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Impact Assessment of Developed parks in the urban Environment- Local context of lalitpur, Nepal.

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Abstract

The over-extraction of groundwater in the Kathmandu Valley is a serious issue that can lead to high-range negative consequences. The depletion of natural recharge capacity can result of the lowering of the water table, which can cause wells to dry up and make it harder to extract water.The government, along with the public and private sectors, can work together to develop and implement effective policies and strategies to ensure the sustainable use of groundwater resources in the Kathmandu Valley. The amount of groundwater extraction In Kathmandu Valley is 21.56 MCM per year, which is more than its natural recharge in the range of 4.6–14.6 MCM/year.

The main objective of this study was to determine the amount of groundwater recharge by urban parks or the amount of groundwater recharge by rainwater of plant ecology by a natural process based on the literature review.

However, the possible techniques use well-shaped structures to infiltrate water into a deep aquifer. Besides recharging well, LMC has used surface runoff water to percolate through the natural infiltration media. Introducing green parks improves soil quality, increases the soil's infiltration capacity, and converts the impervious surface into the previous surface to recharge Groundwater. This method is more economical and ecological for urban human life and other local habitats.

Keywords

Impact Assessments, Urban Parks, Ground water Recharge, Pocket park.

CONTENTS

1. INTRODUCTION

In Lalitpur city, development of parks can also help mitigate the effects of urbanization, such as air pollution, loss of green spaces, and increased water crises. They can provide shade and reduce the urban heat island effect, making the city a more comfortable place to live, and helping groundwater recharge. However, there is a need to assess the impact of these parks on the urban environment and the local community.Parks can also improve the green aesthetic value of the city, making it more attractive to residents and tourists alike. (UN World Water Development Report 2022). The total area of Kathmandu Valley includes three districts of Nepal: Kathmandu, Lalitpur, and Bhaktapur, 899 km2. The Kathmandu Valley is one of the most developed and extensive rapid urbanization areas, with 5 million people. One of the most pressing issues is the limited surface water sources in the region, which has been causing severe water scarcity problems for the residents of Kathmandu Valley. Due to urbanization, rapid population growth, climate change, and other factors, the Kathmandu Valley's (Bajracharya 2020).Due to the excessive demand for drinking water in Kathmandu areas, look for an option source of water in the Kathmandu Valley that can meet this demand. Nowadays, people are using underground water to fulfill daily purposes. Groundwater is the major source of contributing to and supply of drinking water demand in the Kathmandu Valley which is contributes 40 % of water demand. People have been using groundwater for a long time through dug wells, tube wells, and stone spouts. The excessive extraction of groundwater in the Kathmandu Valley poses a significant threat to the long-term sustainability of the water supply. The groundwater extraction rate in Kathmandu Valley is 21.56 MCM per year (Pandey et al. 2009), which is more than its natural recharge in the range of between 4.6–14.6 MCM/year (Lamichhane & Shakya 2019). The imbalance between groundwater extraction and natural recharge has led to a decline in the water table, which may result in good failure, reduced water availability, and land subsidence. Increasing the built-up area, and loss of grassland and forest inside Kathmandu Valley causes the natural recharge of groundwater.

2. THEORETICAL BACKGROUND

The world has faced a water crisis in recent years due to financial and scientific developments. The growing population has an impact on economics and lifestyle. In Lalitpur, Nepal, rapid urbanization is growing at an alarming rate, raising the demand for water for consumer uses like drinking, bathing, cooking, and irrigation (Hack & Rafter 2006). Lalitpur Sub Metropolitan City is in the ancient period, the Newari community used two water sources for their daily needs: water spouts and dug wells (Andualem et al. 2021). Water spouts, also known as *stone spouts* or *Dhunge Dhara* (Public tap stand) in the local language, are a unique feature of the Kathmandu Valley's traditional water supply system. These spouts are made of stone and are in details carved with religious and mythological figures. The water that flows through these spouts comes from natural springs located in the nearby hills. The water seeps into the ground and travels through porous rocks and gravel layers, ultimately reaching the surface at the spout's opening. People were masters of replenishing local aquifers via conveyance canals or Rajkulo through pounds at the time (UN-HABITAT 2008). Now that governing bodies and policymakers are aware of the need to conserve resources, soil settlements, and sustainable development are being dragged down.

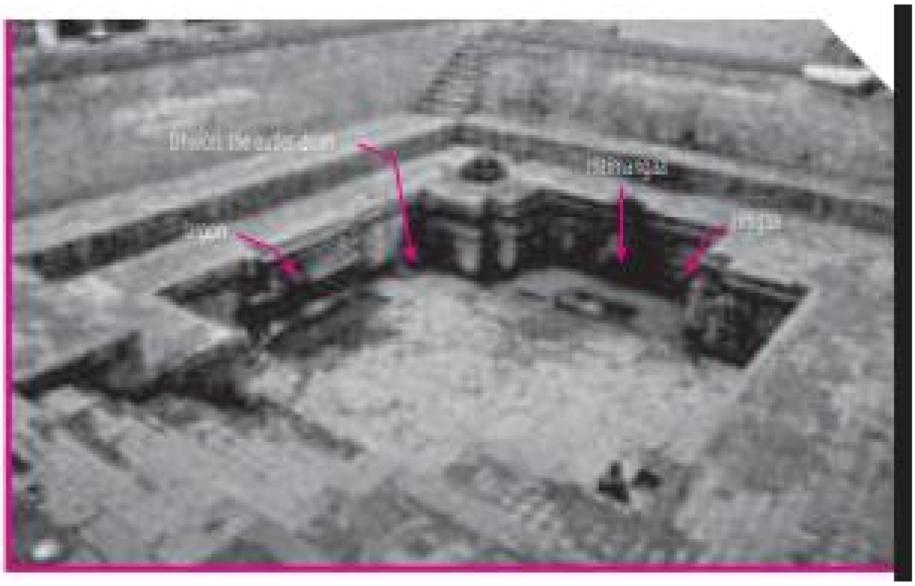


Figure 1. Stone spout (UN-HABITAT 2008)

Figure 1 depicts a typical stone spout (public tap-stand) with a component called *hitigaa*, which is a conduit connected to a tap, a *Jaroon*, a small pit to collect wastewater, a place used to drink water for cows, and an outlet used to drain out the wastewater from the tap stand. The Gaahiti (canal) or stone spouts are designed and constructed in a large and deep pit on the ground because groundwater can easily flow through the spout conveniently.

Figure 2. Dug well (UN-HABITAT 2008)

As illustrated in Figure 2, dug wells are commonly used as domestic water sources in the Kathmandu valley. The well was built of bricks and cement concrete in a circular shape and was used to extract or collect water from the shallow aquifer to penetrate the groundwater table, typically 4 to 6 meters deep (UN-HABITAT 2008). The historical practice of land and water management system in Lalitpur district is known as the traditional *Newari* water management system. This system is based on principles of sustainable use of natural resources and is known for its effectiveness in managing water resources even during times of scarcity. The system involves the construction of stone spouts, dug wells, and ponds to collect and store water. The stone spouts are built in a large pit on the ground to collect the subsurface water flow, which can either be a local aquifer or transmitted through manufactured water channels. Before the water flows into the spouts, it is often filtered through a filtration system to remove impurities (Andualem et al. 2021).

management system are constructed to feed the sub-surface aquifer of most of the stone spouts and dug wells. They were built to recharge the aquifer and groundwater as a reservoir to feeds irrigation canals. These ponds are essential in maintaining the water balance in the region and were designed to withstand seasonal fluctuations in water availability.

2.1 Kathmandu Upatyaka Khanepani Limited (KUKL)

Kathmandu Upatyaka Khanepani Limited (KUKL) is a public company established under the Nepal Government Company Act. It operates under the public-private partnership (PPP) modality, which means that the company has both public and private ownership (Kathmanduwater.org).The project's main objective is to divert water from the Melamchi River to the Kathmandu Valley, which will help to alleviate the water scarcity problem in the region (Kathmanduwater.org). KUKL's existing structure supplies water during different seasons. In the dry season, KUKL's current structures can only be supply 19% of the water required, while in the rainy season, it can supply 31% of the required water (Joshi 2017). Therefore, the Nepal government has planned to harness water from outside Kathmandu Valley Melamchi, and the project known as the Melamchi water supply project" suggests that the Nepal government has identified a need for additional water resources outside of the Kathmandu Valley and has developed a plan to address this need through the Melamchi water supply project (Thapa et al. 2019). The near completion of the Melamchi Water Supply Project (MWSP) and its two major components. The first component involves the transportation of 170 MCD (Million Liters per Day) of water from the Melamchi River to a treatment plant near Kathmandu through a 26.5 km (Kilometer) long tunnel (Joshi 2017). The treatment plant has an initial capacity of 170 MCD, which will later be expanded to 510 MCD. The second component of the projects involves improving the existing bulk distribution system within the Kathmandu Valley to supplement the water supply from MWSP. The project aims to provide enough water to meet the daily demand for quality and quantity of drinking water in the existing and new service areas (Thapa et al. 2019). The overall objective of the project is to improve the health of consumers by providing them with safe drinking water while promoting the judicious use of water resources. The project also aligns with the Sustainable Development Goals (SDGs).

2.2 Statement of the Problem

2.2.1. Excessive water demand

In urban areas, access to clean and sufficient drinking water is always a major concern in terms of quality and quantity. Lalitpur, for instance, faces significant challenges in meeting its water demands, with an estimated daily consumption of 240 million liters. However, the current supply falls short of this demand, providing only 190 MLD during the wet season and 110 MLD during the dry season (Adhikari et al. 2018). Despite residents' willingness to pay for water, there remains a massive shortage of water sources, and alternative sources are constantly being sought out to meet increasing water demands. The completion of the Melamchi water supply project, which would provide sufficient quality and quantity of water, is considered a dream project for Nepal's drinking water supply sector. However, there are doubts about whether the project will ever be completed (Thapa et al. 2019).While waiting for the Melamchi Drinking Water Supply Project, alternative water sources such as stone spouts, wells, springs, rainwater collection, deep boring, and tube wells are used to fulfill water demands in Lalitpur.

