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The Impacts of Land Use Changes in Urban Hydrology, Runoff and Flooding: A Review

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Abstract

The issue of Land Use (LU) change has received considerable critical attention because it is one of the most significant factors caused by human activities worldwide. Recent critical changes in this direction have affected urban hydrology. LU change affects water resources and hydrological characteristics such as runoff and urban flooding. The development of LU causes a rapid increase in impermeable surfaces, increasing the flooding rate. LU also plays a vital role in extending water drainage, groundwater intrusion, and flooding during and after rainfall. This paper aims to investigate LU change impacts on runoff and urban flooding. This review focused on most articles, conference papers, and book chapters published in SCOPUS, including Google Scholar. The study was limitation to the last published from 2017-2021 and also extended some published theories for different years published. In addition, in the short and long term, the development of LU affects the environment, and most factors are involved at a catchment level. However, there is a strong relationship between human activities at the catchment level and runoff. The study concluded that LU strongly influences topography and the landscape in arid, semi-arid, and humid zones. This is why runoff and water distribution happen in urban areas. Furthermore, this study found that built-up area is a critical factor that increases urban flood risk, especially in lowlands along floodplains. It is common for the frequency of floods to become more severe due to a rapid increase in impervious surfaces brought on by urbanisation, increasing runoff. The review concludes that runoff affects by catchment size and its condition. Finally, humans can be reduced runoff and flood risk with a sensibility strategy.

Keywords

Land Use, Runoff, Peak Discharge, Urban Flooding, Surface Runoff

1. Introduction

There has been an increase in populated cities worldwide in developing and developed nations (Nations, 2014), which is the main reason for changing natural lands. Nearly 54% of humans lived in urban areas in 2014 (UN, 2015). Urbanisation is one of the critical processes affecting human societies, especially over the last century (Abass et al., 2018). Therefore, increasing the urban area will transfer natural lands to other occupied human activities, urbanisation, agriculture, and economic regions are clear examples of these changes.

Human history used to live in an urban area, and LU is one of the most human activities impacting the environment due to urban areas. LU usually changed catchment characters at both large and small scales. So that can be influenced to modify a landscape or transfer landscape to other benefits, and this can result in both soil conditions (Abwaly et al., 2018), soil quality (Rogger et al., 2017), and urban area floods (Li et al., 2018).

Over the past century, a significant decline in the urban area is LU change. It has numerous associations with the nature of the hydrological cycle; also, it has strongly impacted floods due to landscape modification (Rogger et al., 2017). In addition, this change has impacted runoff (Kavian et al., 2017) and water distributed at a basin level (Waiyasusri et al., 2016).

On the other hand, much of the current literature on urban hydrology pays particular attention to investigating the effects of both climatology and LU development integrated to enhance runoff (Krajewski et al. 2021; Labat, Foldes, Kohnova, & Hlavcova, 2020; Arantes et al., 2021; Xiong, Huang, & Yang, 2020; Liu, Xue, & Yan, 2020; Lv et al., 2020). For example, Data from the study by Luo et al. (2018) stated that LU and climate change are increasing rainfall sensitivity. This study has taken place in 6 Japanese catchments from 1976 to 2006, and they found that runoff has already improved. Also, Dinka & Klik (2020) argued that both LU development and climate change at Lake Basaka catchment, Ethiopia, increased runoff, especially from 1973 to 2000.

Therefore, LU is a significant factor affecting the Runoff (Igulu & Mshiu, 2020), and it may be a direct reason for the distribution of a flood in the catchment (Rodrigues et al., 2019). Zope et al. (2017) found that the impact of climate change and LU development in the Poisar River basin, Mumbai, India resulted in urban flooding, but LU change had increased from 16.64% to 44.08%, especially from 1966 to 2009. Therefore, the development of LU will lead to a more impressive surface area, which is why the built-up effect on hydrology's character.

This review focused on LU and its impacts on urban hydrology, including runoff and flooding. LU and their change have been widely discussed in many publisher subjects to evaluate that change in many environmental matters. To achieve study aims, we researched many journals indexed in SCOPUS and Google Scholar based on some conditions illustrated in the next section.

2. Methodology

There are a large number of published studies that describe LU impacts on hydrology. Therefore, the identity of the article's aim can be achieved by a simple method to extract relevant terms and evaluations. The most critical ones are from the review of published articles in different journals. Thus, the article extracts relative terms: "Land Use with Runoff" and "Land Use with Flooding." To approach review aims, we implemented the SCOPUS database to seek the above terms within two majority stages: 1) LU Runoff in article title, keywords, and abstract with unlimited time. 2) Article title, keywords, and abstract with a specific time (2017-2021). To approach this aim, we are the most searched database SCOPUS. Also, Publish or Perish has been applied to investigate articles and the top citation. Furthermore, Google Scholar extracted some articles cited in those SCOPUS-indexed articles. Following, Figure 1 explains the article methodology.

