Monika Umre

DEVELOPING STRATEGIES TO REJUVENATE THE DEGRADED PONDS THROUGH INTEGRATION WITH CES ASSESSMENT – A CASE OF JABALPUR CITY.

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MASTERS OF ENVIRONMENTAL PLANNING

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2019MEP003

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL

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Thesis submitted in partial fulfilment of the requirements for the award of the degree of

MASTERS IN ENVIRONMENTAL PLANNING

By

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May 2021

DECLARATION

I **Monika Umre**, Scholar No. **2019MEP003** hereby declare that the thesis titled "**DEVELOPING STRATEGIES TO REJUVENATE THE DEGRADED PONDS THROUGH INTEGRATION WITH CES ASSESSMENT — A CASE OF JABALPUR CITY**" submitted by me in partial fulfilment for the award of Master of Planning (Environmental Planning), at School of Planning and Architecture, Bhopal, India, is a record of bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

Signature of the Student
Date: 20th May 2021

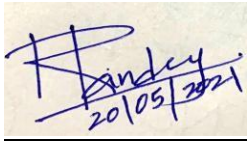
CERTIFICATE

This is to certify that the declaration of **Monika Umre** is true to the best of my knowledge and that the student has worked under my guidance for one semester in preparing this thesis.

RECOMMENDED

Signature of the Guide

ACCEPTED



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Head, Department of Planning

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Thesis Abstract

It is deceptive to overlook small bodies of water as unimportant and meaningless because we all know that small things matter most in our lives. Everyday observations and studies have shown that more and more water sources especially the small water bodies are disappearing from urban and rural landscapes as a consequence of uncontrolled urbanization leading to their encroachment on construction activities; sewage disposal, industrial wastewater, and construction debris; and a change from community-based water use system to person groundwater-dependent system, and so on. Among all water bodies, the major risk of depletion is for ponds and small lakes. WHAT IS POND? The word 'pond' comes from the word 'pound,' which means a small enclosure. Different trusts and conventions have different meanings of ponds. Also, this analysis takes into account the ponds following the International Ramsar Wetlands Convention – The water body's upper limit should be 8 hectares to be known as a pond. The ponds are culturally and historically significant because their sediment records may reveal information about our forefathers' lifestyles. They are important for the protection and promotion of human-wildlife relationships. The ponds are also extremely valuable for recreation.

Every pond can provide multiple ecosystem service benefits at once, but its actual output is defined by its physical characteristics, as well as the size, quality, and timing of water flow. This study focuses only on cultural ecosystem services of the ponds as CES are usually included under non-consumptive direct use values and suffer from inadequate quantification and inclusion in management plans. As a result of cultural services falling outside of the market's sphere of influence, they are invisible in conventional economic research. Cultural services have often been recognized as important, but they are often described as "unquantifiable."

Ponds are one of the most threatened ecosystems. In India, we have lost more than half or more of our ponds. Indian ponds are not considered a priority habitat, even though they are a fragile ecosystem. Since they are considered a small system, ponds with many ecological benefits may lose their identity due to a lack of study. Despite its

many ecological benefits, the pond has lost its identity. In several places, the ponds were the city's landmarks, and they were only known for them. Jabalpur city is one of the examples. It was once known as the “City Of Taals” but now only has 36 taals and tallaiyas (ponds and lakes), the majority of which are degraded. Jabalpur is a city with a vibrant culture and a rich heritage and the ponds have a high cultural value here since ancient times; they serve as a lively gathering place all over the place, and the presence of temples around them, as well as the relation of these ponds with mythological tales, give them various cultural values. However, in recent years, this interaction or connection with the ponds of the local people has been seen to be fading due to pollution, degradation, or a lack of importance or need for these ponds.

The aim of this research is - Developing strategies to rejuvenate the degraded ponds through integration with CES assessment. This aim will be accomplished by surveying CES-producing ponds and examining the interrelationships between the causes of pond degradation and CES. Quantifying the pond's ecosystem services would help in increasing awareness of the main services, which will aid in the development of interventions and strategies. The plans will be long-term and focused on the rejuvenation of the pond's cultural services.

कार्यकारी सारांश

पानी के छोटे शरीरों को महत्वहीन और निरर्थक मानने के लिए भ्रामक है क्योंकि हम सभी जानते हैं कि छोटी चीजें हमारे जीवन में सबसे ज्यादा मायने रखती हैं। हर दिन टिप्पणियों और अध्ययनों से पता चला है कि अधिक से अधिक जल स्रोत विशेष रूप से छोटे जल निकायों शहरी और ग्रामीण परिदृश्य से अनियंत्रित शहरीकरण के परिणामस्वरूप गायब हो रहे हैं, जो निर्माण गतिविधियों पर उनके अतिक्रमण के लिए अग्रणी हैं; सीवेज निपटान, औद्योगिक अपशिष्ट जल, और निर्माण मलबे; और समुदाय आधारित जल उपयोग प्रणाली से व्यक्ति भूजल पर निर्भर प्रणाली में बदलाव, और इसी तरह। सभी जल निकायों में, तालाबों और छोटी झीलों के लिए कमी का प्रमुख जोखिम है। तालाब क्या है? 'तालाब 'शब्द' पाउंड' शब्द से आया है, जिसका अर्थ है एक छोटा सा परिक्षेत्र। विभिन्न ट्रस्टों और सम्मेलनों में तालाबों के अलग-अलग अर्थ हैं। इसके अलावा, यह विश्लेषण अंतर्राष्ट्रीय रामसर वेटलैंड्स कन्वेंशन के अनुसार तालाबों को ध्यान में रखता है - तालाब के रूप में ज्ञात होने के लिए जल निकाय की ऊपरी सीमा 8 हेक्टेयर होनी चाहिए। तालाब सांस्कृतिक और ऐतिहासिक रूप से महत्वपूर्ण हैं क्योंकि उनके तलछट रिकॉर्ड हमारे पूर्वजों की जीवन शैली के बारे में जानकारी प्रकट कर सकते हैं। वे मानव-वन्यजीव संबंधों के संरक्षण और संवर्धन के लिए महत्वपूर्ण हैं। तालाब मनोरंजन के लिए भी बहुत मूल्यवान हैं।

प्रत्येक तालाब एक साथ कई पारिस्थितिकी तंत्र सेवा लाभ प्रदान कर सकता है, लेकिन इसका वास्तविक उत्पादन इसकी भौतिक विशेषताओं के साथ-साथ पानी के प्रवाह के आकार, गुणवत्ता और समय से परिभाषित होता है। यह अध्ययन केवल तालाबों की सांस्कृतिक पारिस्थितिकी तंत्र सेवाओं पर केंद्रित है क्योंकि सीईएस को आमतौर पर गैर-उपभोग्य प्रत्यक्ष उपयोग मूल्यों के तहत शामिल किया जाता है और अपर्याप्त मात्रा का ठहराव और प्रबंधन योजनाओं में शामिल होने से पीड़ित होता है। बाजार के प्रभाव के बाहर गिरने वाली सांस्कृतिक सेवाओं के परिणामस्वरूप, वे पारंपरिक आर्थिक अनुसंधान में अदृश्य हैं। सांस्कृतिक सेवाओं को अक्सर महत्वपूर्ण माना जाता है, लेकिन उन्हें अक्सर "अप्राप्य" के रूप में वर्णित किया जाता है।

तालाब सबसे खतरनाक पारिस्थितिकी प्रणालियों में से एक हैं। भारत में, हमने अपने आधे या अधिक तालाब खो दिए हैं। भारतीय तालाबों को प्राथमिकता वाला निवास नहीं माना जाता है, इस तथ्य के

