging is the ultimate effect of not only the physical, social and environmental problem but also it has an economic burden as well.

3.19 Loss of Income Potential

Sometimes, water enters into houses and the floor and wall remains wetted for a long period and it damages the household goods, stored food grains etc. and 65 per cent respondents mentioned such impact of water logging. The effects of water logging also lead to direct financial costs, loss of income potential, as the poor people may use their home for workplace. Water logging hamper traffic movements; therefore, creates an obstacle for communication and timely supply of goods, which means the loss of time, reduced production and economic losses.

4. Conclusion

Water logging in Khulna City is the consequence of unplanned development. Due to rapid urbanization with unplanned construction it is one of the causes of waterlogging. In monsoon season different point of city create waterlogged due to most of the storm water do not pass through drainage. Because most of the drain have been encroached, filled up, diverted and caused obstruction to the smooth flow of water to the outfall-rivers, and that's why creating severe water-logging. This impact on the city dweller and its responsible huge loss in terms of adverse social, physical, economic and environmental costs.

Efficiency of urban management directly linked to the effectiveness of storm water management through Planning, design, operation and maintenance of urban drainage systems and it is also a challenge for urban authorities because of unplanned development activities hamper the effectiveness of drainage capacity. However, for efficiently sustainable and effectively manageable urban drainage systems then should be emphasis some process and procedure. Such as co-ordination between urban authorities and agencies those who are responsible for different aspects of urban infrastructure provision and management; collaboration and participation between government and non-governmental organizations and effective partnership with civil society and the private sector.

5. References

Awal, M. A., 2014. Water logging in southwestern coastal region of Bangladesh: local adaptation and policy options. s.l., Science Postprint.

BSS, 2019. Heavy rain cripples Khulna. 27 February.

Department of Forest, B., 2016.. Bangladesh National Conservation Startegy, Dhaka,: s.n.

K. Haldar, K. R. R. S. A., 2008. Rapid Urbanization and Impacts on Urban Ponds: An Anatomy of Khulna City, Bangladesh,. Dhaka, DDC Limited.

M. A. Rouf, S. J., 2004. Spatial and Temporal Patterns of Urbanization in Bangladesh. Journal of Bangladesh Institute of Planners.

M. M. Rahman, A. K. A. M. M. K. A. J. a. M. M. R., 2009. Analysis of Water Logging Problem And Its Environmental Effects Using GIS Approaches In Khulna City Of Bangladesh. Journal of Social and Economic Development.

M. Salauddin, M. A., 2011. Nature and extent of population displacement due to climate change-triggered disasters in the south-western coastal region of Bangladesh,. s.l., s.n., p. 620–631.

N. Adri, I. I., 2010. Water logging in Keshabpur: a focus to the coping strategies of the people. Japan, s.n.

Pourbanchal, D., 2005. waterlogging situation in Khulna. 07 July .

BANGLADESH INSTITUTE OF PLANNERS (BIP)
PLANNERS' TOWER (LEVEL 7)
13/A BIR UTTAM C R DATTA ROAD
BANGLAMOTOR, DHAKA, BANGLADESH
www.bip.org.bd
www.facebook.com/bipinfo/