Much literature published on LU conducted in the past years reported that changing natural lands to urban areas, agriculture, or bare ground will lead to frequent environmental issues and flooding due to increased runoff and peak discharge. For example, in the hydrology process (Son et al., 2022; Getachew & Manjunatha, 2022), soil quality (Vanacker et al., 2019; Padbhushan et al., 2022) and climate change (Şen, 2020); these variables are essential to the mitigation of water risk

3. Review and Definitions

It is now well-established from various studies that LU change has been essential in studying the runoff at both basin and city levels. Thus, there has been an

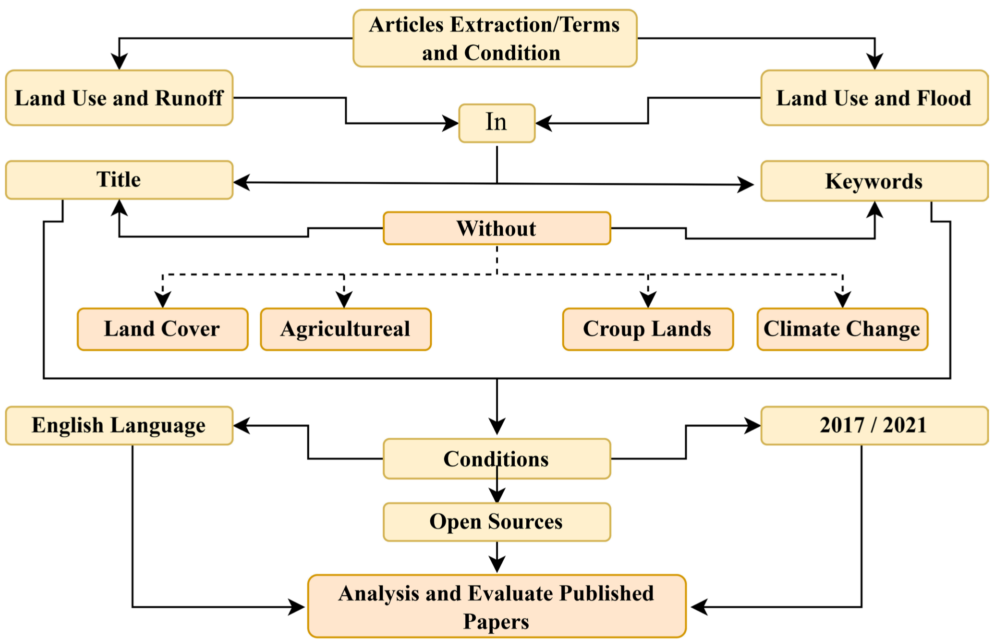

Figure 1. Research method, Extracting Articles from SCOUS. Own work.

increase in the LU rate, which is why modified natural lands have been limited since 1950 (Shrestha et al., 2020b). So, this paper reviewed published papers on LU change impacts on a hydrology regime, including runoff and flooding, and this research was done using SCOPUS and Google Scholar index to extract relevant articles. The following figure shows the application rate and subject documents in both terms, "LU/Runoff" from 1941-2022 and "LU/Flood" for the period 1979-2022 (**Figure 2**).

Figure 2 illustrates the published paper regarding runoff and flooding with the LU. The publication subject is nearly similar except in arts, humanities, business, and material areas. There are ten areas interested in analyzing the impacts of LU changes in these factors in both runoff and flooding, but the environmental domain is the topper community focused on LU in the runoff and flooding domain. It gives strong relationships between the integration and value of the impacts of LU in hydrology.

However, considerable literature has recently grown around the theme of LU change. Bicik et al. (2015) argued that there are two primary reasons why studying LU yields helpful information. First, this is because land use patterns are the end consequence of human engagement with the environment across time, and research into use gives data on shifts in this activity at the interface of the natural and social sciences. Second, in contrast to most other scientific disciplines, land use research has access to massive databases brimming with accurate and well-structured data.

3.1. LU

In the literature, the term tends to refer to LU and is sometimes used to associate with Land Cover (LC). LC definition would not be discussed in this paper because that out the aim of this work. The LC refers to a type of ground including forest, desert, and all the natural, environmental characters.