बावजूद कि वे एक नाजुक पारिस्थितिकी तंत्र हैं। चूंकि उन्हें एक छोटी प्रणाली माना जाता है, इसलिए अध्ययन की कमी के कारण कई पारिस्थितिक लाभ वाले तालाब अपनी पहचान खो सकते हैं। इसके कई पारिस्थितिक लाभों के बावजूद, तालाब अपनी पहचान खो चुका है। कई स्थानों पर, तालाब शहर के स्थल थे, और वे केवल उनके लिए जाने जाते थे। जबलपुर शहर इसका एक उदाहरण है। यह कभी "ताल के शहर" के रूप में जाना जाता था, लेकिन अब केवल 36 ताल और लम्बाइयाँ (तालाब और झीलें) हैं, जिनमें से अधिकांश दूषित हैं। जबलपुर एक जीवंत संस्कृति और एक समृद्ध विरासत वाला शहर है और प्राचीन काल से तालाबों का एक उच्च सांस्कृतिक मूल्य है; वे सभी जगहों पर एक जीवंत सभा स्थल के रूप में सेवा करते हैं, और उनके आसपास के मंदिरों की उपस्थिति, साथ ही साथ पौराणिक कथाओं के साथ इन तालाबों के संबंध, उन्हें विभिन्न सांस्कृतिक मूल्य देते हैं। हालांकि, हाल के वर्षों में, स्थानीय लोगों के तालाबों के साथ यह संपर्क या संबंध प्रदूषण, गिरावट, या इन तालाबों के लिए महत्व या आवश्यकता की कमी के कारण लुप्त होते देखा गया है।

इस शोध का उद्देश्य है - सीईएस मूल्यांकन के साथ एकीकरण के माध्यम से दूषित तालाबों का कायाकल्प करने के लिए रणनीति विकसित करना। यह उद्देश्य सीईएस-उत्पादक तालाबों का सर्वेक्षण करके और तालाब क्षरण और सीईएस के कारणों के बीच अंतर्संबंधों की जांच करके पूरा किया जाएगा। तालाब के पारिस्थितिकी तंत्र सेवाओं को मात्रात्मक बनाने से मुख्य सेवाओं के बारे में जागरूकता बढ़ाने में मदद मिलेगी, जो हस्तक्षेप और रणनीतियों के विकास में सहायता करेगी। योजनाएं दीर्घकालिक होंगी और तालाब की सांस्कृतिक सेवाओं के कायाकल्प पर केंद्रित होंगी।

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CHAPTER 1 INTRODUCTION

This chapter of the report introduced the topic of the study by explaining its importance and necessity. This will also provide a research methodology that was used to accomplish the aim, objectives, and scope of the study.

1.1 Contextual background

Water is one of the most valuable commodities on this planet. It is part and parcel of the atmosphere. It is a key element of life, without which it cannot be maintained. But today, about three billion people face water scarcity for at least one month a year. Policymakers focus on safeguarding the rivers and the seas, but not the ponds. Even when their importance is enormous, they perform a significant role in the global environmental process. Because of a misconception of the importance of ponds, this is overlooked. (Downing, 2010; Céréghino *et al.*, 2014; Kumar and Padhy, 2015; Biggs, von Fumetti and Kelly-Quinn, 2017)

They are an important part of the hydrological system and play a lot of functions in the biosphere, but research on small water bodies is still neglected due to their small scale. They have a large natural, social, and economic effect, despite their small scale, by acting as a source of drinking water, recharging groundwater, acting as sponges to prevent floods, and protecting biodiversity, etc. India's policymakers have drawn ample attention to groundwater resources and rivers as India battles the water crisis, small water bodies that are the other main source of water have fallen under their goal list. This is shocking, given the important role small bodies of water have played in the supply of drinking water, other domestic needs, and agriculture over the years. To help overcome some of the many risks, better awareness of small water sources and more efficient management has enormous potential. They have the potential to offer long-term solutions to major water management concerns as well as climate change-related environmental issues.(Downing, 2010; Kumar and Padhy, 2015; Biggs, von Fumetti and Kelly-Quinn, 2017)

Ponds and small lakes are precious environmental resources in so many parts of the world, even though the water in them makes up a small portion of the overall freshwater supply. Despite the great concern for human health of high-quality access

to safe drinking water, freshwater systems have been exploited for many decades. Ponds play an important role in our entire ecosystem. The global significance of an ecosystem is determined by the sum of the biosphere generated by the ecosystem and the intensity of the fascinating mechanism within it. Small ecosystems will also have a major impact on global natural processes. Ponds and shallow streams influence global waters. Such biological mechanisms and cycles are extremely strong in such small forms of water environments. (Brönmark and Hansson, 2002; Biggs, von Fumetti and Kelly-Quinn, 2017)

1.2 Need for the study

A healthier climate often has positive social and cultural consequences. The natural beauty of the pond is part of the quality of life for landowners and the entire community. Quantifying the pond's ecological resources will aid in a better understanding of its existence. A well-kept pond provides people with leisure opportunities while also allowing the government to profitably maintain the pond. Recreational activities in and around urban ponds can provide a potential source of revenue for local governments if they are implemented properly. The ponds can be used to create urban aesthetics and visual connections by removing obstacles such as walls and high fences in addition to the ponds. If we restore the ponds in a well-designed manner, they will also provide a variety of benefits, including biodiversity, flood relief, pollution reduction, and climate change mitigation.

1.3 Research gap

To find the gap, various literature related to pond rejuvenation, its function, significance, impacts, relationship with ecosystem service was studied.

Due to a lack of information and study on the subject, there is a lack of awareness about the benefits of this small thing in both urban and rural areas. Ponds get less attention when it comes to quantifying the ecosystem services they offer. A consistent definition of a pond is lacking. Ponds undergo less quality assessment and monitoring than rivers and lakes. The main emphasis of studies is on environmental importance rather than social-cultural significance. There has been a dearth of studies into the historical and archaeological importance of the ponds.

1.4 Problem identification

Ponds are extremely important in terms of ecosystem resources, but they are now contaminated and degraded. Ponds face several issues, including a lack of action plans, intrusions and violations of laws, solid waste management, and polluted water. Another major stumbling block is the lack of a clear land use category for the land, making it difficult to protect and preserve it. Ponds are one of the most endangered species on the planet. We have lost more than half or more of our ponds in India. Indian ponds are not considered a priority habitat, even though they are a fragile ecosystem. Since they are considered a small system, ponds with many ecological benefits may lose their identity due to a lack of study. Despite its many ecological benefits, the pond has lost its identity. In several places, the ponds were the city's landmarks, and they were only known for them. The ponds have a high cultural value since ancient times; they serve as a lively gathering place all over the place, and the presence of temples around them, as well as the relation of these ponds with mythological tales, give them various cultural values. However, in recent years, this interaction or connection with the ponds of the local people has been seen to be fading due to pollution, degradation, or a lack of importance or need for these ponds.

Even after the many benefits ponds provide to the ecosystem, there is a lack of government action on pond repair, restoration, and conservation. The inefficiency of management and the utter lack of a systematic approach to water management are the problems facing pond regeneration. It is necessary to develop a policy implementation strategy and then work to carry out the plan on the ground.

1.5 Aim of the study

Developing strategies to rejuvenate the degraded ponds through integration with CES assessment – A case of Jabalpur city.

1.6 Objective

1. To identify ponds that provide CES.
2. To analyze the inter-relationships between the reasons responsible for selected pond’s degradation and CES.

3. To evaluate the CES of selected ponds in non-monetary terms.
4. To propose strategies and interventions that rejuvenate the selected ponds as per the services.

1.7 Scope

The scope of this research is to raise public consciousness about the value of ponds in terms of management and conservation. The research will look into the factors that cause pond degradation as a result of cultural services, as well as its inverse effects on cultural services. The study would exhibit a range of long-term strategies for rejuvenating the degraded ponds.