2.2.2. Rapid urbanization

In terms of time and technology, land conversion into urban areas has been very rapid. Nepal is one of the best examples of unprecedented rapid urbanization in a developing country. Nepal is one of the fastest-growing countries and was listed as the fastest-urbanizing country in the world (Shrestha et al. 2018). The centralization in the capital city (Kathmandu, Bhaktapur, and Lalitpur) is the main factor for people moving in. Land use planning is the management or direction for the long-term management of land resources. Rapid urbanization leads to unplanned land use and poses hazards to developing infrastructure and creating unused pocket areas. Rapid urbanization is an essential factor for economic activity; increased traffic, waste, water scarcity, air pollution, water pollution, and lack of green space settlements are typical in this area (Antalyn & Weerasinghe 2022).The excessive utilization of land and water resources can cause soil porosity to increase and the water table to drop, resulting in significant soil subsidence problems.

2.3 Objectives and limitations

2.3.1 Objectives

The objective of the study are
1. To evaluate the recharge of groundwater by green parks in urban areas.
2. To calculate the amount of groundwater recharge by rainwater by natural phenomena act on land use and land cover.

2.3.2 Scope and limitation

The study has been conducted within the Lalitpur and Kathmandu districts, which is the core urban area of Nepal, so the results only apply to some regions of the country. The number of sampling units was limited due to time constraints and limited resources. The laboratory test of moisture content in soil has yet to be performed or not considered. The study has focused on only soil settlements' groundwater conditions, and green parks improve groundwater recharge and soil quality. However, it is expected to fulfill its objectives within a time limit and with available resources.

2.4 Theoretical review

Water is a renewable but finite resource and one of the five essential elements for human survival. Groundwater has the potential to provide excellent societal, economic, and environmental benefits for humans as well as living lives (Lamichhane & Shakya 2021). Groundwater currently supplies nearly 50% of the total volume of water utilized for household purposes, including drinking water, across the world's population. Groundwater is essential in fighting poverty, food, and water security, creating jobs, socio-economic developments, and resilience developments for societies (UN World Water Development Report 2022). The resilience of groundwater will decrease due to high water demand, a decrease in rainfall, and land use. However, groundwater needs to be better understood, under-evaluated, and mismanaged in its use. Compared to surface water, groundwater is typically less vulnerable to pollution from human activities (Wang et al. 2023). In the case of pollution, restoring its quality or cleaning it up is expensive. Groundwater sources are widely used for domestic, agricultural, commercial, and industrial purposes; hence, they are highly utilized in Nepal. The researcher successfully applies statistical tools to analyze various distributions of groundwater physio-chemical characteristics over a large area. Soil settlements are one of the most exciting topics for research in geotechnical studies and engineering. In general, soil settlements and slope failure occur due to shearing deformation or excessive load-bearing capacity of the soil, heavy rainfall, and a decreased groundwater table (Andualem et al. 2021). Groundwater is located beneath the Earth's surface, and the pore water pressure above the groundwater table is typically negative, indicating the presence of suction or infiltration (Xiong et al. 2014). The loss of suction or infiltration capacity of soil causes a decrease in the soil's effective stress and shear strength, which may cause slope failure or soil settlements.

Figure 3. Stone spouts or *Hitis* Public tap-stand (Bisht 2011)

The *Hitis* are fed from groundwater, rainwater, or pounds. Unsustainable groundwater extraction reduced groundwater level, with very little open space left now and less rainwater infiltration. Consequently, the most of rainfall and surface runoff that flows into rivers or streams goes to waste. As a result, the puku or ponds within the valley are the only crucial sources of water for its historic water supply system.There are approx 40 pounds in the Lalitpur area. Among them, 16 remain the same size; nine have shrunk, and 14 are dried out (Bisht 2011). Figure 7 shows a typical water storage body called a puku or pond. The Water was obtained from distant sources and stored for various purposes such as household consumption, and irrigation, as well as for infiltration and recharging groundwater.

Figure 4. *Pukus* or pond (Bisht 2011)

The *Rajkulo* is a multipurpose canal built above the water storage body and below the intake, located 16 kilometers from the center of Lalitpur from the water intake sources of the Lele and Naldu rivers (UN-HABITAT 2008). An earthen canal was specifically designed and constructed to irrigate fields and provide water to settlements located along the route leading up to the cascading series of ponds and *pukus*. After filling all the pounds and pukus in Lalitpur and Kathmandu Valley, the excess water drains through the canal with fish.

Figure 5. *Rajkulo* and City canal (Bisht 2011)

In the past, An ancient canal referred to as the *Rajkulo* was responsible for refilling the *pukus*, or ponds. The *Rajkulo* has an ingenious design and is multi-purposed, being used inside Kathmandu Valley for feeding water from the source river and streams and filling the pond rather than being used for distributing water for irrigation purposes. In modern times, it is also known as a transmission canal or transmission pipeline. *Rajkulo's* history in Kathmandu valley dates back to 992 A.D. when Malla King monastery extended the canal within Kathmandu valley (Bisht 2011). Hence, the canal is called Rajkulo, which means "Royal canal." Historically, *the Rajkulo canal supplied water for irrigating around 1200 hectares of land situated within the Lalitpur valley* (Cheng et al. 2020). The canal was made by an earthen canal, which is ecological and sustainable for collecting and depositing water into aquifers. Nowadays, *Rajkulo* is more vital than ever; urbanization, water scarcity, and unmanaged land use are the main problems destroying *Rajkulo* and the ancient water supply system (Bisht 2011).

2.4.1 Groundwater recharge

Groundwater recharge occurs when water from the surface infiltrates the soil and moves through it until it reaches the water table, where it becomes part of the groundwater supply (Udegbunam 2020). Groundwater is the water that exists in the subsurface and is stored in the pores of soil, sediment, and rocks. Types of groundwater recharge are the following:,

1. Groundwater recharge by Natural.
2. Groundwater recharge by artificial method.
3. Precipitation, rainfall, and snow melt.
4. Extended by the river and lakes.

Water moves underground through rock and the pore space of soil. Water moving downward through the earth's surface through different soil layers is called percolation. The process of water filtration through the soil is dependent on the water permeable value of the soil itself (Andualem et al. 2021). Soil permeability is the ability of soil to absorb water from the surface and transport it to deeper underground levels. During natural groundwater recharge, water passes through the zone of aeration, which is characterized by pore spaces filled with air and water, as described (Xiong et al. 2014). Subsequently, the water continues its journey downwards, moving from the aeration zone towards the zone of saturation. In the saturation zone, pore space is filled with water, and the upper boundary of this zone is known as the water table. The aquifers are the underground layers of rock that hold Groundwater; they are found in the saturation zone. Groundwater recharges naturally through the infiltration process of rainwater and snow melt on the soil surface.

2.4.2 Artificial Groundwater Recharge

Artificial groundwater recharge refers to the process of elevating the groundwater level by intentionally introducing or augmenting the amount of water that enters the aquifer through measures that are planned or regulated by humans (Reddy et al. 2020). Different techniques can be used to artificially recharge groundwater, such as injecting water onto the soil surface through canals, infiltration basins, ponds, lake wells, or irrigation systems that use furrows or sprinklers. Direct and indirect methods are the two main categories of artificial recharge methods.

Direct Method

The direct groundwater recharge method involves redirecting excess surface water into the ground through various techniques, such as spreading water on the surface, recharging wells, or modifying natural conditions to improve the soil's ability to absorb water. This method was used to increase groundwater levels and replenish depleted aquifers.The indirect method is a water-induced recharge of the Groundwater, pumping wells, or aquifer modification to recharge Groundwater.

Indirect method

The indirect method is a water-induced recharge of the Groundwater, pumping wells, or aquifer modification to recharge Groundwater.
The direct method is described as follows:
1. Surface spreading technique
This technique spreads stream water through a network in different channels such as basins, percolated tanks, ditch and furrow systems, stream augmentation, flooding, or irrigation, basins or percolation tanks, and Stream Water spreads through a channel or tank.
Ditch and furrow system, stream augmentation, flooding.
Furthermore, Over-irrigation. 2. Sub-surface spreading technique including (Injection or recharge well, recharge pits, and charge batteries, Borehole Flooding, Dug well to recharge., natural opening., and cavity filling).
However, indirect methods of groundwater recharges also exist, such as induced recharge through pumping wells, collector wells, infiltration galleries, and aquifer modification techniques like bore blasting and hydro-fracturing. Groundwater conservation structures, such as groundwater dams, and fracturing sealing are also examples of indirect methods. These methods are used to improve the natural recharge of groundwater and help sustain groundwater levels in areas where they have been depleted.