However, there has been increasing research on environmental changes

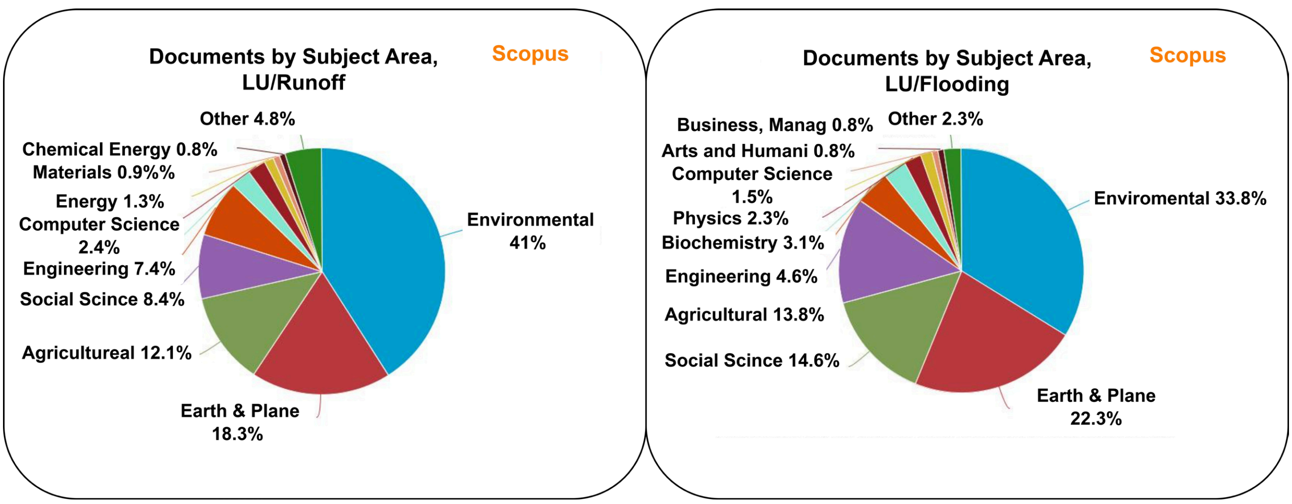

Figure 2. Percentage LU with Ruoff and Flooding, SCOPUS index. Adopted from SCOPUS Dec 2022.

worldwide (Anees et al., 2016). LU is considerably one of these research values due to its dynamic and integrated human activities and natural land processes (Koomen & Stillwell, 2007). But one of the most critical challenges facing researchers of global change is the lack of available information that is both trustworthy and dispersed throughout space regarding the temporal status of LU on an acceptable scale (Garg et al., 2019).

LU refers to the type of land, and its changes in time and ground can be observed as a result of modification. Choudhury & Jansen (1998) defined LU as human activities and change LC. Also, Briassoulis (2019), LU's definition refers to two similar terms. "Land use involves both how the biophysical attributes of the land are manipulated, and the intent is underlying that manipulation – the purpose for which the land is used" and LC "Land cover is the biophysical state of the earth's surface and immediate subsurface." LU usually changes at two scales, including local sites such as farming or owner lands, and the other ones occurring at large scale, for example, urbanisation, industrial area, and economic agriculture (Abdu, 2019).

3.2. Runoff

The current study uses SCOPUS and Google Scholar to extract the abovementioned main terms. There has been increasing in hydrology studies in the world discussing the development of LU and their reaction. These studies have also redefined terms of runoff and refer to water movements.

However, the runoff is an essential hydrology factor that is affected by perception, soil and geology types, and the character of topography. Therefore, this task has been considered for a long time in the hydrology field. So, the clear runoff definition illustrated by USDA (2021) Natural Resource Conversation Service as a "volume of excess water that leaves a watershed, also referred to as runoff volume."

Also, it defines as "a balance of rainwater, which flows or runs over the natural ground surface after losses by evaporation, interception, and infiltration" (Raghunath, 2006). Runoff is the capacity of water that runs on the ground in lower lands due to many factors, as we can read above.

3.3. Urban Flooding

The above section illustrates that runoff and its meaning. A critical factor should be discussed alongside runoff, which is a flood because there is a committed relative between them. It definiens as the overflowing of water beyond its normal confines that creates damage (Utama et al., 2019). So, a flood is an excess of water (inundation) in an area where humans and ecosystems do not need it. Also, it is a natural and recurring phenomenon (Kachholz & Tranckner, 2021). A flood is defined as much water that does not infiltrate into soil placed in the wrong area, causing inundation of land, and it runs everywhere on the ground. Most flood studies have been conducted to discuss its risk and vulnerability in a small or large catchment area; on the other hand, this paper focuses on the impacts of LU on urban flooding.

4. Impact of LU on Urban Hydrology

After LU change has been considered one of the essential variable generations of urban hydrology whenever at the catchment level, identifying LU change before and after is critical to understanding the impacts of human activities on the hydrology system. LU has been recognized as the essential factor affecting hydrology regimes, including runoff and urban floods.