1.8 Limitations

This research will be restricted to a single urban area and will not apply to any other. The cultural ecosystem service will be the sole focus of this study. The research covers only the post-covid phase -1 scenario in the survey. The monetary aspects will not be discussed in this study.

1.9 Expected outcome

This research will develop a generalized structure that will aid in the further exploration of related research. This study will recommend long-term planning measures and strategies for rejuvenating the degraded pond, as well as ways to increase the value of the surrounding areas through pond rejuvenation or development.

1.10 Methodology

For each objective, my thesis analysis will be organized in a step-by-step format. Each step would be targeted at achieving the desired outcome.

Following the selection of the area of interest, a background study was performed on the pond, including its location, significance, impacts, and relationship with ecosystem services. This leads to the identification of a research gap, the formulation of a problem statement, and the determination of the study's need. With understanding, all these aims and objectives will be formulated. Further to that, a site must be chosen that is appropriate to achieving the goal.

The first objective is intent to identify ponds that provide cultural ecosystem services and for this study perform a perception, questionnaire, and photographic survey of Jabalpur Municipal Corporation's water bodies to learn about its current condition, use, area, and location, as well as the activities that take place in and around them. This followed with a conversation regarding the same with the Jabalpur water supply department and the health department, which will be in charge of looking after and maintaining the ponds. As a result, the ponds that have cultural ecosystem service as their essential and predominant service will be finalized.

The second objective intent to analyze the inter-relationships between the reasons responsible for selected pond’s degradation and CES. To achieve this goal, a household survey will be conducted, which will aid in the finding of the causes of the degradation as well as the understanding of the relationship between the impacts of pond degradation on cultural services and the reasons why cultural services contribute to pond degradation.

The third objective intents to evaluate the CES of selected ponds in non-monetary terms. To achieve this goal, we use the stated preference method to measure ecosystem services by surveying residents and asking them to rate the ponds' services.

Lastly, the fourth objective intents to propose strategies and interventions that rejuvenate the selected ponds as per the services and for this we develop strategies to address the issues identified, as well as ecosystem-based solutions for the various ponds examined.

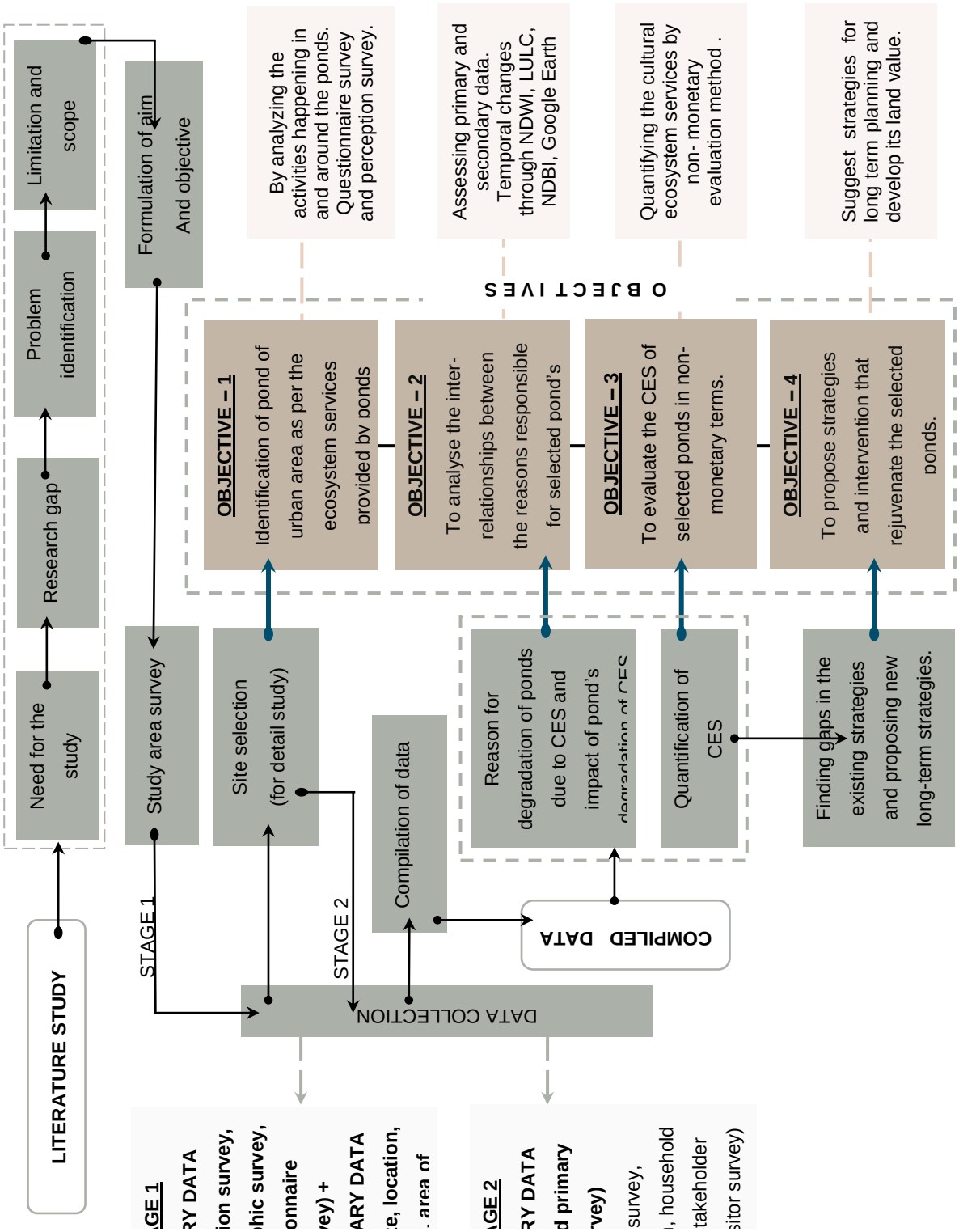


Figure 1.1: Research methodology

Figure 1.2: Research methodology

CHAPTER 2 LITERATURE REVIEW

This chapter focuses on the literature review, which is necessary to lay the foundation for the study that must be completed for the research to be strengthened. It entails a thorough examination of different terms, meanings, methods, and contexts in which to conduct this analysis. It requires numerous actions and regulations, as well as design recommendations, to strengthen the study.

2.1 Terminology

2.1.1 Ponds

India is noted for its diversity, with a diverse spectrum of water bodies and climates spread across its length and breadth. Water bodies experience different levels of environmental degradation. The most vulnerable condition in water bodies is of the pond.(Rao, 1971; Brönmark and Hansson, 2002; Downing, 2010; Céréghino *et al.*, 2014; Kumar and Padhy, 2015; Biggs, von Fumetti and Kelly-Quinn, 2017)

Definition

“The word 'pond' originates from the word 'pound' meaning a confining enclosure”.

What is a pond……...?

“Ponds as water bodies with an area between 1 square meter and 2 hectares (20,000 square meters), which may be seasonal or permanent, including both natural and man-made water bodies”. (Biggs, von Fumetti and Kelly-Quinn, 2017)

To be classified as a pond, 8 hectares (20 acres) should be as the upper limit of the water body”. (Biggs, von Fumetti and Kelly-Quinn, 2017)

Some regions of the United States classify a pond as “a surface water body having a surface area of less than 10 acres”, and many **regions of Europe** adopted an upper limit of the pond is 5 hectares (12 acres). (Kumar and Padhy, 2015)

In compliance with the International Ramsar Wetlands Convention, the ponds will be taken over for further analysis.

2.1.2 Ecosystem services

Wherever you work, you are reliant on ecosystem resources. We depend on healthy environments to do many things as a society: to purify the air so that we can breathe properly, to sequester carbon to combat climate change, to cycle nutrients so that we can drink clean water without having to pay for costly toilets and to pollinate our crops so that we don't go hungry. If the world's population continues to rise, so does our reliance on sustainable habitats to provide the essentials for our life.