2.4.3 The importance of artificial recharge

The primary objective of the artificial recharge of groundwater is to increase the capacity of groundwater reservoirs by altering the natural movement of surface water through use of suitable civil construction techniques (Malu n.d.). Artificial recharge techniques are designed to address several key issues, including:

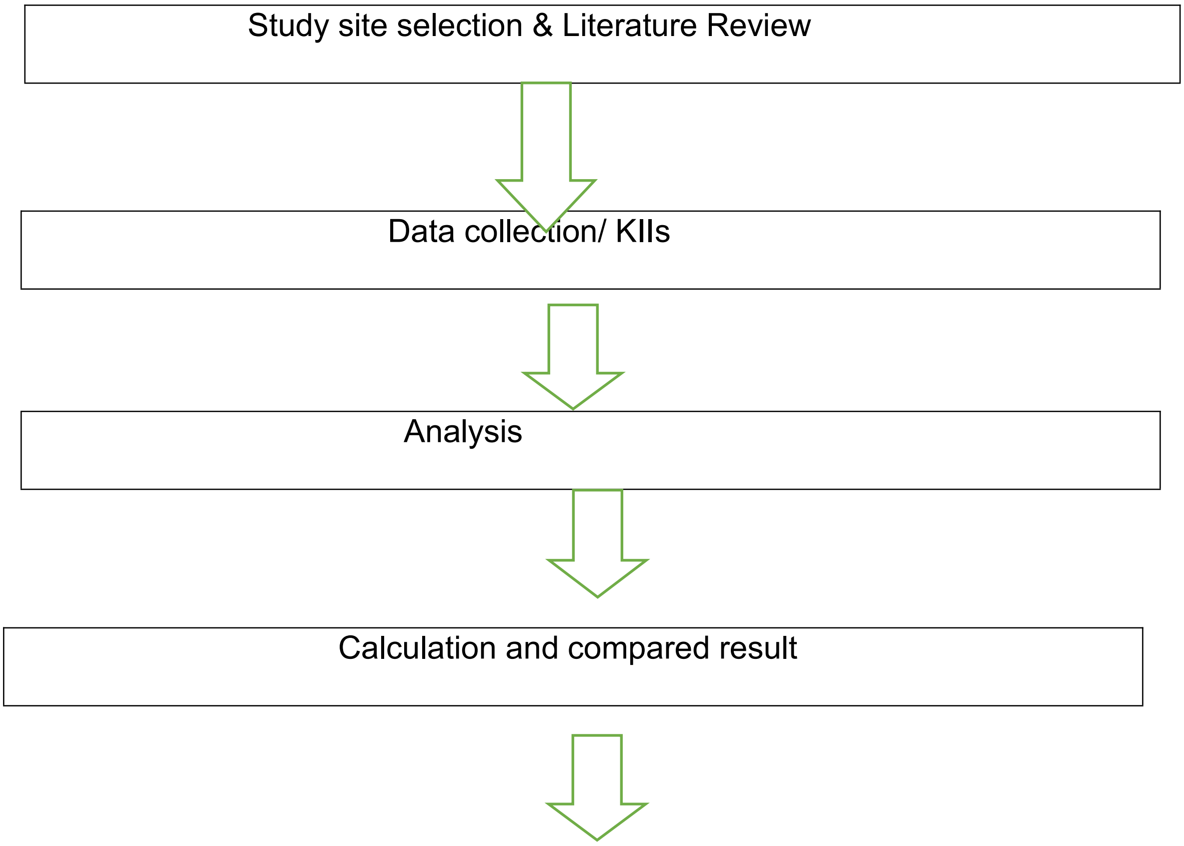
1. Maintaining groundwater levels: Groundwater levels are dropping worldwide due to increased pumping and reduced recharge rates. Artificial recharge can help maintain groundwater levels and ensure enough water is available for future generations to conserve enhance soil quality by minimizing erosion and increasing moisture retention, promoting optimal crop growth and plant development (Xiong et al. 2014).
2. During times of drought, artificial recharge can help supplement natural recharge rates and ensure that groundwater levels stay high. To improve the quality of stored water Filling the pore distances between the soil can improve its quality, strength, and stability, which protects it from soil settlements (Xiong et al. 2014). Adopting these techniques can assist in mitigating drought effects and secure water resources for agricultural, industrial, and residential consumption.
3. Improving water quality: Artificial recharge can help improve groundwater quality by allowing the water to percolate through the soil and natural filtration processes. This can help remove contaminants and improve the overall quality of the water.
4. Supporting ecosystems: Many ecosystems depend on groundwater for survival, and artificial recharge can help support these ecosystems by maintaining groundwater levels and ensuring enough water is available (Malu n.d.). Rapid urban expansion poses a greater threat of clogging due to an increase in impervious surfaces, which alters infiltration, surface runoff, evapotranspiration, recharge, and regional water quality (Ali & Thomson 2020). Overall, artificial recharge is essential for managing groundwater resources and ensuring enough water is available for future generations. However, aquifer recharge and implement water management solutions to improve groundwater quality and infiltration. It emphasizes the need to control subsurface hydrology, urban land use, and water consumption to achieve sustainable groundwater management in metropolitan areas (Foglia et al. 2020).

3 RESEARCH METHODOLOGY

3.1 Research Design

Initially, in conducting an impact assessment would be to plan the study. This would involve identifying the research question, determining the study objectives, defining the study area, identifying the key stakeholders, and developing a research methodology.Two methods were primarily used during the research phase to achieve the study's objectives. One is Key Informant Interviews (KIIs), and the other is the review of research, i.e., the collection of information and finding of facts from available research material, articles, research papers, and literature that has already been done before. KIIs were conducted with the technical person (consultant engineer), a design and construction engineer in Lalitpur district for KNK Engineering Consultancy Pvt. Ltd., and studied master's construction management. The person involved in the design and the construction of an artificial groundwater recharge system inside LMC areas gave me an idea about the technical knowledge and structure overview of the dug well, which was constructed within LMC.

Methodology



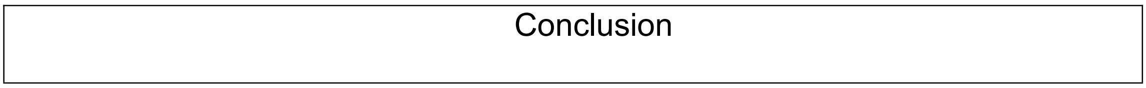


Figure 6. Methodology flow chart (Thapa et al.2021).

Figure 6 Illustrates that the methodology is referring to involves the following steps:
Selection of sites: This involves choosing specific locations or sources for collecting data or conducting the research.

Conducting a literature review: This study aims to investigate the impact of the park on the urban environment through a literature review of existing research.This would help identify the key variables that need to be measured and the appropriate methods for data collection.This study will start by developing an impact assessment framework based on the research question and study objectives. This would include a list of indicators that would be used to measure the impact of the parks on the environment and the community.

Collecting data: Data collection will be done through primary and secondary sources. The researchers will use quantitative and qualitative methods to gather information on the impacts of the developed parks on the urban environment and the local community. The second stage of the study will entail gathering information using a range of methods, such as surveys, interviews, observations, and secondary data analysis. Primary data would be obtained through surveys, interviews, and focus group discussions with park users and stakeholders. Secondary data would be obtained from government reports, academic publications, and other pertinent sources.

Analyzing data: The data collected will be analyzed using appropriate statistical techniques. By doing so, we can ascertain the correlation between park development and its effects on the environment and the local community.

Results and conclusions: Finally, the results are calculated and compared, and conclusions are drawn based on the findings. Possible steps in this process may include exploring the implications of the findings, acknowledging any limitations of the study, and proposing avenues for future research.

3.2 Rational for the selection of the study area.

According to Figure 11 Kathmandu Valley is situated between 27'32'13″and 27'49'10″N and 85'11'31″and 85'31'38″E. This valley have a bowl-like shape, and its elevation ranges from 1212 to 2762 m above the mean sea level (Lamichhane & Shakya 2021). The study area experiences varying levels of precipitation throughout the year, with an average mean monthly precipitation of 4.2 mm in December to 402.1 mm in July, according to the same study (Lamichhane & Shakya 2021). The average annual rainfall for the basin is 1533 mm/yr, with 80% of the rainfall occurring during the monsoon period (June - September), leading to a 20% loss. The climate of the valley, is semi-tropical, with the monthly average maximum and minimum temperatures ranging from 29.8 degrees Celsius to 3.4 degrees Celsius (Lamichhane & Shakya 2021).

Furthermore, the average humidity of the basin is 75% Departments of Hydrology and Meteorology (DHM 2015). The Kathmandu Valley is encompassed by a diverse range of land covers, with mixed forests encircling the area, peri-urban regions comprising a blend of built-up and agricultural lands, and built-up areas occupying the central core of the valley (Lamichhane & Shakya 2021). Kathmandu Valley, situated in Nepal, is home to the country's most densely populated and urbanized area. This region comprises three distinct cities: Kathmandu, Bhaktapur, and Lalitpur, with Lalitpur being a neighboring district that consists of one metropolitan city and five municipalities. Due to the high population density and urbanization, the region experiences a range of environmental and social issues that impact the daily lives of residents (Thapa et al. 2021).

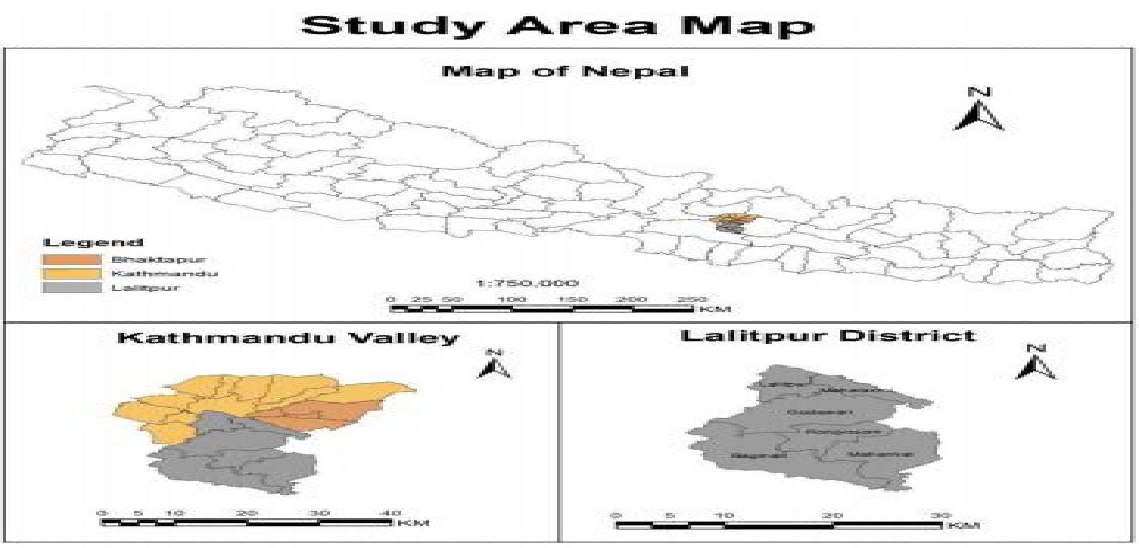


Figure 7. Map of Study Area (Thapa et al. 2021)

3.3 Data Collection

The information regarding population data, its projection, and service area demarcation was sourced from both published and unpublished reports of KUKL and MWSP (Thapa et al. 2019). Furthermore, the data obtained from the 2021 population census was acquired from the Central Bureau of Statistics (CBS, 2021). The present article was composed by analyzing published articles and literature as stated by. Specifically, we examined published information on groundwater, drinking water, water-soil interaction, urban parks, and groundwater recharge from the period spanning 1994 to 2023 (Sharma et al. 2021).The various electronic databases were searched using specific keywords related to groundwater recharge, urban parks, drinking water in Lalitpur, Nepal, Kathmandu Valley, land use land cover, and rainfall. The electronic databases were used for the search, including Google Scholar, Web of Science, Researchgate, Afrilcate, Scitechnol, Springer, and ScienceDirect. The searches were conducted using various keywords related to the topic, and the focus was on literature published in English with relevant abstracts. In addition to published literature, the search also included unpublished documents, news portals, online news, videos, reports, power-point presentations, and web content that were relevant to the research objective. The literature was reviewed and analyzed based on inclusion criteria for the title and abstract.