Surface runoff is crucial in hydrology matter that has not infiltrated the ground. Hence, changing ground cover from natural land to another LU can affect soil quality and reduce water infiltration and runoff (Tabassum, 2017). Shafiei Motlagh et al. (2018) also investigated LU development from 1970 to 2010 in northwest Iran in Maroon Basin 3801 km^2; they found that these changes affected flooding in a floodplain.

Furthermore, LU development can be changed the landscape and enhancement occurring of urban flooding. Therefore, floods are considered one of the natural hazards arising (Elaji & Ji, 2020) frequency and causing losses in urban areas and impacts on life (Wan & Billa, 2018), also occurring everywhere around the world due to natural hazards (Farran, Elfeki, Elhag, & Chaabani, 2021) and human activities (Garg et al., 2019).

4.1. Impact of LU on Runoff

Many studies have investigated LU impacts on runoff, which is the most significant factor influencing increasing runoff (Li et al., 2018). LU change has four distinct but related effects on a region's hydrology: variations in peak and total runoff, water quality, and hydrological amenities (Leopold, 1968). For example, in the urbanisation catchment, On the other hand, Dinar et al. (2018) argued that LU influences hydrology and runoff due to the catchment modified at Lambidaro, the Musi river sub watershed in Indonesia. Therefore, they found a relationship between LU development and sub-catchment morphometry. So, both studies concluded that landscape changes for urbanisation resulted in hydrology matters such as runoff and peak discharge due to this modification.

Moreover, in southeast Asia, floods have become the most natural hazard in human activities, such as in urban areas. For example, Bisri et al. (2017) found that multiple LU development affected runoff at Brantas sub-watershed, Klojen District, Malang City in climate change and LU impacts on hydrology in East Java Province of Indonesia. For example, the maximum runoff in 2000 was 134.26 mm, but in 2010 was 142.76 mm. Similarly, Sha et al. (2021) stated that climate change and LU development are two reasons to make cities face flood risk; this study was carried out in Lanzhou, a city in the interior of Northwest China. So, this study found that topography has changed, which changed hydrology systems, such as transferring water to the floodplain.

It is now well established from various studies that any change in landscape will enhance the vulnerability of runoff. For example, Hu et al. (2020) stated that changes in LU due to urbanization affect runoff. They evaluated runoff at different LU changes. They found that increases in the transformation of LU during 1984-2019 in the center of Beijing led to impervious surfaces; also, there is a committed relationship between LU change and runoff. Shrestha et al. (2021) found that the built-up area at Xiamen city, China, increased the amount of runoff from 14.2% to approximately 27.9% due to the expansion of the urban area from 1980 to 2015.

Therefore, urbanisation and human settlements, including agricultural areas, will be exposure threatening of flooding due to the amount of runoff. Tena et al. (2019) studied the Chongwe River Catchment between 1984 and 2017. They contributed a new scientific knowledge base on the spatial-temporal change of LU and its impact on hydrology, especially in the feature. Similarly, Guzha et al. (2018) investigated land use change and land cover types on runoff, and this study focused on 37 published articles in East Africa. They found that built-up area LU has a significant matter in the runoff, but there is no discernible difference in the amount of water flowing out of the streams caught by bamboo and pine plantations, as well as those detected by cultivated land and tea plantations. Also, He et al. (2021) studied the impacts of the development of LU on runoff at the Luojiang River in China. This study suspects that runoff will increase by 2050 due to LU change.

In recent years, there has been renewed interest in water movement on the earth's surface and runoff, the top hydrology matters. Human activities such as urbanisation usually increase blocked-up surface soil (Feng et al., 2021). The surface runoff flows from several sources, including precipitation, river flood, and snow melting. One of the critical aspects of the hydrology parameter is rainfall measurement, usual infiltration into the soil, and, consequently, surface water movement (Igulu & Mshiu, 2020).

Therefore, Surface runoff estimation is critical in various sectors, including hydrology, agriculture, and environmental studies. It is an essential hydrologic component that has received much attention in water resources and would increase the feature (Barasa & Perera, 2018). But LU has been considered a factor affecting stable conditions and primary urban flooding (Kuntoro et al., 2017) due to changes in the topography foundation (Buisan et al., 2019).

There are many studies carried out on this matter and determined that LU are increased peak discharges in a catchment, such as reduced infiltration of soil and block the surface ground (Yulianto et al., 2019; Garg et al., 2017; Shanableh et al., 2018). Also, Brebante (2017) found that human activities in the Marikina river basin increased urban flooding. Furthermore, Msofe, Sheng, & Lyimo (2019) found that wetland areas decreased from 4.9% to 0.9% due to natural land changes to agricultural activities from 1990-2010 in the Like Kilombero, South-eastern Tanzania.