Ecological resources are the advantages that occur as a result of ecosystem processes. Such facilities support all living species in the niche, including mammals, plants, and humans. Ecosystems have the ability to provide a wide variety of resources critical to human well-being, wellbeing, subsistence, and sustainability. *(Costanza et al., 1997)(Millennium Ecosystem Assessment (MEA), 2005)(TEEB Synthesis, 2010).*

Various definitions of ecosystem service have been proposed so far, and they can be summarised as follows:

"**The benefits that people obtain from ecosystems**" *(MEA, 2005).*

"**The direct and indirect contributions of ecosystems to human well-being**" *(TEEB, 2010).*

Ecosystem services (ES) are now defined as contributions of ecosystem structure and operation (in combination with other inputs) to human well-being in more recent publications. *(Burkhard et al., 2012)(Burkhard B. & Maes J. Eds., 2017).*

The Millennium Ecosystem Assessment (MA), a systematic international initiative to raise awareness and appreciation of community reliance on ecosystems, has proposed four groups.

First is provisioning services - make direct human use of items such as food, freshwater, timber, and fibers; a well-known aspect of the economy.

Second, much less widely known are regulatory services - maintain a biophysical ecosystem in which humans can live, with benefits such as purifying water, flood control, crop pollination, and so on.

The third is cultural services - They offer aesthetic, academic, and moral inspiration and leisure, making the world a place people want to live in.

And lastly fourth is supporting services - provide a basis for cases and processes that are more specifically dependent on society. **(Figure- 2)**

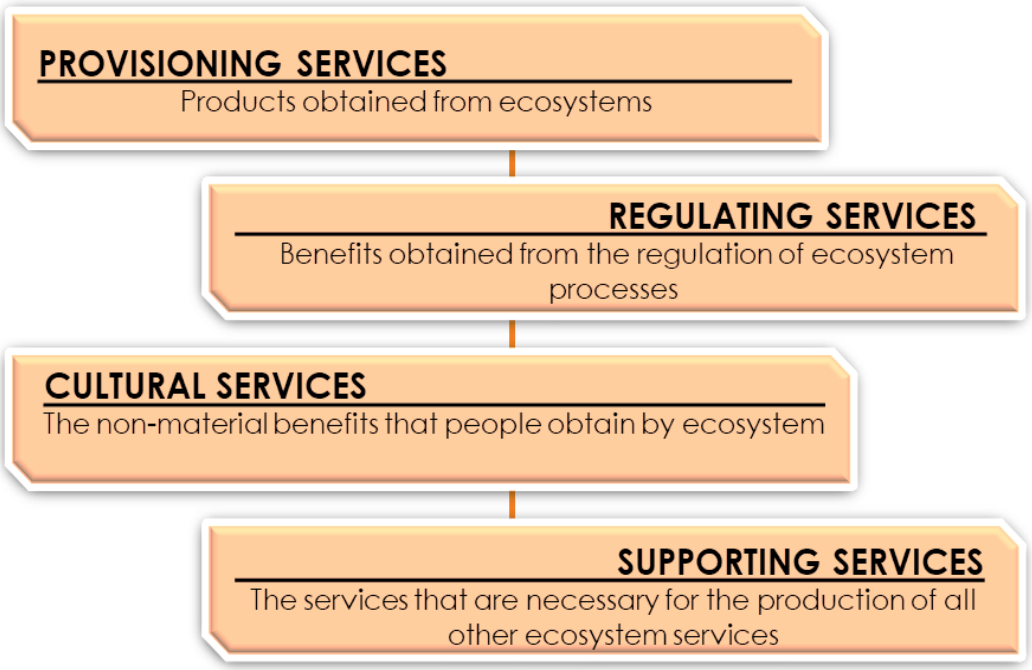


Figure 2.1: Types of ecosystem services

Source – Author generated, Millennium Ecosystem Assessment (MEA), 2005

Ponds play an important role in our entire ecosystem. The global significance of an ecosystem is determined by the sum of the biosphere generated by the ecosystem and the intensity of the fascinating mechanism within it. Small ecosystems will also have a major impact on global natural processes. Ponds and shallow streams influence global waters. Such biological mechanisms and cycles are extremely strong in such small forms of water environments. *(Downing, 2010)*(Landuyt *et al.*, 2014)

All pond has the potential to give a variety of ecological services at the same time, but the exact performance of each would be determined by the physical properties of the basin as well as the amount, consistency, and timing of water flow. Ecosystem

resources and benefits will be impacted as anthropogenic impacts rise. (Bingham *et al.*, 2000)*(EPA, 2000)* (Rustogi and Singh, 2017)

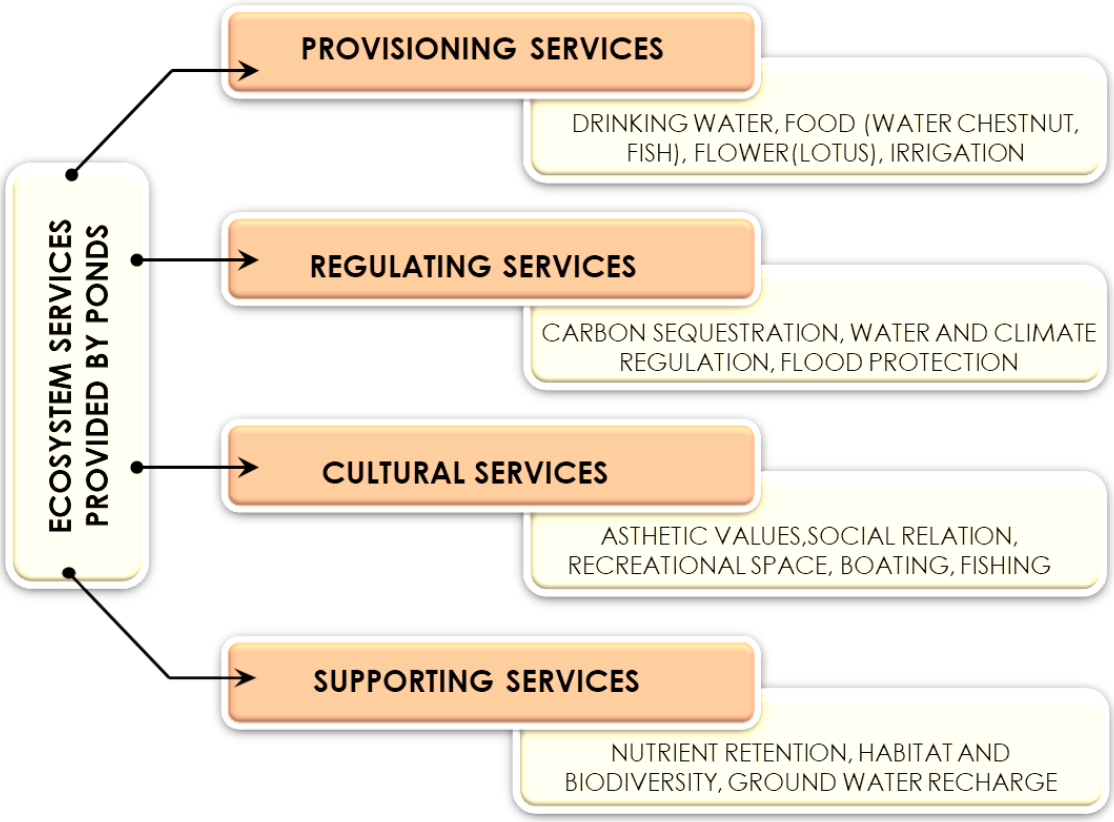


Figure 2.2: Ecosystem services provided by ponds

Source – Author generated, Millennium Ecosystem Assessment (2005),

1. **Provisioning Services -** Food, water, medicines, and other services are examples of products or raw materials or energy outputs from ecosystems. Ecosystems include food, water, medicine, biomass, biofuels, and other resources. They also provide criteria for the development of these resources.