3.4 Study site selection and literature review.

The total population of Lalitpur Metropolitan City (Figure 10) is 548,401 (2021 Nepal census). The area is 385 km2, and the population density is 1424/km2. By city Population data 1.5% population change from 2011-Nepal.

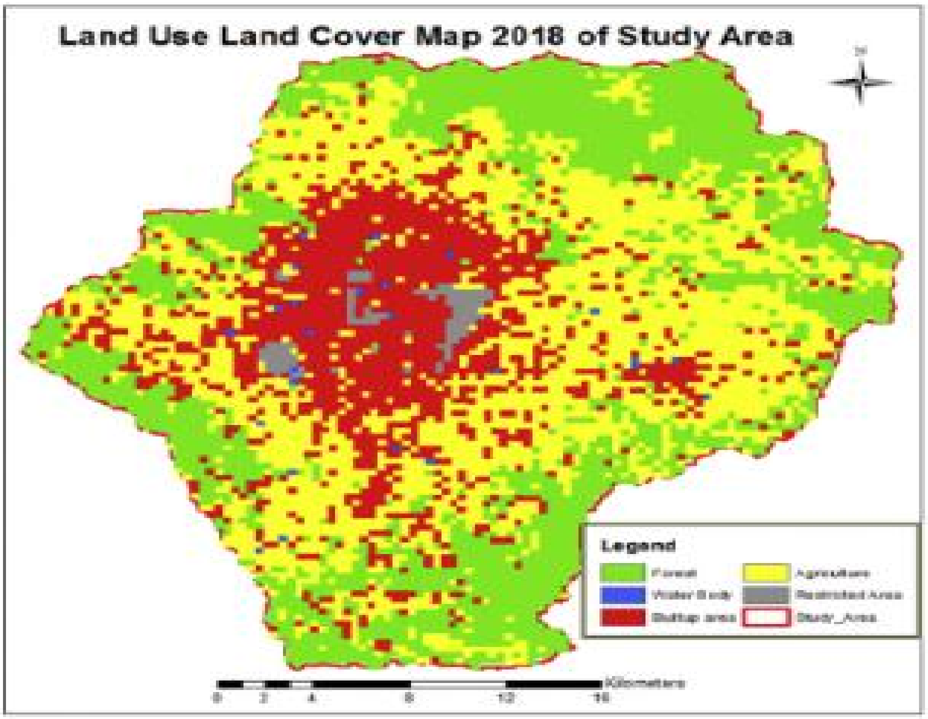
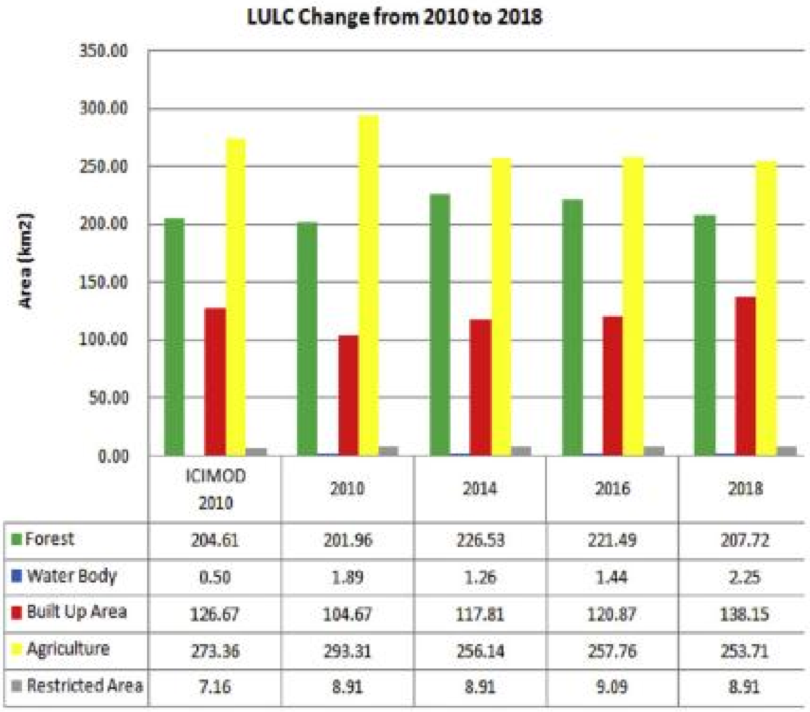


Figure 8. 2018 LULC map of study area (Lamichhane & Shakya 2021).



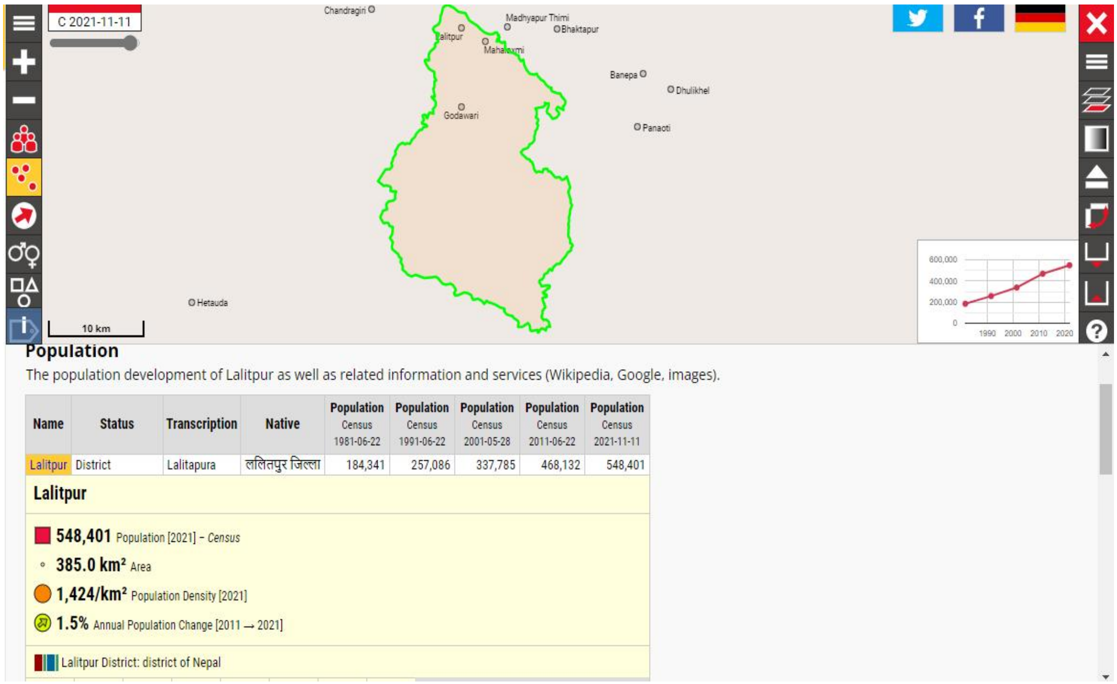
	ICIMOD 2010	2010	2014	2016	2018
🟩 Forest	204.61	201.96	226.53	221.49	207.72
🟦 Water Body	0.50	1.89	1.26	1.44	2.25
🟥 Built Up Area	126.67	104.67	117.81	120.87	138.15
🟨 Agriculture	273.36	293.31	256.14	257.76	253.71
⬜ Restricted Area	7.16	8.91	8.91	9.09	8.91

Figure 9. Comparative Diagram LULC (Lamichhane & Shakya 2021).

From the above figure, we can see a clear view of the increase in built-up area from 126.67 km2 to 138.15 km2, where decreasing agricultural land is from 273.36 km2 to 253.71 km2. Considering only the forest area and agricultural land as the recharge area of Kathmandu Valley, it was 461.43 km2 by 2018, with an annual rainfall of 1533 mm. According to Lamichhane and Shakya (2021), excessive use of groundwater may exceed the natural resources and cause groundwater depletion inside the Kathmandu Valley (Gautam & Prajapati 2014). To restore or recharge the groundwater in the Kathmandu Valley Governments of Nepal, some national and international agencies have artificially recharged the groundwater. Artificial Groundwater Recharge directs water spreading on the surface toward the ground. Furthermore, the process where surface water moves to groundwater. In addition, recharging water into the ground is the primary method for water to enter an aquifer. Groundwater is recharged naturally by rain, snow melt, and surface water in lakes and rivers. The process of groundwater recharge usually occurs below the plant root level. However, human activity may impact groundwater recharge, such as paving, developments, logging, and excessive groundwater use (Gautam & Prajapati 2014). The loss of topsoil due to human activity leads to reduced water infiltration and recharge, affecting the natural ecosystem. Groundwater recharge is essential for long-term groundwater management, avoiding soil settlement, and promoting sustainable urban development.