The overpopulation leads to an On the other hand, the development of urban areas and human activities at the top of the upper catchment increases runoff and reduces the time for rainfall in urban areas (Saberifar & Shokri, 2016). Saber et al. (2020) argued that urban runoff, which occurred in Al-Arish in 2010 and New Cairo city in 2018, has resulted from LU development in the aridity basin and lousy management. Pertiwi et al. (2020) investigated LU change in the inundation area at the Pompong watershed. They concluded that runoff was influenced by LU change from 2009 to 2013.

Furthermore, urbanisation negatively impacts increasing surface runoff when urban areas develop impervious surface soil and enhance the vulnerability of urban flooding (Tingsanchali, 2012). Therefore, surface soil's development and change characters will increase runoff's future (Shrestha et al., 2020a). Manan et al. (2020) measured the runoff volume at the Sungai Gombak (116 km^2) model with changes in land use base. This study evaluated landscape and LU change in the value of CN and concluded that CN increased with LU types.

Multiple LUC and their developments along riversides enhance the vulnerability of stream flows. Hu et al. (2021) studied different LU changes in the Tahe River Basin in southeast China. This study focused on grasslands, wetlands, shrublands, and forests. Runoff has been altered by transfers between these land-use types from 1980 to 2015 by less than 5%. The amount of runoff that was simulated reduced from grasslands to wetland areas, to shrubland areas, and eventually to forestland areas when extreme land use change scenarios were used. So, this study provides strong evidence of a committed relative between LU change and their types of runoff amount.

4.2. Impact of LU on Urban Flooding

One of the most significant current discussions in LU change is urban flooding. Urban flooding has affected human property and deaths. Analysing flood events and their history in an urban area is critical to achieving and approaching this aim. For example, Zhang et al. (2018) analysed the flood historical at Beiluo River, China. This study stated that methodology could be applied in similar areas, such as humidity environments. Also, they found that floods would be more sensitive in the future. For example, urban floods have increased in the southeast Spain basin due to urban development (Jodar-Abellan et al., 2019). Rogger et al. (2017) stated that studies examining how LU changes the effect of streamflow and flood events often produce different results for the same type of change (Rogger et al., 2017).

Also, the results of existing studies are valid, but it is hard to make general statements about the effects because each study looks at things from a very narrow and specific point of view. For example, Baky, Islam, & Paul (2020) estimate Bangladesh's vulnerability to risk floods. Bangladesh locates in humid zones, and overpopulation and climate matters increase urban flooding. They found that highly vulnerable to flood depth at cropland 2.8-m depth, while settlement is highly vulnerable above 3-m depth.

Therefore, urbanisation development in lowlands may enhance the susceptibility to urban flooding. Sha et al. (2021) found that urban areas are making way for certain developed regions as a direct result of global urbanisation, and the space in urban waterways currently open is unavoidably being filled in as well. The disruption of the equilibrium between land available for development and water space, combined with changes in the global climate, makes it more likely that places may experience flooding. The study's findings indicate that although the created region was once made up of water bodies and floodplains, its topography susceptibility hasn't decreased.

LU change will increase the amount of runoff and distributed water at the catchment level due to surface soil and morphology changes. For example, Hartanto & Rachawati (2017) studied the impacts of LU on flooding at Mijen and Wedung North Coast of Central Java, Indonesia, from 2000 to 2014. They found that flood affected the LU pattern, especially in the north area of Mijen and Wedung. Another study in Indonesia by Utama et al. (2019) investigated the consequences of floods in Batang Arau Watershed, Padang, Indonesia; the floods which occurred on 26 Sep 2018 and 2 Nov 2018 resulted from both LU changes and sensitive rainfall. Moreover, Lestari et al. (2019) studied the impacts of LU change in CN, which increased peak Discharged at the Sekanak watershed between 2004 and 2014. This study found that LU development increased the peak discharge and distribution of catchment floods.

Also, in the humid zone, Barasa & Perera (2018) investigated how LU changes impact flash floods in the Sosiani River basin, Kenya. This study has applied Rainfall Runoff Inundation RRI to model influenced LU development from 1973 to 2013. They concluded that changing ground from a natural to a build-up area affected peak discharge and flash floods. Finally, Wu et al. (2020) studied 14 historical urban flooding from July 2013 to Aug 2018 in Zhengzhou city, China. This study also stated that climate change and urban growth influenced the urban flood in the area study.

In addition, floods have horrible impacts on human activities. Park & Lee (2019) focused on urban floods and their risk in an urban area. This study occurred in Changwon City, Korea, so urbanisation and development have increased from 3.95% to 13.61 from 1975 to 2007. Furthermore, this study recommends that urban area design be implemented in urban planning to avoid flood risk. Furthermore, Mukesh & Katpatal (2021) investigated the impact of road networks and their changes, classified as one of the factors changing the topography character of Nagpur city in central India, which led to urban flooding.