2. **Regulating Services-** This is about the tools that keep the ecological equilibrium in check. Earthly ecosystems, for example, purify and manage air quality, prevent soil degradation, and regulate greenhouse gas emissions. Birds, rodents, and frogs, for example, act as natural controls and thus aid in the management of pests and diseases.

3. **Supporting services -** Both programs are built on the foundation of social services. They provide habitat for a variety of life forms, as well as ecosystem preservation, nutrient cycling, and some other life-supporting functions on the earth.

4. **Cultural services -** Tourism is included, as well as recreation, aesthetic, educational, and spiritual resources. Landscapes, cliffs, and caves, for example, are used as locations for cultural and artistic purposes. They deem even a handful to be holy. Furthermore, landscapes have enormous economic opportunities in the name of tourism.

2.1.2.1 Cultural ecosystem services

Cultural ecosystem services (CES) are non-material benefits that people get from the ecosystem that have a significant impact on their quality of life. Both CES and other programs represent what people benefit from the natural world, raising public consciousness and encouragement to protect the environment. Why cultural ecosystem services – as they are usually included under non-consumptive direct use values and suffer from inadequate quantification and inclusion in management plans. The importance of cultural services has consistently been recognized, but they are often defined as "unquantifiable,".(Cheng *et al.*, 2019)

2.2 Monitoring of ponds

Under the National Water Quality Management Program 9, the CPCB (Central Pollution Control Board) monitors certain ponds in 11 states and the Union Territories (UTs). There are 60 monitoring stations (monitoring network) for pond water quality. The majority of the sampling stations (60%) are in India's north-eastern states (Assam and Manipur), with 15% in India's eastern states (Bihar, Jharkhand, and Odisha States). Southern India (Andhra Pradesh, Kerala, and Lakshadweep), Northern India (Uttar Pradesh and Delhi), and Western India (only Gujarat) account for roughly 13%, 8%, and 3% of the sampling stations, respectively. **(Figure-4)**

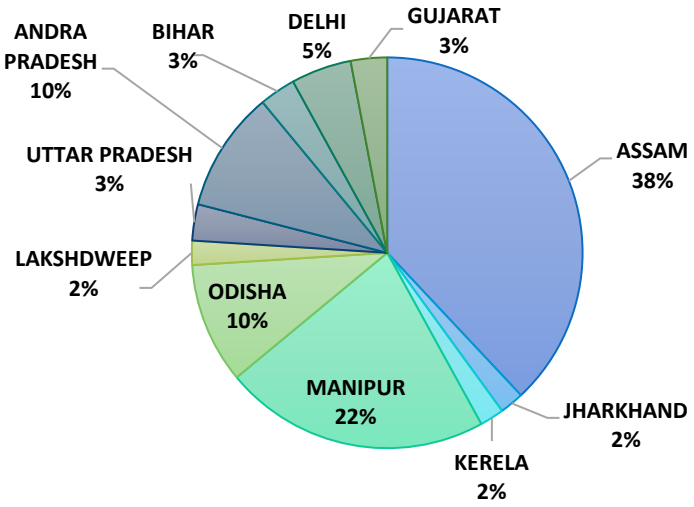


Figure 2.3: Water quality monitoring stations present in various states and UTs pertaining to Ponds

Source: Author generated, (Kumar and Padhy, 2015)

While there are studies in other areas, physicochemical studies and hydrobiological inventories have dominated Indian research. The majority of research (60 percent) centered on 'physicochemical only' pond water features, supplemented by 'combined physicochemical - hydrobiological studies' (20 percent). Microbiological studies (for the cholera epidemic) account for 10percent of all studies, whereas 'hydrobiological experiments only' and 'habitat loss and biological impact studies' each account for 5%. **(Figure 5).**

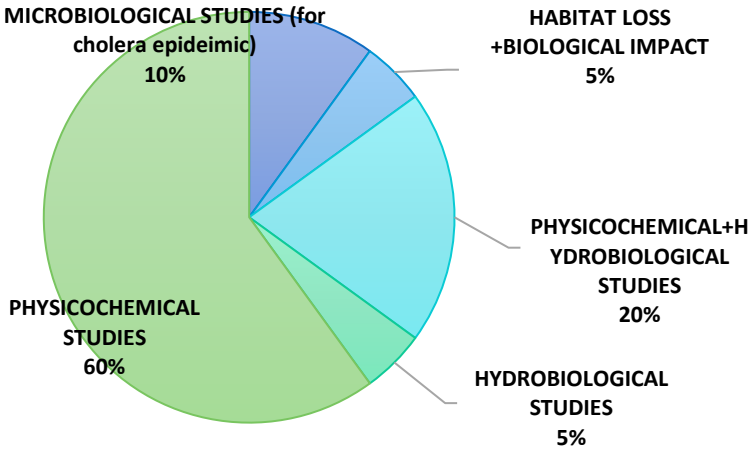


Figure 2.4: Types of investigations carried out by Indian researchers about Ponds

Source: Author generated, (Kumar and Padhy, 2015)

Daily observations and research have shown that more and more water sources are diminishing from urban and rural environments as a consequence of uncontrolled urbanization leading to their encroachment on construction activities; sewage disposal, industrial wastewater, and construction debris; and a change from community-based water-use system to person groundwater-dependent system, and so on. In addition, multiple human actions, such as population development and industrial agriculture, as well as climate change, placed the ponds in jeopardy. Several experiments have shown that ponds may have both more and fewer effects on the environment than larger bodies of water.(Kumar and Padhy, 2015)

