

Identifying the Factors Leading to Mismanagement of Floodplains in Kelani River Basin; Particular Reference to Kaduwela Divisional Secretariat of Colombo District in Sri Lanka

Kanchana Rajapaksha¹, Weththige Varunika Nishani Fernando²

¹University of Kelaniya, Sri Lanka
1992kanchana[at]gmail.com

²University of Kelaniya Sri Lanka
Wvnfernando[at]klh.ac.lk

Abstract: *The research investigated the factors for inefficient management of flood plains in Pahala Bomiriya A and Kaduwela A Grama Niladhari (GN) divisions of Kaduwela divisional secretariat of Colombo district in Sri Lanka. It has observed the underlying factors for mismanagement of floodplains while looking at the threats that floodplains face, and the impact of inefficient floodplains management. An analysis has been provided. Human settlement in river reserves, reclamation of low-lying lands, and unplanned development activities such as constructing buildings and houses in low-lying areas have affected the impact of flooding and caused flood plains management inefficiently. Further, the research emphasizes the urgent requirement of policy approach in the country to flood plains management.*

Keywords: Flood plains, Kelani River Basin, Kaduwela, Pahala Bomiriya, Colombo district, Mismanagement, Flood plains management

1. Introduction

Sri Lanka is a tropical monsoon country with more significant potential to flood (Meteorological Department of Sri Lanka, 2013). A flood could be identified as a one of the most frequently occurring natural disaster that common in Sri Lanka (NDRSC, 2008, Disaster management Centre, 2015) and Kelani river basin is one of the unique river basins prone to flood (Fowze et al., 2008, De Silva & Weerakoon, 2012). The Kelani River's total length is 145 Km and nutrition area 2292Km², and it is the fourth-longest river in the country. Further, 37 Divisional Secretariat Divisions (DSD hens after) has been directly engaging with Kelani river basin, and it has 3452 cubic meters of annual rainfall and overflow is 3417 cubic meters (Department of Irrigation Sri Lanka, 2015).

Flood plains are key landscape element with a high diversity of natural function and services. They are dynamic systems shaped by repeated erosion and deposition of sediment, inundation during rising water levels, and complex groundwater-surface water exchange processes (Tockner et al., 2008). Flood plains representing most biologically productive and diverse ecosystems on earth. There were further identified as a cultural hearts and land of early civilization.

Interestingly the Kelani river valley also has a historical validity and identified as an early settlement area in the country. Recently most populated regions in the Kelani river basin are located in the western province in Sri Lanka, and the overpopulation and unplanned settlement could be identified as a significant issue related to mismanagement of

floodplains. It has directly affected the increasing effect of being victims of seasonal flood in the area and caused increased vulnerability of the people and impact the country's economy. Further, it has occurred repeatedly in the year cycle, flood management becoming an essential topic in a scientific forum in Sri Lanka.

Based on the situation, this research had the main objective of understanding the factors that affected the mismanagement of floodplain area in Kelani river valley and recommended the implementable steps to be taken by relevant policy authorities in Sri Lanka.

2. Methodology

This research conducted from May to October in 2016 in two DSDs (See figure 1 & 2) mentioned above, and research followed the semi-structured interviews with 200 residents in both areas and observation used as a primary data gathering method. The sample has been selected based on random sampling methods.

Kaduwela A and Pahala Bomiriya A were identified as the worst affected Grama Niladhari divisions¹ (GN Hens after) of the flooding that occurs in the Kelani river valley. The Kelani River marks the boundaries of Kaduwela A GN division from north, Gala Uda para and Pannaguru ela from West, Pattiyawatta para and Hettige ela from the south and Maha ela from east. The Pahala Bomiriya A, GN division boundaries are marked by the Kelani River from the north, Hettige Ela from the west, and high way on the east.