Dahanayake & Wickramasinghe (2022) argued that most of the urban flooding in Sri Lanka was monsoon rainfall and urbanisation activities such as flooding In the Colombo District of Sri Lanka, urban flooding in urban areas resulted from LU development from 1999 to 2018. Therefore, urban sustainability can't be achieved due to current urban planning.

Integrated development of both urbanisation and LUC can also be affected by floods. Luo et al. (2022) studied that LU and urbanisation development have increased urban flooding in China's cities in the last 40 years, especially in the Yangtze River basin, Pearl River basin, Southeast basin, Haihe River basin, and Huai Rivers basin. They concluded that the risk of urban flooding increases in the feature in the Chinese metropolitan area. Also, Wang et al. (2020a) found that flood risk increased during the piored from 1975-2014 in the northern plan of China. They recommended that urban resilience to flood risk be enhanced using a green infostructure plan. Kachholz & Trancker (2021) mentioned that runoff due to LU change increased flood, especially in the urban catchment. Also, this study stated that LU increases surface runoff with an area of 530 km^2 in Rostock, northeast of Germany.

Flood has been shown to occur in many different worldwide as a result of factors. But modification of land surface enhancement of its appearance, especially in lowlands and floodplains. On this side, Shrestha (2019) examined the LU change from 1996-2016 in the Pampanga River basin of the Philippines. He concluded that an increase in the built-up area would be increased flood, runoff, and flood volume in the Pampanga basin of the Philippines. Ayiti (2017) analysed that multiple human activities at Reedy Fork-Buffalo Creek, North Carolina, increased the runoff volume from 2001-2011. Similarly, Hajian et al. (2019) stated that peak discharge at the Casilian basin in northern Iran has resulted from LU. They found the amount of peak discharge affected by the transfer of forest lands to another human activity. However, this study stated that climate change had affected flooding.

5. Result and Discussion

Humans used to modify the earth's surface for their activities, transferring a landscape from natural lands to an occupied form. Therefore, studying ground changes is attributed to a critical objective to enhance and increase planer knowledge for sustainability. On the other side, good urbanisation management includes built-up urban areas, industrial and agriculture, minimizing the risk of flooding. Therefore, these increases and actions have affected the character of the hydrology watershed (Tabassum, 2017); also, geomorphology, geology, and soil types have impacted surface runoff, and anthropogenic has strongly influenced runoff (Rezaei et al., 2019) and water quality (Camara et al., 2019).

Urban growth is one of the vital factors influencing urban flooding (Bayazıt et al., 2021). However, previous research typically only investigated the impacts of LU and their changes in runoff and Urban Flooding. These changes affect environmental matters such as groundwater, soil erosion, and climate change at city and catchment levels. Therefore, there can be no doubt that LU change modifies surface and landscape, and this is a primary reason for the environmental matter listed below:

A: Reducing the time between rainfall and runoff (Feng et al., 2021); this means water runs on the ground after infiltration with a built-up area is shorter than in natural lands.

B: Reduced soil infiltration. Total runoff and peak discharge usually result from LU development (Moghadasi et al., 2018), increased water volume (Cotugno et al., 2021), and reduced time of runoff and low infiltration in the urban catchment (Rezaei et al., 2019). For example, Rwanda's runoff from 1990 to 2016 resulted from LC development from the forest and natural lands to croup and built-up areas (Karamage et al., 2017).

Runoff usually increases in the middle and low areas due to anthropogenic activities (Shrestha, 2019). On the other hand, increasing development in LU practice in catchments may increase urban flooding. Paul & Kundpura (2021) found that LU change significantly affects runoff more than rainfall. In addition, LU changes will reduce the time between rainfall and runoff (Saberifar & Shokri, 2016).

Therefore, it is common knowledge that the characteristics of watersheds, such as the soil, land use, and vegetation, affect the amount of water discharged into rivers and streams (Al-Rawas et al., 2015). Urban runoff can be influenced by a number of variables, many of which have complex connections, including land use, soil texture, prior soil moisture, and rainfall intensity (Rezaei et al., 2019). Watershed character and its scale affect runoff and flooding as well. Apollonio et al. (2016) argued that urban flooding is affected by surface soil and catchment size, and there is a correlation between flood area and LU changes. **Figure 3** illustrates this idea.

Also, topography and soil types have influenced aspects of this matter. Topography conditions and hydrology parameters also contributed to the Runoff factors' effect (Saberifar & Shokri, 2016). Therefore, in most of the lowlands with multiple human activities, a runoff will increase in the future, especially in urban areas. Also, this feature would be increased runoff in an urban area (Shrestha, 2019).