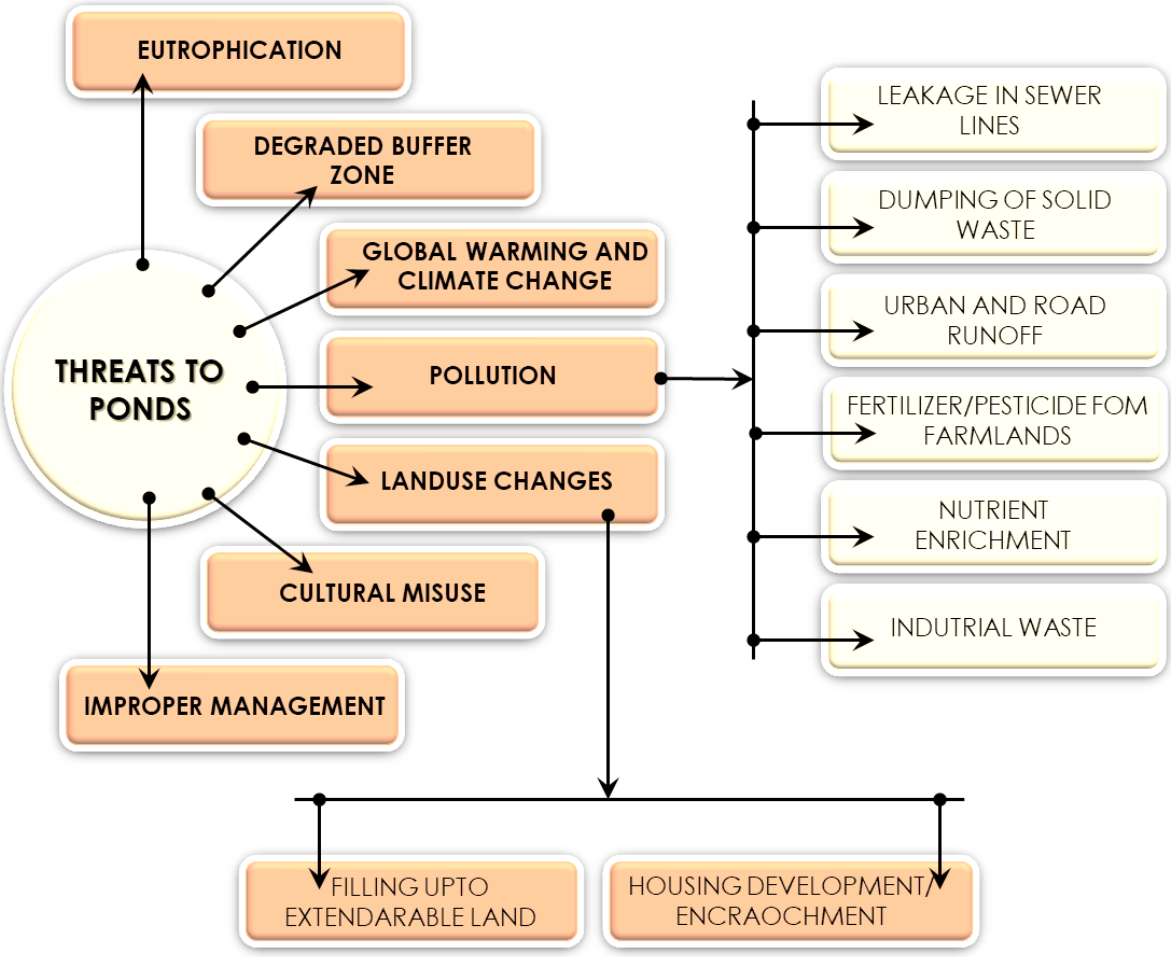


Figure 2.5: Threats to the ponds

Source: Author generated, (Kumar and Padhy, 2015)

Despite their cultural, social, and economic significance, these water sources have been voluntarily neglected and destroyed by urbanists. While adequate policies and programs are in place to conserve and restore small water bodies, they are still in very poor condition and their statistics continue to decline.

2.3 Threats to the ponds

1. **Pollution -** The metropolitan population has exploded in the last two decades, with no accompanying extension of municipal facilities such as adequate waste management facilities. As a result, as more residents migrate to cities, urban public services become less successful. As a result, almost all of India's urban water bodies suffer from pollution and are used as the disposal of untreated municipal sewage and solid waste, and in many instances, the water sources have eventually become landfill sites.

2. **Encroachment** - Encroachment is a major danger to water bodies once again, particularly in urban areas. The availability of land becomes restricted as more people migrate to cities. In today's cities, only a limited portion of land has significant economic value. As a result of their ecosystem services, these commercial water bodies have been renamed real estate. Both of these opportunities are particularly beneficial to both the government and private developers.

3. **Eutrophication** - The ponds, which are mostly lentic water bodies, are nearly closed ecosystems. Since only a percentage of the pollutants entering the lakes can be removed based on the process of water exchange, a significant number of them are a permanent part of the setting. As a result, untreated waste nutrient infiltration is a part of the lake environment, causing various adverse changes in the water body, such as excessive aquatic weed growth in lakes and wetlands, which ultimately damage and kill the ecology of the water body. Assam's Bheels are a well-known example of high hyacinth development as a result of contamination.

4. **Cultural misuse -** Local resident's misuse of these water sources for cultural or religious festivals such as idol immersion is also contributing to the awful condition of urban water bodies. These activities, in fact, are a major cause of contamination in ponds.

2.4 Indian scenario

Indian ponds are not considered a primary concern habitat which tries to make them a vulnerable ecosystem. For a wide range of operations, ponds are both sources and sinks. They are used for drinking water, drainage, other aquaculture operations, and fishing, bathing, and washing utensils and clothes, dumping household waste, immersing idols, discharging municipal wastewater/sewage, dumping animal waste, and other miscellaneous waste, as well as recreational uses. Other factors, such as global warming and climate change, are expected to have an effect on pond habitats in India. Here are a few examples showing the condition of Indian ponds:

In **Khandwa district (Madhya Pradesh)** freshwater content is deteriorating, and the results of chloride, phosphate, and nitrate tests revealed a water body's tendency toward eutrophication.

In **Jabalpur (Madhya Pradesh)** there were 52 big water bodies "Tals" and 84 small water bodies "Tallaiyas" reportedly existed in Jabalpur in the past but at present, only 36 water bodies are in existence within the town. Many of the water bodies have been completely vanished due to changes in land-use patterns, encroachment, urbanization, and anthropocentric activities.

Both dams in the **Ayodhya-Fizabad** district of Uttar Pradesh had degraded water quality. Pollution and eutrophication are largely caused by wastewater discharge into wetlands.

The most important cause for water quality depletion in an urban pond in **Vadodara (Gujarat)** was the discharge of untreated sewage. Eutrophication due to sewage and surface runoff was also discovered in an analysis of a Vadodara urban marsh.

A physicochemical study of the perennial water of a pond used for aquaculture near **Erode (Tamil Nadu)** revealed that illegal toxicant discharge could pose a serious

threat to the pond's ecology. These are used for agriculture, fishing, and other fisheries operations, as well as as a source of drinking water.

A hydro chemical study of ponds in the **Santiniketan – Bolpur – Sriniketan region (West Bengal)** identified organic wastes and phosphate as the most serious polluting agents, both of which are harmful to the pond habitats' proper ecological functioning.

According to the literature review, nutrient enrichment has made pond waters in India highly eutrophic, especially in terms of phosphate and nitrate. In almost all of the studies listed above, anthropogenic pressure was responsible for the loss of pond biodiversity in India, and the majority of the studies found pond water unfit for domestic water purposes. In a small phrase, the condition of ponds is unpleasant and unacceptable in India. Despite their cultural, social, and economic importance, humans ignored and destroyed these waterbodies**.**

2.5 Policies

National Water Policy (NWP) 2002 AD mildly stated small waterbodies in India. Common water management activities, such as rainwater harvesting, were highlighted in the strategy, as well as pioneer research & innovation in those regions. The strategy also stated vaguely that required laws would be used to avoid encroachment and preserve natural water sources. The NWP 2012 AD is a little more positive about the country's pond waterbodies in terms of restoration, growth, and management. The strategy emphasizes increasing water holding capacity in different ways, such as dams and other small water sources, particularly as a means of coping with climate change. This proposal also calls for the rehabilitation of natural water sources and bodies to extract water. To improve the availability of water in the agricultural sector, the policy proposes extending existing programs, such as the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), that allow farmers to extract rainwater using farm ponds.

Recognizing the gravity of the issues confronting water bodies, the Centre initiated the “Repair, Renovation and Restoration (RRR) of water bodies” program in 2005, intending to enhance and restore existing water sources in a variety of ways, including

improved storage space, groundwater recharge, better drinking water quality, and improved catchment areas.