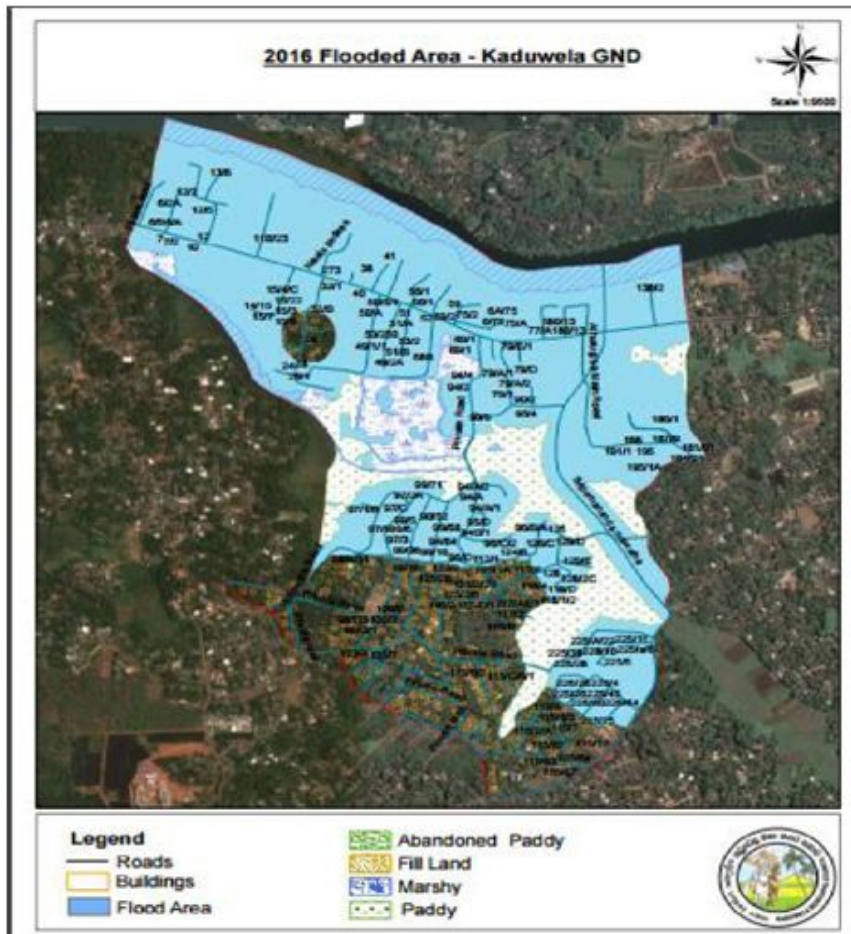


Figure 1: The Flooding in 2016 - Kaduwela GN Division³

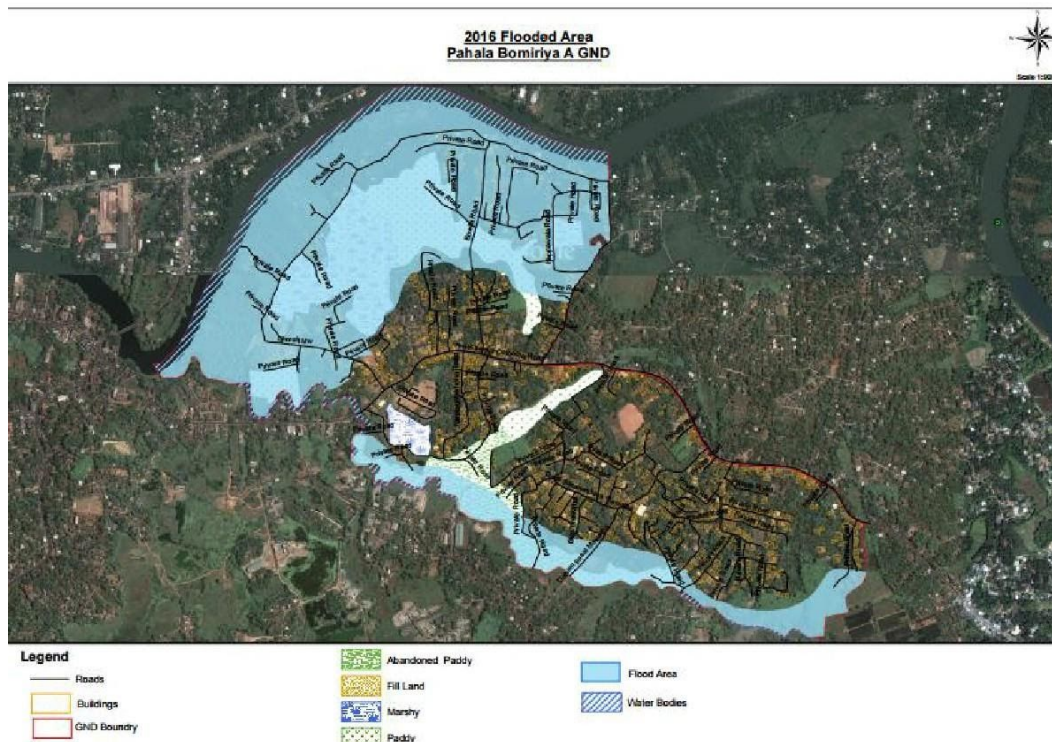


Figure 2: Flooding in 2016- Pahala Bomiriya A GN division⁴

From observing the table 1, it could be identified that the GN divisions of Kaduwela A and Pahala Bomiriya A were the worst affected areas in the 2012 floods. In the Pahala Bomiriya A GN division, 250 families were affected, and in Kaduwela A GN division it was 150 (See table 1).

Table 1: The Impact of floods in 2012⁵

Affected GN division	Number of families affected	The total number of affected
Pahala Bomiriya A	250	600
Kaduwela A GN	150	300

According to table 2, in 2016, Pahala Bomiriya A GN division, 43 houses were fully damaged. For Kaduwela A GN division this number was 51.

Table 2: Impact of floods in 2016 by damage to the property⁶

GN division	Nature of Impact			
	Fully Destroyed	Half Destroyed	Minor Damages	No Damages
Pahala Bomiriya A	43	257	97	75
Kaduwela A	51	99	87	91

Thus, a full picture of the impact of regular floods could be observed. Compared to the number of people affected by the floods in 2016, the numbers in 2012 appears low. In 2016, this number was significantly high. During the flooding in 2016, 39 GN divisions in the Kaduwela divisional secretariat were highly affected. The Kelani river valley and 15 GN divisions were fully affected. 10%-12%, which is around 25,000 of the total population of Kaduwela divisional secretariat, was concerned and displaced by the floods. Based on these facts above, two GNDs have been selected as a study region to identify the factors leading to the mismanagement of floodplains in the Kelani river valley.

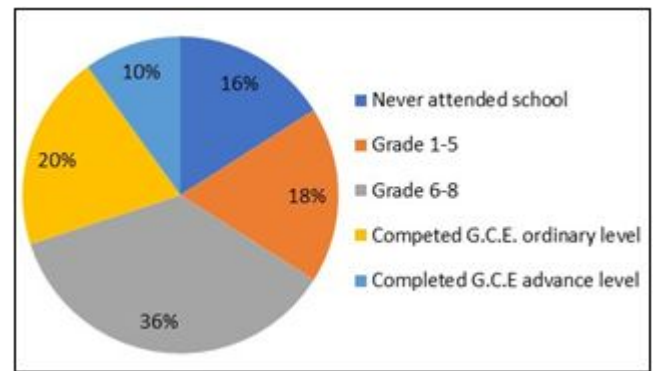
3. Result

The Kaduwela A and Pahala Bomiriya A GN divisions' sample population was distinguished into five main age groups. Observing the population's demographic by the age group, a higher percentage of sample people in the age group 36-59 was noticed in both Kaduwela A and Pahala Bomiriya A GN divisions. The second-highest rate represented people between 20-35 years old. The population under five years of age was reported as 10% and 14% respectively in Kaduwela A and Pahala Bomiriya A GN divisions (See table 3). Therefore, it could be predicted that, in the future, a significant part of the population will be aged. Thus, in the future, more people would move to the areas because of the urbanisation of Kaduwela and Bomiriya, and these areas would further populate.