Therefore, human activities and LU development usually affect lowlands at

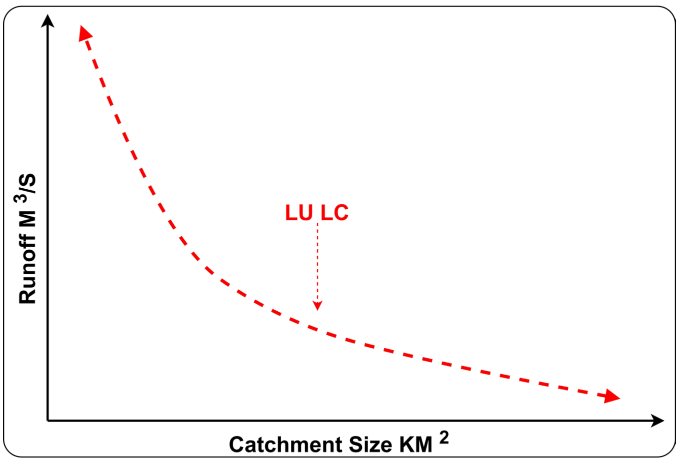

Figure 3. Impacts of LU at Catchment size in runoff and urban flooding. Adopted from Apollonio et al. (2016).

catchment size. Most urban area cities are located in the lowlands (McClean et al, 2020). Human activities in the catchment level are destroying protected cover such as forests and plants and increasing the potential of floods (Buisan et al., 2019), and Low development in an urban area is usually affected by runoff and peak discharge (Siregar et al., 2020; Zhou, 2019). However, he stated that the development of LU was responsible for runoff and reduced stormwater quality.

The following **Figure 4** shows *how LULC change does affect runoff in cities and catchment scales*.

Uncontrolled developments of LU, particularly in the riverbank development environment, will enhance the variability of flood events (Shafapour et al., 2017). However, Understanding LU change is essential for sustainability to minimize its impacts on the ecosystem and hydrology matters at a catchment scale (Mansour et al., 2020) and sustainability in urban management (Shrestha et al, 2020b). Thus, good LU management would be reduced runoff and flood hazards. Calculating and estimating flood and runoff volume is the best result for enhancement planer and management (Bayazıt et al., 2021). Chilagane et al. (2021) recommended that planning LU in the Little Ruaha River catchment (6370 Km^2) in the Southern Agricultural Growth Corridor of Tanzania, should be management agriculture practices.

Thus, using the LU change map increases the knowledge of urban planners to evaluate the risk of urban flooding (Rogger et al., 2017).

Studying the impacts of LU and changes involve some factors, including catchment character climate conditions. Catchment character, including morphometric and geomorphology, is vital in hydrology regimes. It usually reduces

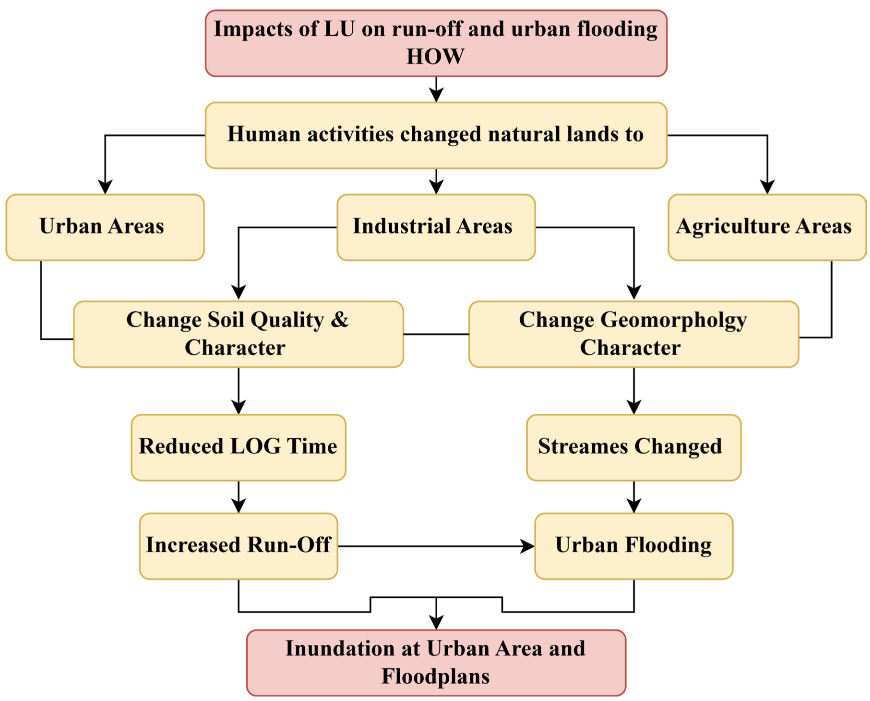

Figure 4. Impacts of LU changes on runoff, urban flooding. Own work.