2.6 Linkages to SDGs

It is important to protect the world's water supply to meet the United Nations Sustainable Development Goals (SDGs). Water is the 'critical thread' that runs across all 17 SDGs, since it is vital for life and wellbeing, including health, food, and a sustainable economy. For all those species that depend on it, water is essential. A safe, consistent, and continual supply of water is necessary to secure our economic future and well-being. Conserving and controlling small entities indirectly achieves further SDG targets, such as—

1. GOAL 3: Good Health and Well Being
2. GOAL 6: Clean Water and Sanitation
3. GOAL 13: Climate Action
4. GOAL 14: Life Below Water
5. GOAL 15: Life on Land

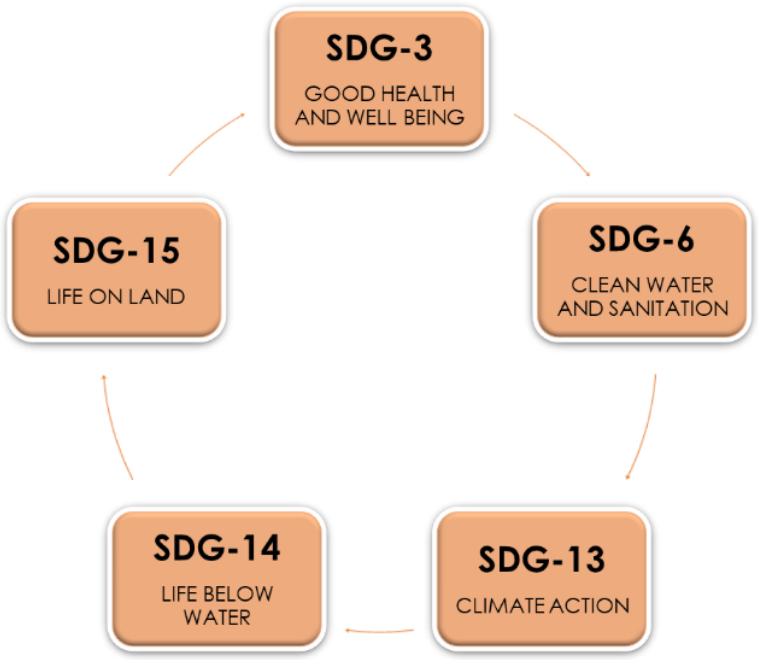


Figure 2.6: Linkages with SDGs

Source - The 2030 Agenda for Sustainable Development

CHAPTER 3 STUDY AREA PROFILE

This chapter reflects the features of the Jabalpur district, including its specific demographic profile, the history of ponds, and the reasons for the ponds' decline.

3.1 Introduction

The capital of the Kalchuri and Gond regimes was Jabalpur. The Narmada River is important, as is the abundance of natural and manmade water sources in the area. Former rulers of the region are said to have constructed many water bodies to store rainwater and to meet the region's recreational, domestic, and agricultural needs. There were reportedly 52 large "Tals" water bodies and 84 small "Tallaiyas" water bodies in Jabalpur in history, but there are only 36 ponds in the city presently.

Many of Jabalpur's water sources have been lost due to changes in land-use patterns, invasion, urbanization, and anthropocentric activities. Controlling water supplies is a critical issue that is causing global concern.

Among 100 cities of Indian smart cities, Jabalpur is one of them. It is Madhya Pradesh's third-largest urban agglomeration and India's 38th-largest urban agglomeration. The Narmada River flows through this area, which is lined by temples and ghats for tourists to enjoy. The city of Jabalpur has a population of 2,88,065 people (2011 census). Summers are hot, and winters are cold, with temperatures ranging from 9.8 degrees Celsius to 41.7 degrees Celsius on average. Jabalpur a cultural city of Madhya Pradesh is also regarded as Sanskaardhani. West Central Railway, Madhya Pradesh Electricity Board, Tropical Forest Research Institute (TFRI), and the Army all have headquarters in Jabalpur.