Table 3: Population by age group, Field survey 2016

Age Group	Kaduwela A GN division (%)	Pahala Bomiriya A GN division (%)
Below five years	10	14
6-19 years	18	16
20-35 years	24	24
36-59 year	28	26
Above 60 years	20	20
Total	100	100

Table 4: The education level of the sample in Pahala Bomiriya GND, Field survey 2016

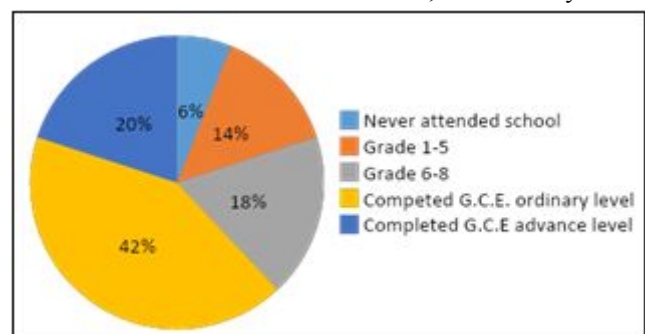


When observing the study sample from Pahala Bomiriya A GN division, it is apparent that a significantly higher percentage, that is 70% have low education levels means below grade 8. Besides, from the chosen sample, approximately 16% have never attended school. People with higher education levels are comparatively low and remain at 10% (See table 4).

Referring to table 5, it was noticed that a significant portion of the population (42%) in Kaduwela A GN division had completed GCE Ordinary level examination. Although there is are people who never attended school, the figures are significantly low, and in terms of the chosen sample, it was approximately 6%.

1. The smallest administrative body in Sri Lanka
2. Department of irrigation, 2011
3. Kaduwela City Council, 2016
4. Kaduwela City Council, 2016
5. Kaduwela divisional secretariat office, 2014
6. Kaduwela divisional secretariat office, 2014

Table 5: The categorisation of population by level of education in Kaduwela A GN division, Field Survey 2016

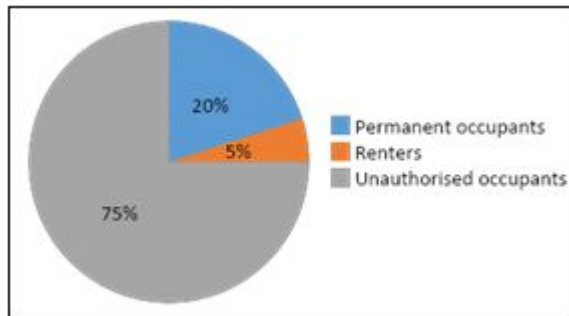


Although a significant number of school-aged children were noticed in the chosen sample, it appears that they do not even complete the GCE Ordinary Level. Among the adult population, the number of people with a higher education level is insignificant, and individuals who never attended school were also noticed. Even though the adult population lacks higher education skills, their experience, assisted to a great extent in gathering information for this study. Furthermore, despite their low education levels, they provided valuable information for the questionnaire through their life experiences. Historical information about flooding could be gathered from this cohort. Further to that, the information about temporal changes in riverside low laying

lands could be collected from them.

It is observed that the low education levels of the people living in riverside lowlands could be a cause for mismanagement of these areas in question. Moreover, because of the people's low education levels in this area, the lack of understanding about the ecological value of lowlands, marshy lands, and canals is a threat to environmental well-being.

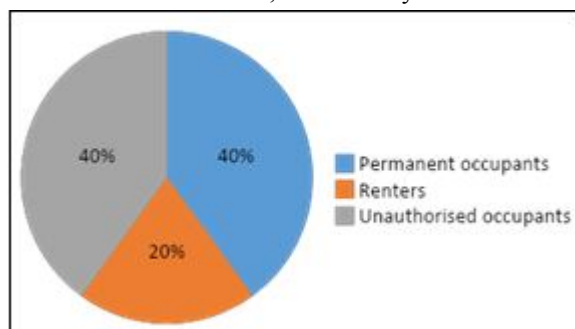
Table 6: Status of occupancy of the population in Pahala Bomiriya A GN division, Field survey 2016



According to table 6, most of the chosen sample living in riverside lowlands of Pahala Bomiriya A are unauthorised occupants. Approximately 30 families were observed to live in the river reserve of the floodplains as unauthorised occupants. It was confirmed that 75% of unauthorised occupants were living in floodplains. In terms of the renters, they represented 5% of the chosen sample.

Table 7 illustrates the occupancy status of the population in the GN division. Observing the sample chosen for the study, it was noticed that the majority of the people living in lowland areas are to be permanent occupants and unauthorised occupants, and it is 40%. And 20% of the occupants lived in rented properties in more urban areas of Kaduwela.

Table 7: Status of occupancy of the population in Kaduwela A GN division, Field survey 2016



When observing the nature of occupancy, compared to the percentage of unauthorised occupants in Kaduwela A GN division (See table 7), the number of unauthorised occupants in Pahala Bomiriya A is more significant, and it is about 30 families. When unauthorised occupancy is taken as a percentage, it remains at 40% and 75% in Kaduwela A and Pahala Bomiriya A. As a number, 8 families in Kaduwela A GN division and 30 families in Pahala Bomiriya A.

The settlements of unauthorised occupants in the riverside lowland areas is a significant factor that influences the inefficient management of riverside floodplains. Unauthorised occupants' settlement influences adversely on the riverside areas, canals, marshy lands, and the water bodies.

Table 8 illustrates the length of occupancy for the families in the sample group. In terms of Kaduwela A GN division, most people have moved to the area quite recently. Thirty five percent (35%) of the chosen sample families have lived only 1-10 years in the area. Ten percent (10%) of the occupants have lived in the area for less than a year. Kaduwela could be identified as a populated area.

Table 8: The length of occupancy, Field survey 2016

Number of Years	Kaduwela A GN division (%)	Pahala Bomiriya A GN division (%)
Less than 1	10	5
1-10	35	10
10-20	20	35
20-30	15	25
Over 30	20	25

A large number of people have moved to this area for economic activities. According to table 8, it appears that the number of occupants in the area was low, and over time, it has grown the past.