The artificial groundwater recharge process is necessary for balancing groundwater levels (Gautam & Prajapati 2014). The artificial recharge process involves introducing water into an aquifer, thereby augmenting the amount of water that enters the aquifer through human intervention. Water is injected directly into the subsurface through canals, basins, or sprinkler systems. Groundwater recharge is subject to a variety of factors, including the porosity and permeability of the soil, infiltration capacity, precipitation rate, climate changes, and types of surface plant cover. However, the keys factor in groundwater recharge is the porosity and permeability of the soil. Porosity is the open space within the soil volume or its capacity to hold water. The rate of water movement within interconnected pores within soil or rock is called permeability. Due to the excessive load of structures and vehicle loads, concrete and blacktop surfaces in urban areas decrease the permeability of the soil (Gautam & Prajapati 2014). Due to the unreasonable load of structures and vehicle loads, concrete and blacktop surfaces in urban areas decrease the permeability of the soil (Gautam & Prajapati 2014). Open space and treatments that surface the soil by applying plants or grass increase the soil's porosity and permeability and improve groundwater recharge.

The historical practice of the Lalitpur district's land and water management system was to build water spouts in a large pit on the ground to collect subsurface flows of water. The water source can come either from a nearby aquifer or be channeled from natural subsurface water through human-made channels. A filtration system may be installed before the stone spouts to ensure water purity. To build the dug well, a brick masonry wall was utilized. Typically, water is collected from a shallow aquifer that ranges from 4 to 6 meters in depth (Vardhman Envirotech 2021). In conclusion, the Ponds are constructed to supply the sub-surface aquifer that feeds most of the stone spouts and dug wells.They were built to recharge the aquifer and groundwater as a reservoir to feed irrigation canals (Bhandari 2020).



Population

The population development of Lalitpur as well as related information and services (Wikipedia, Google, images).

Name	Status	Transcription	Native	Population Census 1981-06-22	Population Census 1991-06-22	Population Census 2001-05-28	Population Census 2011-06-22	Population Census 2021-11-11
Lalitpur	District	Lalitapura	ललितपुर जिल्ला	184,341	257,086	337,785	468,132	548,401

Lalitpur

🟥 **548,401** Population [2021] – *Census*
∘ **385.0 km²** Area
● **1,424/km²** Population Density [2021]
● **1.5%** Annual Population Change [2011 → 2021]

Lalitpur District: district of Nepal

Figure 10. population density of lalitpur district 2021 census national Data (Citypopulation.de)

3.4.1 Groundwater recharge

Surface water scarcity is impacting a country's socioeconomic growth, necessitating the use of groundwater as an alternate water source. Accurately determining groundwater quantity and quality is vital for hydrological studies, fulfilling water needs for various applications. As a result, groundwater recharge plays a crucial role in groundwater development initiatives. Recharge can happen naturally through rainfall or water bodies' percolation or infiltration, but human activities such as irrigation, injection, urbanization, borehole development, and river diversion also contribute to artificial recharge. (Andualem et al. 2021).

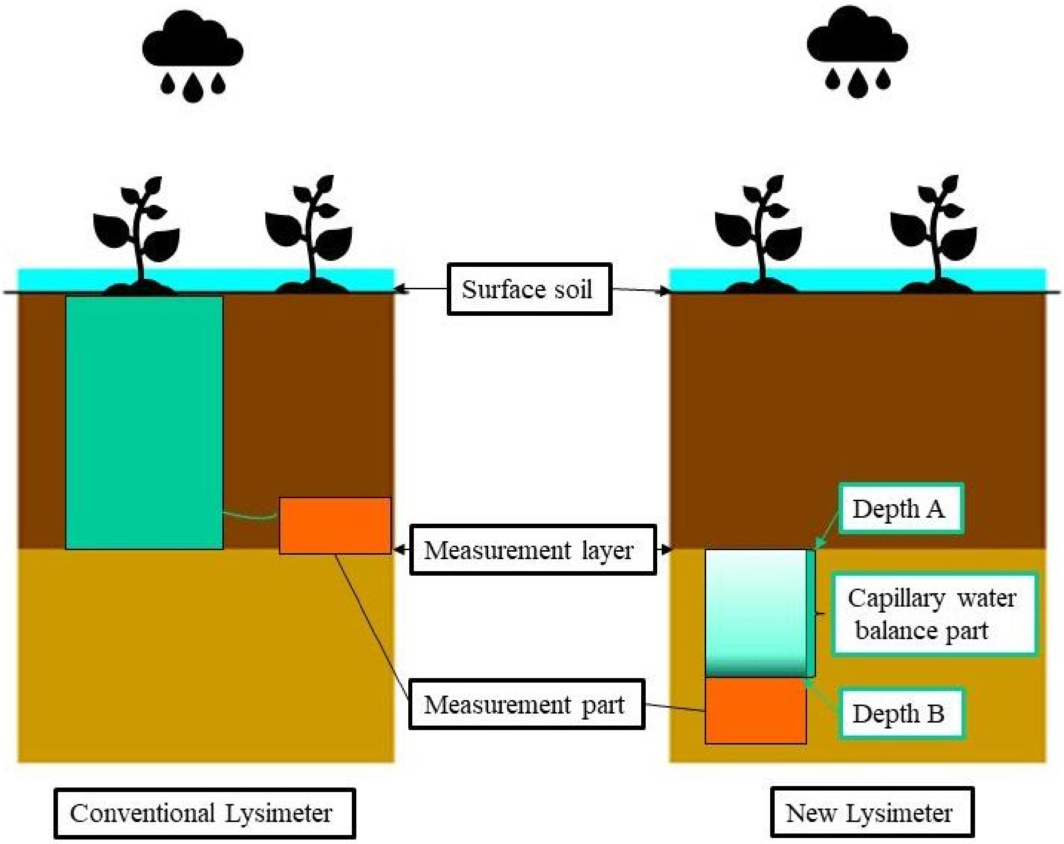


Figure 11. Ground water recharge by hydro-logical process (Cheng et al. 2020)

Figure 11 describing is commonly known as groundwater recharge, which refers to replenishing groundwater resources through various mechanisms such as infiltration of precipitation or surface water and percolation of water from higher to lower soil layers. The hydrological or water balance equation is a mathematical model describing water's movement and distribution in a particular area. Accurate estimation of groundwater recharge rates is a key factor in maintaining the health of aquifers and ensuring the availability of clean drinking and irrigation water for communities around the world (Stanley Udegbunam 2020).

Gross ground water recharge=Total input(Rainfall+imported water)-(runoff+evaporation+change soil moisture storage)

$$Gr=((R+Win)+(Ro+Ea+\Delta S))\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where,

Gr = groundwater recharge (mm)

R = rainfall (mm/hr)
Win = water input for irrigation (mm)
Ea = evapotranspiration (mm)
ΔS = change in soil storage (mm)
Ro = runoff rainfall across the land. (mm)

Net groundwater recharge =Change groundwater storage +Ground water extraction.

Groundwater recharge is a hydrologic process in which water from precipitation or surface water sources infiltrates the ground and moves downward to recharge an aquifer. This process typically occurs below the root zone of plants and vegetation. The groundwater recharge can be Calculated from the water balance equation as

$$Gr=P-Ea+\Delta S-Ro \text{..........................(2)}$$

Where,

Gr = groundwater recharge (mm)
P =precipitation (mm)
Ea = evapotranspiration (mm)
ΔS = change in soil storage (mm)
Ro = runoff rainfall across the land. (mm)

Assume A= 100000m2, Time period Δt= 1 hour, Rainfall intensity i= 30 mm/ hour whereas P= 30mm, Surface runoff Ro=15m, Ea=2 mm, ΔS=12mm. groundwater calculated by

$$Gr=P-Ea+\Delta S-Ro$$
$$=30-14-15, 1\text{mm/hr.}$$

We can calculate the amount of groundwater by the above method continuously.Considering the recharge area of only Kathmandu valley was 86 km2 and 253.71 km2 of Lalitpur by 2018 and 51mm recharge in term of depth total amount of water recharge calculated by the water balance method were 4.4MCM and 13.2 MCM over the year (Pandey et al. 2009).

3.4.2. Recharging of aquifers from rainfall

The quantity of groundwater recharge from rainfall data fluctuates on an annual basis, and this fluctuation is heavily impacted by the characteristics of the soil and geology in a given area (Singh et al. 2019).The equation is expressed below

$$Qr = (Cr-(Ro+Et)) X\ Ac \text{.................}(1)$$

Where,

Qr = the volume of water available for recharge (mm)
Cr= contributing part of the rain (mm)
Ro = a direct runoff (mm)
Et = evapotranspiration
Ac = The Area of the catchment (mm)

In 1970, Krishna Rao formulated an empirical model to estimate the groundwater recharge in a uniform region (Andualem et. al. 2021).

$$R = K(P-X) \text{...................}(i)$$

Krishna Rao has further developed the following relationships for different levels of annual rainfall:

$R = 0.20 (P – 400)$........................(ii) annual normal rainfall (P) between 400 and 600 mm

$R = 0.25 (P – 400)$ ....(iii) P between 600 and 1000 mm

$R = 0.35 (P – 600)$ ....(iv) P above 2000 mm

where R and P are expressed in mm. (Kuruppath et al. 2018)

3.4.3 The technical aspect of dug well recharge methods

Dug well recharge is used to recharge groundwater by diverting excess surface water to the dug wells. This method is used in areas where the groundwater table has dropped due to over-exploitation or other factors. Various technical aspects of dug well recharge methods need to be considered to ensure their effectiveness. In Figure 12

The process of designing a recharge well that can hold rainwater from a catchment area during peak rainfall intensity periods. The statement also emphasizes the importance of having information about the catchment area(A), runoff coefficient(C), and peak rainfall intensity in 15 Minutes (R) designing the recharge well. To calculate the required volume of the well, the formula V = A*R*C is used (Vardhman Envirotech 2021). Once the required volume of the well is calculated, the recharge structure can be designed accordingly to hold the rainwater from the catchment area during peak rainfall intensity periods. The recharge structures can effectively recharge groundwater and prevent flooding during heavy rainfall events.