water infiltration into the soil, which may be a reason for urban flooding. Abdelkarim et al. (2019) measured the impacts of LU and morphology to increase flood risk in train trucks Riyadh-Dammam. This study found that the flood, which occurred on 18 Feb 2017 and destroyed the train path along 10 km, which linked Dammam to Saudi Arabia capital city, resulted from modifying geomorphology. Koyari & Asmaranto (2018) analysed the impacts of LU on flooding at Sentani catchment, Jayapura, Papua, Indonesia. Urbanization development in 2007, 2010, 2012, and 2016 has changed landscape-Geomorphology and enhanced urban flooding generation. So, the amount of discharge between 2007-2010 was 6.616%, and in 2012-2016 also can be around 8.42%.

Therefore, The LU change is currently occurring all over the planet, and it is widely regarded as one of the most profound shifts that can be attributed to human activities. For instance, having constant access to information on how LUs are changing is necessary for formulating policies and their management. When it comes to hydrological problems, water quality is one of the elements that a wide variety of factors can impact. LU is a critical component that has the potential to influence both the quality of the water and how it is dispersed throughout the ecosystem.

However, urban resilience can be an achievement when LU management is enhanced. For example, Muttaqin et al. (2021) argued that the impacts of LU change from a non-built area to a built area and vegetation to a non-vegetation extent would increase runoff because vegetation roots absorb rainfall. So, this study has taken place in the Keduang sub-watershed, Wonogiri District, Indonesia, using the Retinol method and GIS, RS to compute runoff. This study found that the runoff increased from 2009 was 358.73 m^3/s and 2020 was 363.38 m^3/s. Also, Wang et al. (2020b) stated that managing flood risk in urban areas can be achieved when understanding the relationship between LU and flood vulnerability.

In Indonesia as well, LU changes in the Citarum watershed Indonesia enhanced the generation of runoff due to LU development. They stated that the LU change increased CN from 70.98 in 1999 to 72.04 in 2018. However, this study recommended that management is vital to reduce runoff (Atharinafi & Wijaya, 2021). Adnan et al. (2020) investigating the impacts of LU change in the poverty area in the southwestern embanked area of Bangladesh, this study aimed to estimate flood risk using the Wealth Index and multi-blade LU scenarios. They found that LUC impacts on flooding were not fully understood in Bangladesh. Therefore, the study concluded that flood risk would increase in the future due to unavailable urbanisation plans. Yusuf et al. (2017) estimated that LU change impacts surface runoff at the Mapili watershed, Indonesia. This study concluded that morphology plays a significant factor in occurring of flooding.

Jodar-Abellan et al. (2019) found that the development of human activities in the five catchments' urbanisation in the south of Spain influenced floods, especially in catchment urbanisation from 1990-2012. This study concludes that Poor urbanisation planning will lead to occurring of urban flooding. Moreover, Areu-

Rangel et al. (2019) analysed the inundation area in Villahermosa, Tabasco, Mexico. This study argued that LU change and un-urban planning enhancement urban flooding. LU change has been analysis from 1992 to 2013.

Therefore, natural hazards will increase due to human activities and natural systems changes. Flood is one of these hazards risks that distrusted in the feature. Song et al. (2020) analysed the impacts of LU change in a flood southwest of Jiangsu province, China. They stated that the pattern of LU development increased flood risk by 80% due to impermeable surface expansion; this area increased about four times from 1994 to 2013.

Thus, catchment condition and their attributes are significant in hydrology matters. For example, Hung et al. (2018) estimated the amount of runoff in three; this study compared three catchments in South Carolina, the USA; two are heavily urbanised, and one is a forestry catchment. This study found that unit hydrograph and runoff are significant in urban catchment more than in forest side, which would increase urban flooding in the future.

6. Conclusion

LU and human activities have been dramatic growth globally. This has impacts on the environment and hydrology matters. As a result of this change, runoff, and urban flooding became negative LU impacts. LU has effects of runoff in urban areas resulting from the impressive soil surface, which reduces construction time and impacts water storage and environmental matters. Solid evidence has been that human activity on a catchment scale will change the landscape, affecting surface and ground infiltration water movements. Humans' activities are used to cut down the ground cover and to change surface soil, and all these activities will become a reason to increase runoff on the basin scale. LU has a high denomination to increase water salt when the landscape significantly changes inundation and low lands.

On the other hand, LU change without management leads to more and more runoff in an urban area. Therefore, understanding catchment characters, including their morphometric and geomorphology, is urgent to formulate and evaluate human activities. Evaluation of LUC should be done using the implementation of both ground observation and Remote Sensing data.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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