When observing the data from Pahala Bomiriya A, 35% of the chosen sample residents have lived in this area for only a short period that is for 10-20 years. And 5% of them were identified as moved there quite recently.

Quite clearly, the sample families settled in the riverside lowland areas in the Pahala Bomiriya A and Kaduwela A GN divisions have moved to these areas in recent times and were not born in the area.

Causes for improper management of floodplains in the sample area

● **Establishment of settlements in the river reserve areas**
The study observed a settlement in river and canal reserve areas of the GN divisions of Kaduwela A and Pahala Bomiriya A. According to the irrigation reservations boundaries provisions of public land code, as per No 9912 of Government land regulations 11 dated 15.10.1948, the reservation boundaries are as follows,

- 1) Small scale rivers, streams - rivers less than 15 feet in width. A strip of land with the width of one chain from the bank (20m)
- 2) Mid-scale rivers and streams - for the rivers with a width of 15-50 meters, a strip of land with the width of two chains from the banks (40m)
- 3) Main rivers - rivers more than 50 feet in width, a strip of land with a width of three chains (60m)

Thus, the reserve boundary for the Kelani River is 60m. According to the Act of reserve boundaries, the establishment of settlement within the reserve should be avoided. However, in the GN divisions of Pahala Bomiriya

A and Kaduwela A, several unauthorised settlements can be seen in the reserve areas, and such human consumption activities in the river reserves negatively influence the floodplains.

rivers as well as the canals. For a canal with a width of 15-50 feet, the reserve area is a strip of land with a width of 40m from each bank. Unauthorised occupants were noticed in the river reserve areas where this study was conducted.

The department of irrigation has defined reserve areas for



Figure 3: Unauthorised occupants in Pahala Bomiriya A, Field survey 2016

Figure 3 and 4 shows the houses of the unauthorised occupants. It was observed that approximately 30 families live as unauthorised occupants in the river reserve and canal reserve areas. Figure 4 shows the houses of the unauthorised

occupants in Kaduwela A GN division. It was found out that approximately eight families are living in the Kelani river reserve area and canal reserve area.



Figure 4: Unauthorised occupants of Kaduwela A GN division, Field survey 2016

- **Reclamation of Low-Lying Land and Unauthorised Constructions.**

The low-lying lands have been reclaimed in the GN divisions of Kaduwela A and Pahala Bomiriya A. The study-related information on this was gathered using a questionnaire and through field observations. At present, the marshy lands and the low-lying lands GN divisions of Kaduwela A and Pahala Bomiriya A are being impacted. The low-lying lands have been reclaimed for several commercial constructions and industrial activities. Large-scale businesses engage in construction on marshy lands, and consequently, these lands are being reclaimed. As a result, the areas are hugely impacted. All the marshy lands in Pahala Bomiriya A GN

division appeared to have been reclaimed. Observations in the area confirmed it.

The sample area where this study was conducted has historically been a marshy land. However, by the time of the study in the GN division of Pahala Bomiriya A (See figure 5), only one marshy land was not reclaimed. The rest of the surrounding marshy lands were reclaimed, and industrial buildings were constructed in these areas. Thus, the presence of human activities is apparent in the low-lying lands as well as marshy lands.



Figure 5: A marshy land Pahala Bomiriya A GN division, Field survey 2016

Further to that, these areas with an ecological value are being used as rubbish disposal sites. These marshy lands are being

filled using industrial and residential garbage.



Figure 6: How marshy lands and low-lying lands appear after landfill, Field survey 2016

Figure 6 illustrates how the low-lying lands and the marshy lands appear at present after being reclaimed and further shows the compost plant used for compost recycling constructed on reclaimed land. Before the constructions, this area has been a sizable marshy land.

● **Obstruction of the canals and the drainage system**

According to the information gathered from the houses in the study area, the canals and the drainage lines in the floodplain

are poorly maintained. The canals, Hettige ela (See figure 7), Medilla ela, Meda ela, and Maha ela in Kaduwela A GN division are blocked due to the rubbish deposited. The obstruction of the canal system that does not allow rainwater flowing has impacted to intensify the flooding. As per the families' information in the Kaduwela A GN division, Kadugam Medilla ela is not being cleaned. Thus the mismanagement of canals in the area could be identified as a significant factor for the destitute flood plains.



Figure 7: The pollution in Hettige Ela, Field survey 2016

The obstruction of the canals by rubbish disposal is one of the main factors for worsening the flash floods that occur due to intense rainfall. This obstruction delays the water flow from the canal to the river. Consequently, flooding has become more severe and lasts for an extended period.

● **Digging of Clay for the Pottery Industry**

Another reason for poor floodplains management is digging clay for the pottery industry (See figure 8). Historically, the brick and tile industry has been massive in the GN divisions of Pahala Bomiriya A and Kaduwela A. The clay needed for the sector was dug out from the low lying areas of the floodplains. Deforestation has occurred due to this digging,

and several clay pits have been created.



Figure 8: Clay pits created by digging of clay for pottery, Field survey 2016

- **Absence of appropriate zoning process for the floodplains.**

Lack of appropriate zoning processes for the floodplains is a factor behind the poor management. Further, the floodplains are not identified in different zones to manage human activities in these areas. When the water level of the river rises, it floods onto the floodplains. Zoning the floodplains of the river valley reduces the harm of the floods and manages the impact of human activities on floodplains. However, floodplain zoning was not seen in the study areas, and the floodplains and the reserve are hugely impacted by human activity.

In most of the studied area houses stand less than 50m from the river banks. 80% of the homes in Pahala Bomiriya A were built in the river reserve area. In Kaduwela A GN division this percentage is about 40%. Therefore, the lack of laws non-execution laws was identified as one reason for the poor management of floodplains in the area.

Many families in the sample group, whose houses were damaged were living temporarily in relief camps during the floods caused by heavy rainfalls. Fifteen families out of 20 of the sample group stayed in relief camps during annual floods. As a percentage, it was 75. In Kaduwela A GN division 11 out of 20 families remained in relief camps during yearly floods. Approximately 45% of the sample group did not stay in relief camps. Instead, they stayed with friends and family or in the second story of two-story buildings.