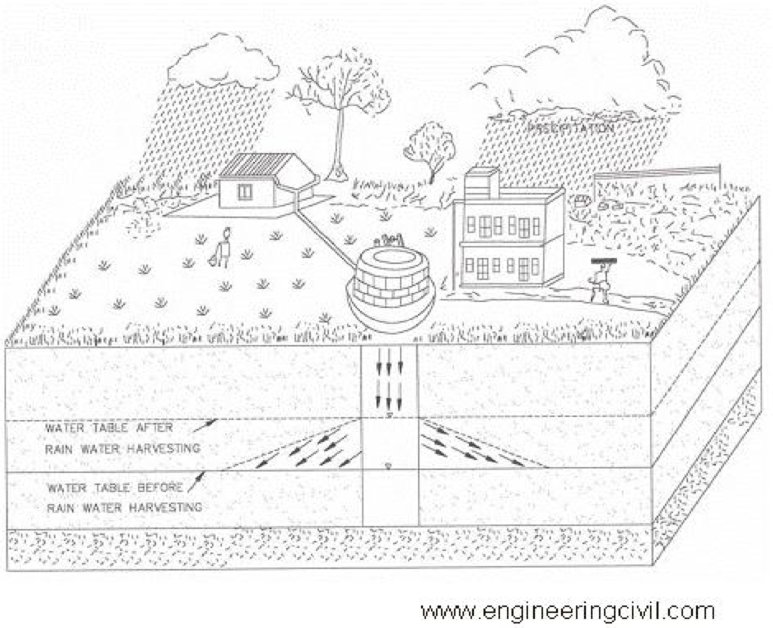


Figure 12. Dug well groundwater recharge(Civil Engineering Portal)

As can be seen in Figure 12 During rainfall, percolation and infiltration rates depend upon the LULC, Soil types, Temperature, Evapotranspiration rate, and Moisture that affect the amount of water entering the groundwater (Malu, n.d.).

3.4.4 Groundwater recharge by green infrastructure in urban areas

Green infrastructure can play a crucial role in recharging groundwater in urban areas. Green infrastructure uses natural or engineered systems, such as permeable pavements, green roofs, and rain gardens, to manage storm-water and water quality improvements (Udegbunam 2020).

In urban areas, impervious surfaces such as buildings, roads, and sidewalks prevent rainwater from infiltrating and recharging groundwater. Instead, storm-water runoff is typically directed to storm drains and discharged into nearby waterways, which can cause water pollution and erosion. Green infrastructure practices can act as a solution to mitigate the unfavorable consequences of storm-water runoff by promoting infiltration into the soil, which can recharge groundwater, and diminish the influx of water into storm-water systems.By increasing infiltration, green infrastructure practices also help to reduce the risk of flooding and erosion. Permeable pavements, for example, allow rainwater to infiltrate the pavement surface and into the ground. Permeable pavements allow for the natural recharge of groundwater and reduce the storm-water runoff that enters storm-water systems (Sing et al. 2019).
Green and vegetated roofs that capture and absorb rainfall can also help recharge groundwater. Rain gardens are designed to capture and retain rainwater, allowing it to infiltrate the ground over time.Soil water recharge during vegetation restoration such as plants, and vegetation keep moisture on soil and minimize evapotranspiration. The roots of plants and vegetation absorb water from the surface (Cheng et al. 2020).The following are the common types of infrastructure used in underground recharge(Camus 2017).

In conclusion, green infrastructure can be an effective way to recharge groundwater in urban areas. In addition, by managing storm-water runoff and promoting infiltration, Planting trees and creating green spaces can also help to mitigate the urban heat island effect, reduce flooding, improve water quality, reduce energy consumption, and improve air quality. A group of scientists from Virginia Tech found through experiments that urban tree roots have the potential to penetrate compacted soil surfaces and increase the infiltration capacity of the soil. That method increases infiltration capacity and introduces the ability to store storm-water. They collect two tree samples, according to the experiments: the roots of a black oak tree and the sap of a red maple tree. The result was that both trees' roots penetrated clay loam soil to a depth of 1.6 g/cm3, increasing the infiltration rate by 153%. (SciJournal 2008) Injection It is injecting water into groundwater using recharge wells or pumps. The recharge well looks like regular water but is opposed to water extraction.

Spreading Basin: A water basin with a porous bottom allows water to sink into the ground through these porous media.

3.5 data analysis and statistical use

The growth of the urban population in Kathmandu Valley were closely monitored, as illustrated in the map (Gurung et al. 2012).

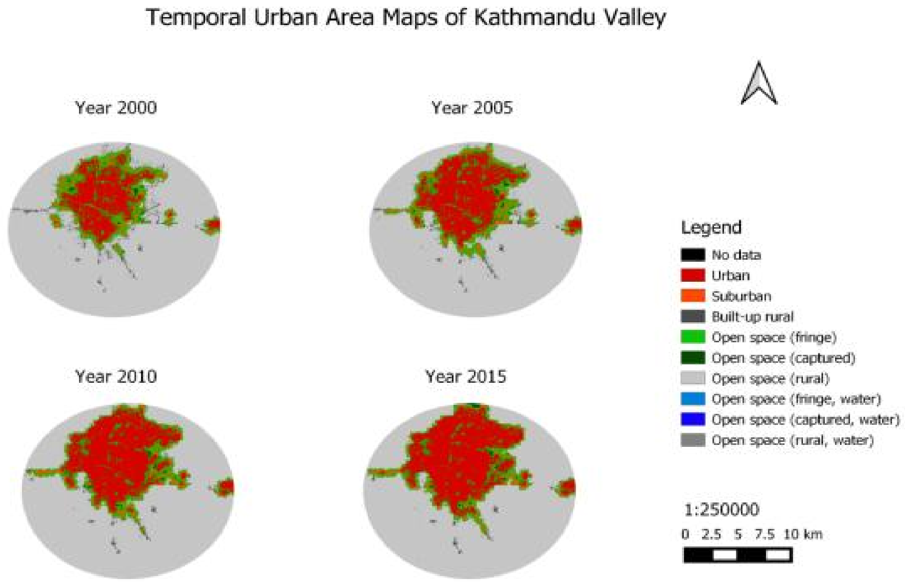


Figure 13. The population growth rate of Kathmandu valley in last 15 years, The following result was obtained based on the population density consistent with the national census and population growth (Thapa et al. 2021).The population growth at the Kathmandu Valley not only changed the city's shape but also destroyed the open space; the change in area is shown in the table below.

Table 1. shows the population of the Kathmandu valley has grown (Thapa et al. 2021).

Period	Population Change	Population Growth rate	City area change (Hectare)	Land Consumption Rate
2000-2005	358775	0.109456	1965.22	0.034094
2005-2010	743510	0.125557	2515.59	0.036568

2010-2015	1311344	0.120019	1371.33	0.017436

The angle of the declination affects how long water holds in contact with the soil layer. A steeper slope means that water flows quickly and has less time to recharge the soil, while a gentler slope allows water or rain to remain in contact with the soil for a longer time, leading to greater recharge. The researcher used for validation of the Analytical Hierarchy Process (AHP)-generated potential groundwater recharge area by the actual field condition, and the (83 no) number of spouts was identified as per the geological, hydro-meteorological, and socioeconomic changes location. That describes a study in which the effectiveness of a method for identifying potential groundwater recharge areas (using the Analytical Hierarchy Process) was tested by comparing the results to actual field conditions. (Lamichhane & Shakya 2021).

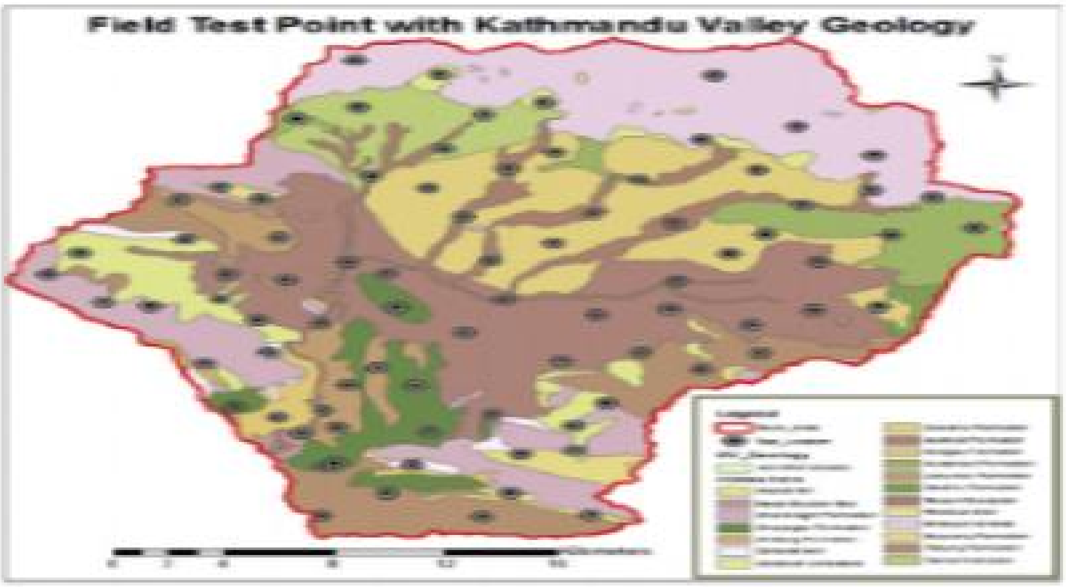


Figure 14. Infiltration test Location (Lamichhane & Shakya 2021).

The variation of outcome from the test is influenced by several factors, including geological formation, land use changes, and alterations in soil texture. Each of these factors is taken into account when determining the test results for a specific area.

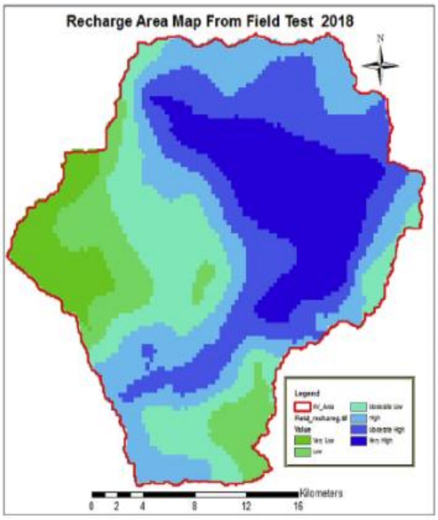
Table 2 Ground water recharge potential value (Lamichhane & Shakya 2021).