During the floods in 2016, 2000 people from Pahala Bomiriya A GN division were living in camps. The camps have been established in Temple, Schools, SANASA hall, Road camps and pre-school. In Kaduwela A GN division 3450 people moved to camps, and the centres have been established in temples and schools.

By observing the trends, it could be concluded that the temporal and spatial changes in floodplains have influenced to worsen the impact of floods. It was identified that the floodplain where the families of the sample group were established had been marshy lands, water bodies, and low lying areas historically.

During the 2016 floods in Kaduwela A GN division, the spread of floodwater can be seen in Figure 12 As per the

- **Inadequacy and non-enactment of current laws in protecting the river reserves**

According to the irrigation reserve border act of Public Land Code, people must not be allowed to settle in reserve areas. Instead, these areas need to be covered in forest. However, in the area of study, the river reserve area is impacted by unauthorised settlements and adverse land consumption patterns. Thus, it was identified that the laws associated with managing human activities in floodplains are inadequate and are not being executed practically. It was determined observing the sample area that ecologically valuable marshy lands and low lying lands are not meaningfully protected.

mas; the entire Kaduwela A GN division was affected by the floods. It was also identified that the flood water flowed to the river with a delay causing floods to last longer. This was caused by the reclamation of low lying areas, unplanned developments in floodplains, and human settlement in river reserves. In 2016 the flooding in Kaduwela A GN division remained for 21 days.

- **Temporal and Spatial Change of Flood Plains in Pahala Bomiriya A GN division**

According to figure 9, it was concluded that the reserves around the Kelani River and the canals are being used for human land consumption activities. The settlements are established even within the 60m zone, which is considered the reserved area. It was identified that settlements are established in the river reserve. Further to that, the river reserve areas are being used for agricultural activities as well. Apart from the agricultural activities, it was revealed from the map that low-lying lands and marshy lands were reclaimed for industrial activities.

In 2004, there were approximately 25 houses in the floodplain area of Pahala Bomiriya A. Most of these houses were located in the river reserve. On the western end of the map, the disperse of unauthorised occupants was noticed. Moreover, the river reserve was used to cultivate, and Rambutan⁷, Coconut, and Mahogani⁸ were identified as the main crops.

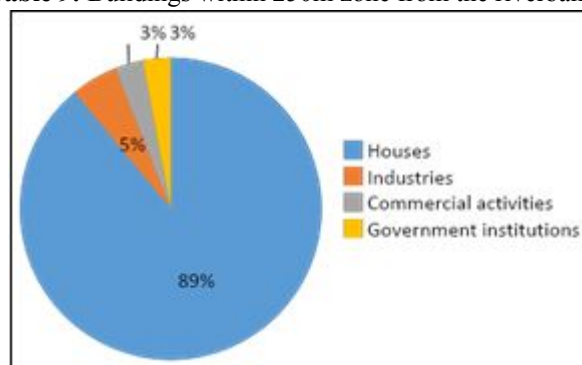
Mainly Rambutan cultivation is much widespread. Towards the GN division's western end, several marshy lands, low-lying valleys, and the deforested areas created by clay digging can be noticed. In 2004, human land consumption in

the area had been minimal. However, when looking at the map, it is apparent that social activities have occurred in the south western and north eastern parts of the GN division. In the south western part of the GN division, several marshy lands, water bodies, low laying ground, clay pits, and fields were observed. According to the map from 2004, it is evident that these areas with an ecological value were preserved at that time.

Further to that, the land was used only for land consumptions associated with agriculture. In terms of unauthorised settlements and building constructions, in 2004 it has been minimal. It was identified that a significant part of the area was preserved and protected from human activity.

Many industrial buildings, schools, and houses have been constructed in the zone within 250m from the riverbanks. Kumaratunga Munidasa school and industrial areas are noticed towards the western side of the GN division. Several houses and marshy lands were observed in the north eastern region. When looking at the 250 m zone from the riverbanks, most agricultural activities were noticed within the 66m zone, which is considered the river reserve.

Table 9: Buildings within 250m zone from the riverbanks



According to table 9, the most familiar buildings in the floodplains were houses, representing 85% of the total buildings. Industrial buildings remained at 6%. Also, within 250m, from the river banks markets, shops and markets were noticed. From 2010 to 2015, the temporal and spatial changes that occurred in the floodplains due to human consumption are evident. It was also observed that, by 2015, in the Northern part of Pahala Bomiriya A GN division, there were 5 acres of Mahogany, 5 acres of Cinnamon, 5 acres of Coconut, 1 acre of Teak, and 25 acres of Rambutan cultivations within the zone of 250m from the river banks.

7. One of the typical tropical fruits

8. Hard-core tree

9. "Several water bodies" It was called this name, meaning that there are many ponds, water bodies, and marshy lands.

Figure 9 of 2010 and 2015 illustrate the disperse of house building and unauthorised occupants. By 2010 and 2015 the water bodies, marshy lands, and the low lying lands in the northeastern region have been entirely reclaimed, and human settlements have been established. Comparing 2004 with those of 2010 and 2015 it is clear that the marshy lands and the water bodies have been reclaimed to build houses as well as for agricultural land consumptions.

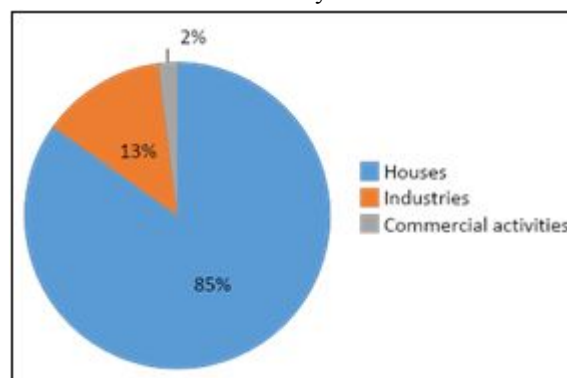
In terms of the river reserve zone or the region within 66m of

the riverbanks, compared to 2004, in 2010 and 2015 unauthorised settlements have prevailed further. By 2016, approximately 30 unauthorised houses were established in the area.

Pahala Bomiriya, A GN division, was referred to as "Bowila." ⁹, however, by 2010, the marshy lands were only limited to the GN division's western region. Further, the marshy lands in the northwest and southwest regions remain unthreatened by human activities.

By 2004, the prevalence of industry in the floodplain area was 6%. However, according to the table by 2013, it has increased to 13%. It appears that the marshy lands have been reclaimed for building constructions and gradually the areas around these constructions have been further reclaimed. The marshy lands, valleys, and lowlands in the western region have been reclaimed to establish industries. Towards the southwest of the GN, large marshy land and a low laying land on both sides of the road have been reclaimed to build commercial buildings. In 2004 there were only two buildings in the area. However, by 2010, this has increased to 14 buildings. Thus, it is apparent that the marshy lands in the western region have been reclaimed for constructions.

Table 10: Buildings on floodplains as a percentage - 2010, Field survey 2016



Towards the south western region, a large deforested area could be seen. As a result of digging clay for the pottery industry, several clay pits and deforested areas can be seen in Pahala Bomiriya A's western region.

Also, as per the map, the number of houses has further increased in the south western low laying lands. In 2004, these areas were marshy lands with an ecological value.

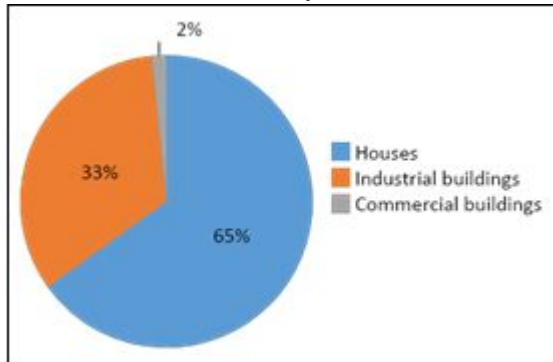
When observing the area of study, it was noticed that the marshy lands, low-lying lands, and water bodies present in 2010, have almost vanished. There are a few untouched marshy lands in the western region. All the other marshy lands have been reclaimed.

Further to that, even in the north eastern region, the number of houses built on the river reserve is more significant in 2015 compared to 2010. In 2010, there were 196 houses within the 250m zone from the riverbanks, and by 2015, it has increased to 298. The number of industrial buildings has also grown. It has jumped from 34 to 52 between 2010 and 2015. The industrial sites that initially consisted of two or so buildings have further reclaimed the marshy land for new

constructions.

According to table 11 out of all the constructions present in the floodplains understudy, the percentage of houses is 65%. The number of industrial buildings has increased to 33%. The map illustrates how human activities have temporally developed in Flood plains.

Table 11: The number of building in floodplains - 2015, Field survey 2016



Observing all this, the spatial and temporal changes in floodplains within the 250 m zone, including the river reserve are evident. In 2004 the river reserves, marshy lands, and low lay lands in flood plains were presented as valuable ecosystems. However, by 2015 these have been impacted by human activities causing noticeable Environmental degradation.

The Temporal and Spatial Change of Kaduwela A GN Division

This section explored the temporal and spatial changes that occurred in floodplains of Kaduwela A GN division. Figure 9 illustrates how the river and canal reserves in floodplains are used for human land consumption activities.

In 2005, towards the western end of the figure, Kaduwela town had triggered commercial activities to develop on both sides of the road. There are quite a few shops, markets and commercial buildings. The northern half consists of several houses, several marshy lands, and low-lying lands.

According to table 12, in the reserve area within the 60m zone, there are 30 houses and 21 commercial buildings. Thus, the human impact on the reserve is evident. There are eight houses of unauthorised occupants In Hettige ela reserve. Further to that, within the 250m zone, there are 84 houses and 109 commercial constructions. In 2005, there were no industrial constructions within the reserve, and there were nine buildings within 250m boundary.

Table 12: The number of buildings in the floodplain- 2005, Field survey 2016

Type of building	Within 60m zone	Within 250m zone
House	30	84
Commercial buildings	21	109
industrial buildings	-	9

There are several low-lying lands on the eastern end of the map, and there is a sizable marshy land in the southwest.

Also at the eastern end, brown areas are visible where clay was dug. From the data from 2005, it is apparent that the riverside reserves have been used for human activities.

Compared to 2005 the number of ecologically significant marshy lands and low-lying lands in Kaduwela A GN division dropped in 2010. Many of the marshlands in the eastern region have been reclaimed. This has caused the number of marshy lands to drop. It was also noticed that the human activities in the river reserve and within the 250m zone had increased gradually.

Table 13: The number of building in the floodplain- 2010, Field survey 2016

Type of building	Within 60m zone	Within 250m zone
House	32	16
Commercial buildings	21	158
industrial buildings	1	9

According to table 13, by 2010, the number of buildings in the reserve area increased compared to 2005, and the temporal-spatial changes in floodplains are evident. By looking at the 2010 map of Kaduwela, it is observed that the low-lying areas in the eastern region have been reclaimed for houses. Further to that, by 2010 the marshy lands in the eastern region have significantly decreased in size. Commercial and residential buildings have been built in the river reserve area. By 2010, there were 32 houses and 21 commercial buildings within the reserved area. Observing all this, the changes in the floodplains within the 250m zone from 2005 to 2010 can be identified.

Figure 9 illustrates how the marshy lands and the low-lying lands in Kaduwela A GN division are reclaimed between 2005 and 2010. By 2015, all the marshy lands in the eastern region have been reclaimed. As figure 9 illustrates the extensive marshland there was in 2010 towards the northwest has been entirely reclaimed by 2015.