S.N	Very low	Low	Moderate low	Moderate high	High	Very High
Recharge potential value	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	7.1-8.0

From table 2 from the analysis, there are some geological factors, i.e., land use and land cover are the main key factor for precipitation and groundwater recharge. This research identifies the potential groundwater recharge using GIS and AHP weights factor. Table.4 is the test pit potential value result classified into 2.1-3 very low, 3.1-4 low, 4.1-5 moderately low, 5.1-6 moderately high, 6.1-7 high, and 7.1-8 very high, respectively.

3.6 Assessment of groundwater recharge map

The theoretical capacity for recharge is determined and assessed using field data on infiltration. The infiltration method using a double ring was conducting the in situ field test for determination within a different location within Kathmandu gave better performance. The infiltration rate is taken from 86 locations from Kathmandu valley spatial coverage (Lamichhane & Shakya 2021).



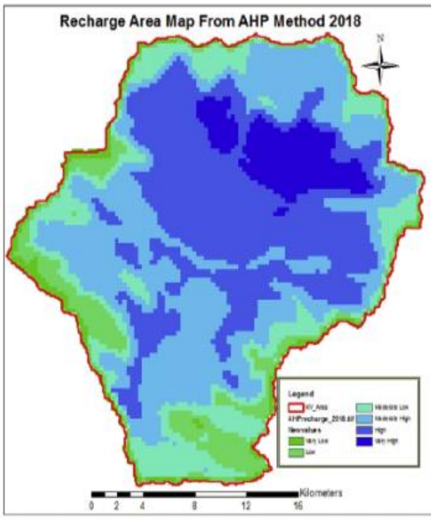


Figure 15. Recharge Area map (Lamichhane & Shakya 2021).

The rapid urbanization of Kathmandu valley has had a significant impact on the city's shape, and beauty, as well as its open spaces. According to a study by (Lamichhane and Shakya 2021), the potential area output of the study area was divided into six categories based on quintile mapping in Arc-GIS. These categories included very low, low, moderately low, moderately high, high, and very high coverage areas, which accounted for 4.29%, 9.14%, 14.72%, 32.59%, 32.89%, and 7.37% of the total area coverage, respectively. The maps shown in Fig. 15 indicate that every decade, urbanization is projected to be destroyed the open areas (agriculture and forest land) of the Kathmandu valley.The data from the study suggests that on average, by every decade, 6% of open land is projected to decrease, and each year, 3.66 km2 of open land will change into urban areas (Lamichhane & Shakya 2021).

Table 3. Comparison land cover with Time 2010 -2018 (Lamichhane & Shakya 2021).

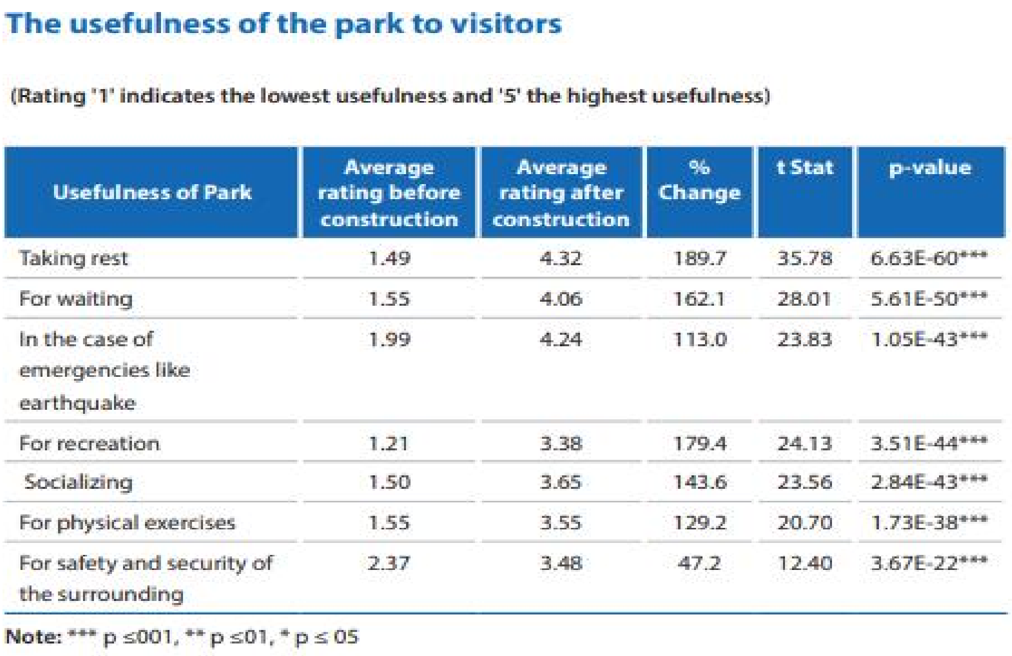
Land use Land cover	Land use cover 2018(%)						
		Agricultural land	Built up Area	Forest	Restricted Area	Water body	Grand Total
Land use land cover 2010(%)	Agricultural land	32.06	8.07	8.73	-	0.04	48.91
	Built up Area	4.00	12.50	0.34	0.11	0.02	16,97
	Forest	6.31	1.26	24.87	00	0.02	32.46
	Restricted Area	0.02	0.09	-	1.31	-	1.42
	Water body	0.02	0.01	-	-	0.21	0.25
	Grand Total	42.40	21.93	33.94	1.42	0.30	100.00

The researcher utilized land use and land cover (LULC) data acquired from the USGS website, which were based on Land sat images, and processed the data using Arc-GIS tools. The findings of the study, presented in Table 3 indicate that, there was a 4.96% increase in built-up areas, while the agricultural area decreased by 6.51% of the total land between 2010 to 2018. This shift in land use is partly due to the establishment of community forests, which has led to a reduction in user group encroachment on forest land (Lamichhane & Shakya 2021). However, the expansion of built-up areas is also leading to a decrease in open agricultural land and barren land, which can negatively impact groundwater resources.

3.7 An Urban Green Park and Its Benefits

The urban green park is an artificial structure formed by the joint function of natural and artificial surface-spreading groundwater recharge techniques. The significance of green spaces or urban parks has developed alongside human civilization and is closely linked to the urban environment, as highlighted by (Xiong et al. 2014). The growing importance of these spaces can be attributed to several factors such as urban air pollution, sound pollution, and the hustle and bustle of city life. People face many problems, such as drinking water, open space, and green environments, and cities can potentially decrease livability quality (Jirel 2022). Green spaces can also help to regulate temperature and humidity, reducing the urban heat island effect and improving overall comfort for residents for city livability (Shrivastav & Sigdel 2019). The advantages of parks extend beyond just a place to relax and enjoy nature. They provide numerous benefits to individuals and communities, including environmental, health, recreational, and economic benefits. Parks that are well-maintained and properly managed can also serve as green infrastructure, helping to improve the local environment by controlling pollution and adding aesthetic value to the surrounding area. Parks offer a wide range of recreational activities that benefit the public, including opportunities for relaxation, exercise, tourism, children's playgrounds, and cultural programs. In addition to these individual benefits, parks also have the potential to enhance social interactions and community engagement, ultimately contributing to social cohesion (Rosso et al. 2022). Urban parks serve as valuable spaces during emergencies like fires and natural disasters such as earthquakes, providing a safe haven for individuals who need to evacuate their homes. In addition, these parks offer recreational opportunities that are particularly beneficial for children, students, and the elderly, enabling them to make better use of their leisure time. Engaging in activities within the park has been shown to have a positive impact on mental well-being.

Table 4. Benefit of the park to visitors (Adhikari et al. 2021).



The usefulness of the park to visitors

(Rating '1' indicates the lowest usefulness and '5' the highest usefulness)

Usefulness of Park	Average rating before construction	Average rating after construction	% Change	t Stat	p-value
Taking rest	1.49	4.32	189.7	35.78	6.63E-60***
For waiting	1.55	4.06	162.1	28.01	5.61E-50***
In the case of emergencies like earthquake	1.99	4.24	113.0	23.83	1.05E-43***
For recreation	1.21	3.38	179.4	24.13	3.51E-44***
Socializing	1.50	3.65	143.6	23.56	2.84E-43***
For physical exercises	1.55	3.55	129.2	20.70	1.73E-38***
For safety and security of the surrounding	2.37	3.48	47.2	12.40	3.67E-22***

Note: *** p ≤001, ** p ≤01, * p ≤ 05

Table 4 defines the survey conducted to park visitors regarding their response to green parks. Most of the participants evaluated excellent the usefulness of the park before and after the construction of green parks. The research question is based on the use of parks such as taking rest, waiting, in the case of an emergency like an earthquake, for recreation, socializing, physical exercise, and safety and security. From table 4, we have the result of a P value is P.01, which is highly significant for our question and is a relevant and positive result.

4.RESULTS

4.1 Groundwater Recharge by Rainfall

Groundwater recharge by rainfall refers to the process by which water from rainfall penetrates into the soil and eventually reaches the groundwater table, thus replenishing the groundwater supply. This process is particularly important in areas where surface water resources, such as rivers, lakes, and reservoirs, are scarce or unavailable, and where groundwater is the primary source of water for domestic, agricultural, and industrial use. During a rainfall event, any excess water that is not lost to evaporation or surface runoff will seep through the soil and rock layers until it reaches the level of saturation known as the water table. The amount of water that infiltrates the ground is influenced by a variety of factors, including the intensity and duration of rainfall, the composition and structure of the soil, the amount of vegetation covering the land, and how the land is utilized. It is also critical for maintaining the ecological balance of groundwater-dependent ecosystems. However, excessive groundwater recharge can lead to groundwater contamination and water logging, which can adversely affect human and environmental health. Various methods can enhance groundwater recharge by rainfall, such as rainwater harvesting, land use management, and artificial recharge techniques. These techniques involve capturing, storing, and infiltrating rainwater into the ground to increase groundwater recharge and improve the availability and quality of water resources.