Table 14: The number of building in the floodplain - 2015, Field survey 2016

Type of building	Within 60m zone	Within 250m zone
House	39	185
Commercial buildings	23	265
industrial buildings	2	10

According to table 14, there were 39 houses and 64 total buildings within the reserved area. The building that is close to the marshy land, towards the southern end of the map of 2015, is a compost production plant. It is not appropriate to build such a plant on low-lying riverside lands. During the flood season, the rubbish recycling plant gets submerged underwater causing several issues to the people living in the area. Thus, such low laying riverside lands are not appropriate to build a compost plant. A marshy land and a low-lying land has reclaimed to build the compost plant.

Further to that, observing the canals in the study area, it was noticed that the banks of the canal have eroded over the years from 2005 to 2010, causing the canals to increase in width. This widening can be seen on the map of 2015. Thus, it is apparent that the banks of the canals have eroded.

Temporal and spatial changes in the flood plains of the Lower Bomiriya GND

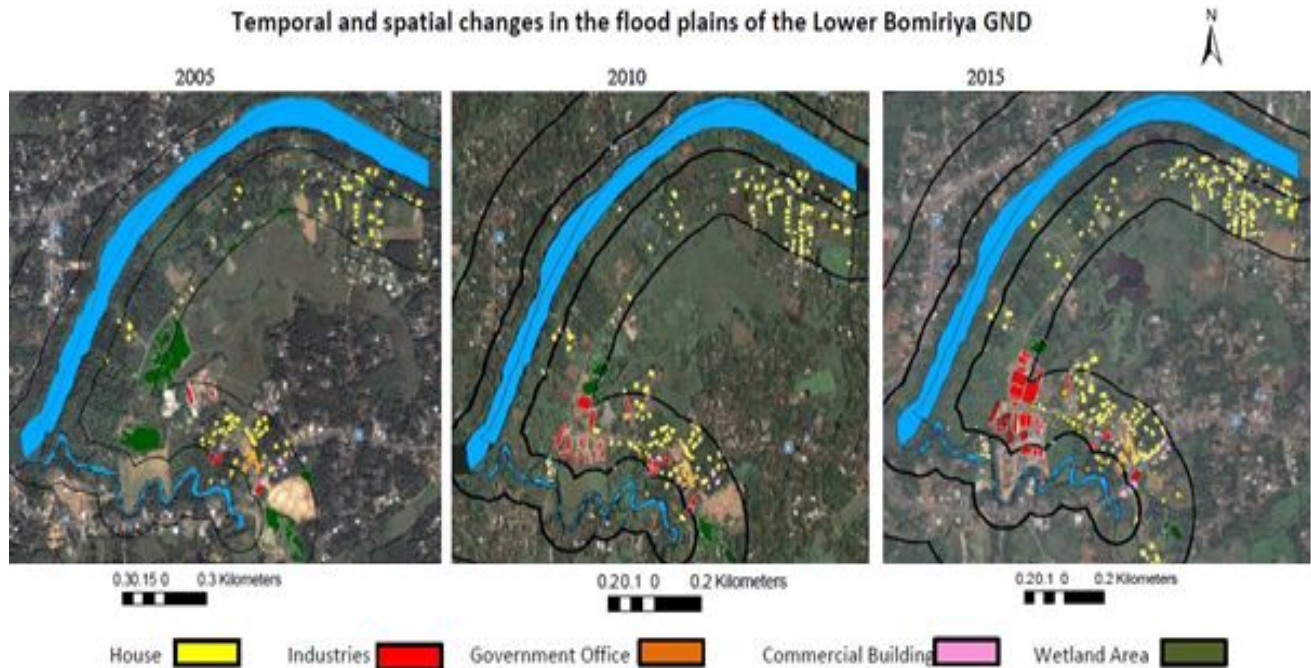
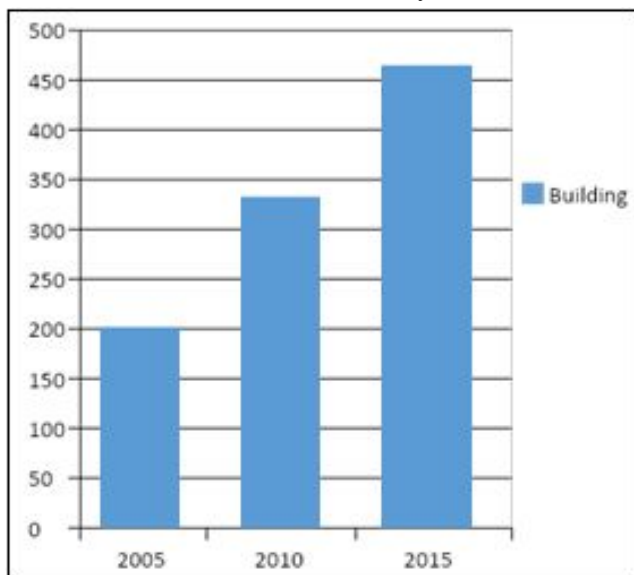


Figure 9: Temporal and Spatial Changes in the flood plains of the Pahala Bomiriya GND

According to figure 9, the temporal growth of the number of buildings in floodplains of Kaduwela A GN division over the time from 2005 to 2010 is apparent. In 2010, there were 333 buildings on the floodplains; it is a growth from 202 in 2005. By 2015, this number has increased to 465.

In terms of the study areas of Pahala Bomiriya A and Kaduwela A, 250m flood plain, including the reserved areas, have been impacted by human activity. Thus the spatial changes of the floodplains could be identified. At present, the ecological value of the site has hugely degraded. The harm done to low laying lands, marshy lands, and forest cover in the river reserves in the GN divisions under investigation is apparent. The human impact can be seen on the river reserves and floodplains.

Table 15: The temporal increase of buildings in Kaduwela GN division, Field survey 2016



4. Conclusions and Recommendations

Pahala Bomiriya A and Kaduwela A GN divisions were chosen for the study that investigated the association between the mismanagement of flood plains and the occurrence of floods. Data and information were collected by the field surveys done in the area. The reasons behind the poor management of floodplains could be identified by analysing the gathered data. Several conclusions were reached, and some recommendations are suggested. At present, the floodplains are impacted by human activities. As the population grows, the riverside floodplains have been further consumed. This study mainly focused on identifying the main reasons for the poor management of floodplains. Accordingly, several causes have been identified for the poor management of flood plains in Kaduwela A and Pahala Bomiriya A GN divisions.

- Unauthorised settlement in river reserves
All the significant rivers and canals have a reserved area. Accordingly, the area for the Kelani river reserve is 60m. However, the reserve is impacted by human settlement. The human impact on the river reserve was identified by looking at the temporal and spatial changes that occurred in the flood plains (See figure 10).
- Land reclamation and unauthorised constructions in the floodplains.
It was observed that the low lying lands in the area of study had been reclaimed. It was identified that the land reclamation causes degradation of the ecological environment. The low lying lands in the floodplains have reclaimed for constructions.
- Inadequate management of canals and the drainage system
By reflecting on the area, it was clear that the canals in the area are not well maintained. Thus blocked canals could be identified as one of the leading causes of flooding. Such obstructions hinder the water flow

resulting in floods.

- Digging for clay has adversely impacted the floodplains. The pottery industry is significant in Kaduwela A and Pahala Bomiriya A GN divisions. Quite a few numbers of clay pits were noticed in the floodplain area. Thus one of the main reasons for the mismanagement of floodplains is the pottery industry.
- The issue in a zoning procedure. It was identified that there is no zoning procedure, although there were riverside reserves. The zoning of floodplains helps to manage the human activities on those. Thus not having an appropriate zoning method was identified as one reason for the poor management of floodplains.
- It was identified that the river reserves are not protected. It was identified from the study that despite being a river reserve, no action had been taken to preserve it. The human activities occurring in the area are threatening to the safety of the reserve.
- The spatial and temporal changes of floodplains at present were identified through a geographical information system.

It was confirmed that the mismanagement of floodplains caused the floods to be intense after heavy rainfalls.

5. Recommendations

- Every river needs to have a protected floodplain zoning system.

The author recommends a system for zoning of riverside floodplains (Sivakumar, 2015). The land consumption activities in the area need to be prohibited by implementing strict laws. 100m zone is known as the limited zone. As the water flow is considerably slow, this area is ideal for farming and animal husbandry. Engaging in and consumption in this area is not appropriate. The 200m zone is known as the danger zone. As this area is less likely to get flooded, land consumption activities can be carried out in this zone, creating flood plain zoning to keep the natural balance of overflow of water from the channels of rivers and streams.

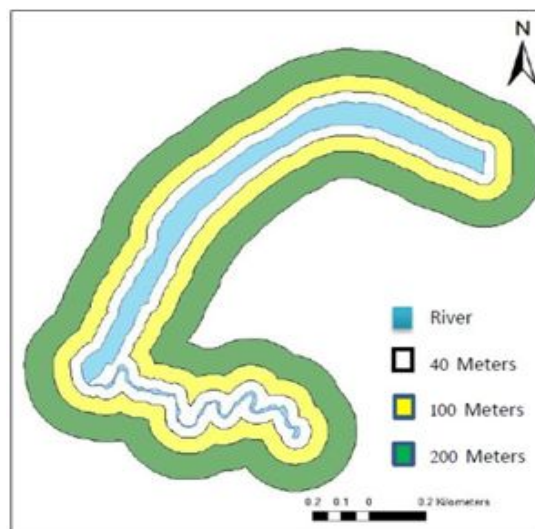


Figure 10: Zoning of Riverside floodplains, Drafted by the author using geographical information technology

- Steps need to be taken to protect the river reserves. Laws should be implemented and executed to protect these areas.
- Reconstructions should be avoided in the river reserve zone. Laws need to be implemented to do it.
- The reclamation of marshy lands, paddy fields, and low lying lands in floodplains needs to be stopped, and the laws should be implemented.
- The people in the area should be educated about the significance of the floodplains.
- The ecologically valuable areas in floodplains should be mapped out, and the people should be educated about this.
- If buildings need to be made on the floodplains, they should be built to be tolerant to the impact of floods.
- When constructing construction in the floodplains, steps need to be taken to elevate it if the land is not elevated.
- The shape of the buildings needs to be adjusted. Therefore, they are tolerant to the impact of floods.
- Land consumption laws and regulations need to be followed when engaging in river development activities.
- The floodplains need to be protected by bunds.
- All land consumption activities in the river reserves need

to be abandoned.

In contrast, in a country context, the policy approaches the need to develop a medium and long-term strategy and action plan for the management and conservation of the Kelani River basin. Further aim focused approaches are required urgently because the Kelani River Basin is home to over 25% of the Sri Lankan population.

References

- [1] De Silva, M. M. G. T. & Weerakoon, S. B (2012) Flood Inundation Mapping along the Lower Reach of Kelani River Basin under the Impact of Climatic Change' pp. [23-29]' The Institution of Engineers, Sri Lanka ENGINEER (Accessed 4 Nov 16)
- [2] Department of Irrigation, 2011, Sri Lanka.
- [3] Department of Meteorology Sri Lanka, 2015, Sri Lanka.
- [4] Disaster Management Centre (DMC), (2010), Flood Situation Report, Colombo, Sri Lanka.
- [5] Fawze, JSM., GunasekaraIPA., Liyanage PP, Hazarika,

- MK., Samarakoon, L., 2008, Flood hazard mapping in the lower reach of Kelani River, Sri Lanka, Proceedings of the 29th Asian conference on Remote Sensing, ACRS, Researchgate.net
- [6] Getrevising (2014) Flood Plain Zoning" https://getrevising.co.uk/grids/flood_plain_zoning (accessed 18 Nov 16)
- [7] National Disaster Relief Services Centre (NDRSC), (2008). Floods & Landslides Situation Report - May/June 2008.
- [8] Sampath Pathikada, Kaduwela divisional secretariat office, 2014, Sri Lanka.
- [9] Tockner, Klement., Bunn, Stuart E., Gordon, Christopher., Naiman Robert, J., Quinn, Gerry., Stanford, Jack., (2008)" Flood plains: critically threatened ecosystems", Cambridge University Press. Foundation for Environmental Conservation.