Recreate barren land or pocket area into urban parks or pocket parks that replace impervious surfaces with the previous surface to improve the soil's infiltration and water-carrying capacity. Plantation of native grass and tree help the infiltration capacity of the urban area and help to recharge the ground water table through natural rainfall water and balance ground water table (Sing et al. 2019). Calculated from the water balance equation is $Gr=P-Ea+\Delta S-Ro$, Where Gr is groundwater recharge, P is precipitation in mm, Ea is evapotranspiration, ΔS changes in soil storage, and Ro is runoff rainfall across the land. Assume A= 100000m2, Time period Δt= 1 hour, Rainfall intensity i= 30 mm/ hour whereas P= 30mm, Surface runoff Ro=15m, Ea=2 mm,

ΔS=12mm. groundwater calculated by $Gr=P-Ea+\Delta S- Ro$, =30-14-15, 1mm/hr. We can calculate the amount of groundwater by the above method continuously. Considering the recharge area of only Kathmandu valley was 86 km2. From the table 5 the comparison land cover land used with time 42.40% agricultural land and 33.94% forest area, then 76.34% to convert with a total area of Lalitpur is equal to 293.909 km2 of Lalitpur is recharge area by 2018 and 51mm (Business Bliss Consultants FZE 2018) recharge in term of depth total amount of water recharge. Considering the recharge area of Kathmandu valley was 86 km2 by 2018 and 51mm recharge in term of depth total amount of water recharge calculated by the water balance method were 4.4MCM - 14.9 MCM over the year,(Business Bliss Consultants FZE 2018). The forest area increased between 2010-18 by 1.48 %, equal to 5.698 km2 and 0.29 MCM or 290,598 Cubic meters by the urban park.The amount of area increased by urban parks or community parks that are clearly shown as the result of urban parks contributes to the groundwater recharge. Furthermore, plant and deep-rooted trees also help to penetrate Impervious surfaces to carry rainwater through this root and store groundwater. The presence of parks offers a multitude of advantages, including environmental benefits such as reducing pollution and improving local air and water quality. Additionally, parks provide mental health benefits by providing space for physical activity and promoting relaxation and stress reduction. The recreational opportunities provided by parks also contribute to a healthier community, while the economic benefits of well-managed green spaces can include increased property values and a boost to local businesses.

In addition, I reviewed studies that groundwater recharge is important for sustainable development because of the rapid declination of surface water. Groundwater recharge by natural process from rainfall is the only convenient and economical way to recharge sustainably. Groundwater recharge from rainfall depends upon various factors such as the amount of rainfall, contribution part of the rain, surface runoff, evapotranspiration, area of catchments, land use, soil type, and water storage capacity of the soil (Singh et al. 2019). Artificial groundwater recharge is a technique that can help to replenish depleted aquifers and increase water availability. It involves deliberately adding water to an aquifer, often through infiltration or injection, to augment the natural recharge through rainfall and other means. For example, the technique was used in the Lalitpur district of Nepal, where an old, historically dug well is used for groundwater recharge. By collecting rainwater from rooftops, paved roads, and walking streets and injecting it into the well, the aquifer is being recharged, which can help increase the well's efficiency and improve groundwater availability.

Overall, this is a promising approach that can help address water scarcity in many areas worldwide. Therefore, it is important to continue exploring and developing new technologies and techniques for artificial groundwater recharge to ensure sustainable water management in the future.

4.2 Benefits of Urban green park.

Parks offer a multitude of benefits to society, including environmental, mental health, recreational, and economic benefits. Green space can minimize environmental pollution and carbon control, which can harm physical and mental well-being and affect human health and increase city livability (Shrivastav et al. 2019). The effective management of green infrastructure, such as a well-maintained park, can contribute to a cleaner local environment and help control pollution while enhancing the aesthetic appeal of the surrounding area.Table 1 from the survey result from the park visitors responses clearly shows the benefits and uses of parks inside urban areas. P value is P.01, which is highly significant. The survey was conducted in the case of an emergency like an earthquake for recreation, socializing, physical exercise, and safety and security, (Udhyami et al. 2021).In addition, The soil water recharge during vegetation restoration such as plants, and vegetation keep moisture in the soil and minimize evapotranspiration. The roots of plants and vegetation absorb water from the surface (Cheng et al.
2020). Achievements of green infrastructure can include storm-water management, water treatment, flood resilience, erosion prevention, air quality improvement, conservation, and food production. This process occurs naturally when artificially constructed infrastructure environments replace

pavements and degraded land that don't readily absorb water. Urban tree roots improve the soil infiltration capacity of the compacted soil surface through storm-water management.From the review of research trees' roots penetrated clay loam soil to a depth of 1.6 g/cm3, increasing the infiltration rate by 153% (Environmental Protection 2008).

Developed parks in urban areas can have several positive impacts on the local environment, such as: The parks serve as a natural habitat for diverse plant and animal species, promoting biodiversity in the urban environment. Enhanced recreational opportunities: Parks offer a space for people to engage in physical activities, such as jogging, cycling, and playing sports, leading to improved health and well-being. The presence of a park can increase property values in the surrounding areas, making it an attractive place to live.Parks provide a space for community events and gatherings, fostering a sense of community among residents.

5. Discussion and possible recommendations

The development of parks in urban areas can have a positive impact on the local community, providing social, economic, and environmental benefits.The context of Lalitpur, Nepal, the development of parks can help address various issues, such as air pollution, groundwater recharge, lack of green space, and physical inactivity.One of the primary benefits of developed parks is that they provide a space for people to engage in physical activity, which can improve their health and well-being. Parks can also serve as a place for social interaction and community gatherings, fostering a sense of community and social cohesion.In terms of economic benefits, developed parks can attract tourists and visitors, generating revenue for the local economy. Parks can also provide job opportunities for residents, such as park maintenance staff, vendors, and tour guides.From an environmental perspective, parks can help mitigate the effects of air pollution by providing a source of clean air and reducing the heat island effect in urban areas. Parks can also serve as a habitat for wildlife, which can help preserve biodiversity in the local area. However, the development of parks can also negatively impact the local environment, such as by destroying natural habitats and displacing wildlife. Additionally, the maintenance of parks can require significant resources, such as water, electricity, and human labor, which can have an environmental impact.To ensure that the development of parks in Lalitpur, Nepal, maximizes their benefits while minimizing their negative impacts, the following recommendations can be considered:Involve the local community in the planning and development of parks to ensure that they meet the needs and preferences of the community.Ensure that the development of parks is sustainable and environmentally responsible by using eco-friendly materials and technologies and minimizing water and energy consumption.Establish a system for effectively maintaining parks to ensure long-term sustainability and minimize negative environmental impacts.Provide education and awareness programs for the local community to promote the responsible use of parks and foster a sense of ownership and pride in the local environment.By following these recommendations, developing parks in Lalitpur, Nepal, can provide significant benefits to the local community while minimizing their negative environmental impacts.

6. Conclusion

The main objectives of all organizations are to overcome drinking water and recharge the groundwater table by using various recharge methods to recharge Groundwater and recover water sources in urban areas. Introducing an urban green park inside the city area increases groundwater recharge over the year and also manages the greenery inside the city's ecological balance within the city area. The purpose of study is to evaluate the recharge of Groundwater by green parks in urban areas. Open space or an urban park can increase the resilience of urban areas. Using artificial recharge methods and developing green parks in urban areas helps recharge Groundwater during monsoon, keep moisture in the soil, and increase soil infiltration capacity by planting trees, grass, herbs, and plants. Introducing green parks improves soil quality, increases the infiltration capacity of the soil, and converts the impervious surface into the previous surface to recharge Groundwater. The amount of groundwater recharge is already present in the result section by green parks or urban pocket parks. From the above discussion, we cannot completely control the problem arising from population growth, but we can minimize its effect by introducing measures against the problems.

In addition, by providing these benefits, urban green parks enhance the quality of life for the public and contribute to the overall well-being of the community.The green park emphasizes how green parks can enhance the resilience of urban areas by providing a clean and aesthetically pleasing environment.Urban parks provides shelter during an emergency like an earthquake, recreation, socializing, physical exercise, and safety and security. The amount of groundwater extraction In Kathmandu Valley is 21.56 MCM per year which is more than its natural recharge in the range of 4.6–14.6 MCM/per year.The natural replenishment of groundwater is progressively declining as the built-up area expands and the recharge area within the Kathmandu valley reduces significantly.Furthermore, we need to increase green urban parks to increase natural recharge as long as trying to fulfill water demand without water extraction from the ground.

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APPENDICES

Key Informant Interviews(KIIs), KIIs were carried out with the technical person (Consultant engineer) Amardeep Chaudhari who is working as a design and construction engineer at Lalitpur district in K.N.K Engineering Consultancy Pvt.Ltd. and studied in Master of construction management.The person involved in both the design and construction of the artificial groundwater recharge system is located in the LMC.This gave me the idea about the technical knowledge and construction overview of the dug well which was constructed within LMC.

1. Design criteria of dug well.

Calculation of Dimension and size of dug well,

Types of dug well

Filter materials used in the dug well.

Estimation cost of dug well.

Repair and maintenance plan policy of dug well.

The present condition of the dug well available in LMC.

2.Calculated from the water balance equation is $Gr=P-Ea+\Delta S-Ro$, Where Gr is groundwater recharge, P is precipitation in mm, Ea is evapotranspiration in, ΔS change in soil storage, and Ro is runoff rainfall across the land. Assume A= 100000m2, Time period $\Delta t= 1$ hour, Rainfall intensity i= 30 mm/ hour whereas P= 30mm, Surface runoff Ro=15m, Ea=2 mm, $\Delta S=12$mm. groundwater calculated by $Gr=P-Ea+\Delta S-Ro$, =30-14-15, 1mm/hr. We can calculate the amount of groundwater by the above method continuously. Considering the recharge area of Kathmandu valley was 86 km2 by 2018 and 51mm recharge in term of depth total amount of water recharge calculated by

Depth of recharge in term of mm by water balance method is 51mm = 0.051 M

Area (A) = 86km2

Ground water recharge over the year GR=86X 1000000M2 * 0.051m= 4.4MCM

Area (A) = 293.909km2 , Ground water recharge over the year GR=293.909 X 1000000M2 * 0.051m= 14.9MCM