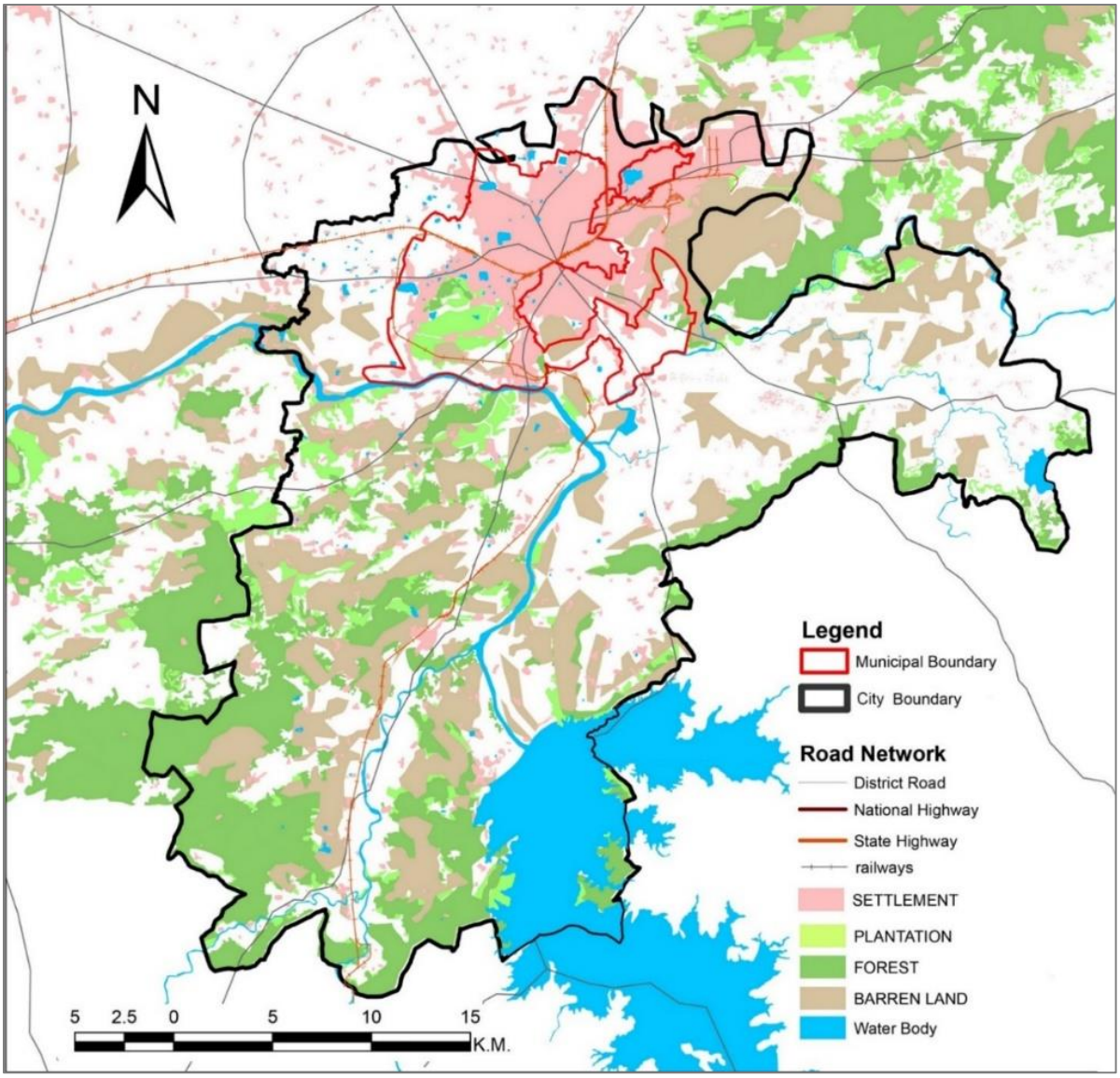


Figure 3.1: Base Map of Jabalpur Tehsil

Source: Author, DCHB

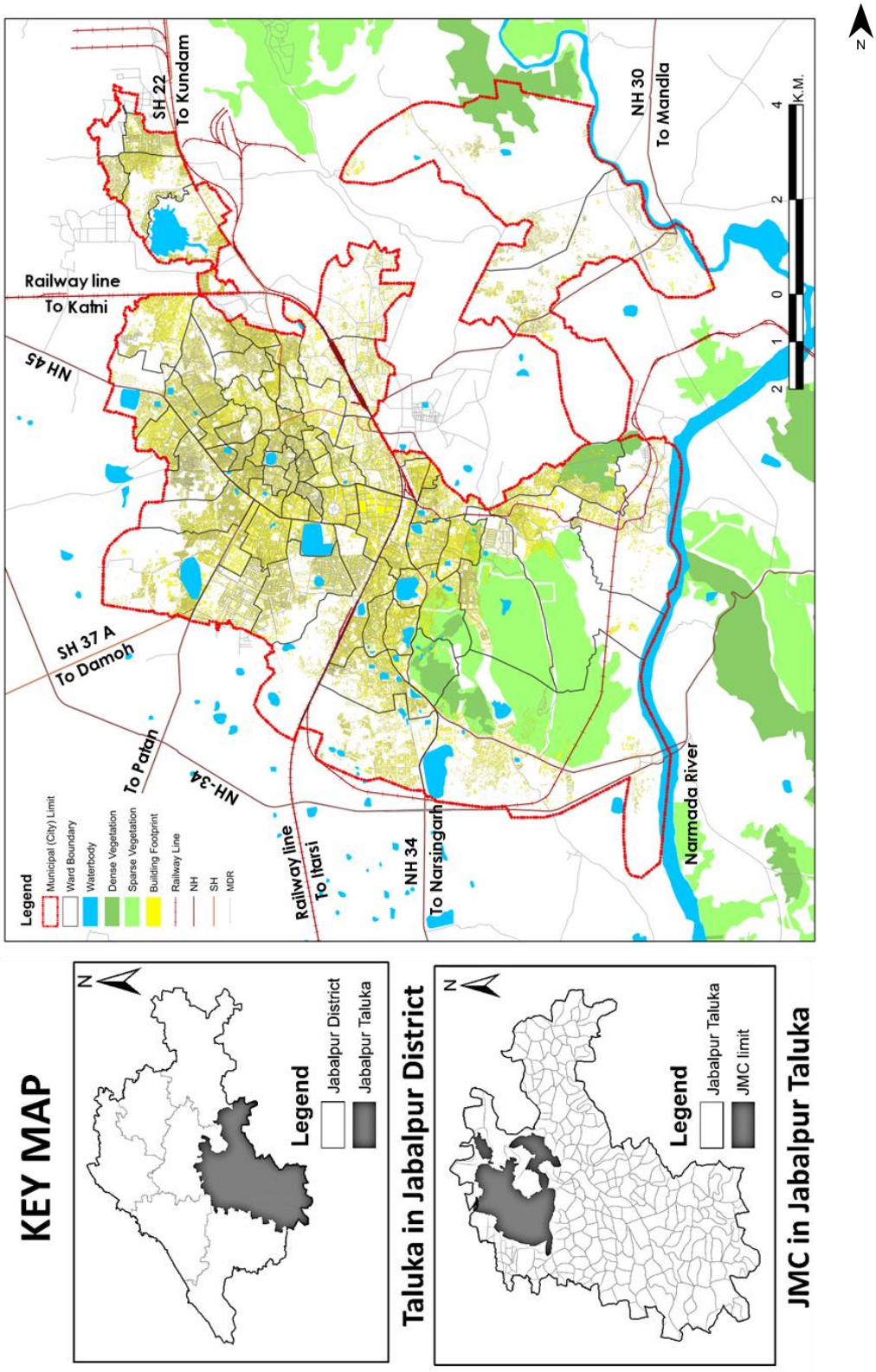


Figure 3.2:Base Map of Jabalpur Municipal Corporation

Source: Author, Masterplan Jabalpur 2021

This includes the planning, development, distribution, and control of water as a resource, as well as meeting the needs of its users as a key to long-term growth. Despite numerous actions taken by international and national leaders, water remains a global problem. Government agencies are not always capable of completing their missions. Water and water supply must be carefully monitored, and the government will benefit from a general understanding of water management.

Jabalpur is a town in Madhya Pradesh's eastern region, about 300 kilometers from the state capital, Bhopal. The coordinates are 23° 10′ 32″ N, 79° 53′ 44″ E, and the MSL is 402 M. Jabalpur is a tier 2 city in Jabalpur district. The city is 411 meters above sea level on average (1,348 feet). The municipal boundaries of Jabalpur comprised an area of 152.53 square kilometers. Just north of the Narmada River, Jabalpur is a mountainous basin surrounded by low hills with ponds and temples.

The city is traversed from north to south by National Highway No. 45, which connects Varanasi and Nagpur. The city is connected to Bhopal and the western part of the state and country through National Highway No. 34, which leads to Jaipur. State highways SH-22 and SH-37 also link the city to other regional nodes such as Damoh, Dindori, Amarkantak, and Mandla.

3.1.1 Criteria for Selection of Study Area

The ponds were the city's landmarks in many places, and they were only recognized for them. One such example is the city of Jabalpur. It was once known as the "City of Taals," but now there are only 36 taals and tallaiyas (ponds and lakes), the majority of which are in poor condition. The ponds have had a high cultural value in Jabalpur since ancient times; they serve as a lively meeting place all over the place, and the presence of temples around them, as well as the connection of these ponds with mythological tales, offer them a variety of cultural values. However, due to pollution, degradation, or a lack of value or need for these ponds, this contact or link with the ponds of the local people has been seen to be waning in recent years.

Also in Madhya Pradesh, Jabalpur is the city which on development after Indore and Bhopal. Jabalpur is a city equipped with colorful culture and rich heritage. Jabalpur a cultural city of Madhya Pradesh is also regarded as Sanskaardhani. The area is

bestowed with bountiful water resources both natural and manmade, important being the river Narmada. Jabalpur has the highest no of ponds in the state.

In Jabalpur, there is as many as 132 Taal (ponds), out of which only 36 are remaining in the current scenario. Many of the water bodies of the Jabalpur city have been completely vanished due to changes in land-use patterns, encroachment, urbanization, and anthropocentric activities.

Figure 3.3: Images showing anthropogenic activities around water bodies

3.1.2 History of waterbodies

Rani Durgavati, who ruled the Garha-Jabalpur area for 16 years between 1548 and 1564, built the majority of the water bodies in Jabalpur city.

These ponds were constructed to meet the needs of a dispersed community, preserve rainwater, and meet recreational, domestic, and agricultural needs. It is said that at that time more than 130 water bodies existed in Jabalpur in the past but at present, only 36 lakes are in existence within the town.

The majority of water sources have been polluted by garbage and municipal solid waste (MSW) such as Bhaantallaiyal, Shreenath ki talaiya, Madfaiya taal, Haathi taal, Beni Singh ki Talaiya, Bhanwartaal, Madhataal , Phuta Taal, Tilak bhumi ki Talaiya, etc and then these transformed areas have been intruded upon by people or built by builders and colonizers.

Figure 3.4: Images showing the current situation of the vanished taal area.

3.1.3 Spatial-temporal analysis

We have done spatial-temporal analysis to get to know the situation about the water bodies.

3.1.3.1 Land Cover

The Land Use Land Cover [LULC] was prepared to analyze the spatial-temporal change undergone for the land cover in the Jabalpur Municipal Corporation. The land cover was prepared for the years 2000 and 2020. The land cover is classified into five categories, namely:

1.Barren land, 2. Built-up, 3. Dense vegetation, 4. Sparse vegetation
Barren land consists of soil that is so poor that plants cannot grow in it and built up refers to the land on which construction has been undertaken. As the name suggests, Dense vegetation consists of forest and dense plantation whereas sparse vegetation consists of scrubs, etc.

Table 3.1: Land Cover break-up: Year 2000

Land Cover: Jabalpur Municipal Corporation		
Category	Year: 2000	
	Area [sq.km.]	Percentage
Water body	2.94	2.6
Built-up	36.57	32.1
Barren Land	28.70	25.2
Dense Vegetation	17.26	15.1
Sparse Vegetation	28.55	25.0
Total	114.02	100

Source: Author, Landsat Imagery [USGS], 2020

Table 3.2: Land Cover break-up: Year 2020

Land Cover: Jabalpur Municipal Corporation		
Category	Year:2020	
	Area [sq.km.]	Percentage
Water body	2.28	2
Built up	38.77	34
Barren Land	41.05	36
Dense Vegetation	19.38	17
Sparse Vegetation	12.54	11
Total	114.02	100

Source: Author, Landsat Imagery [USGS], 2020

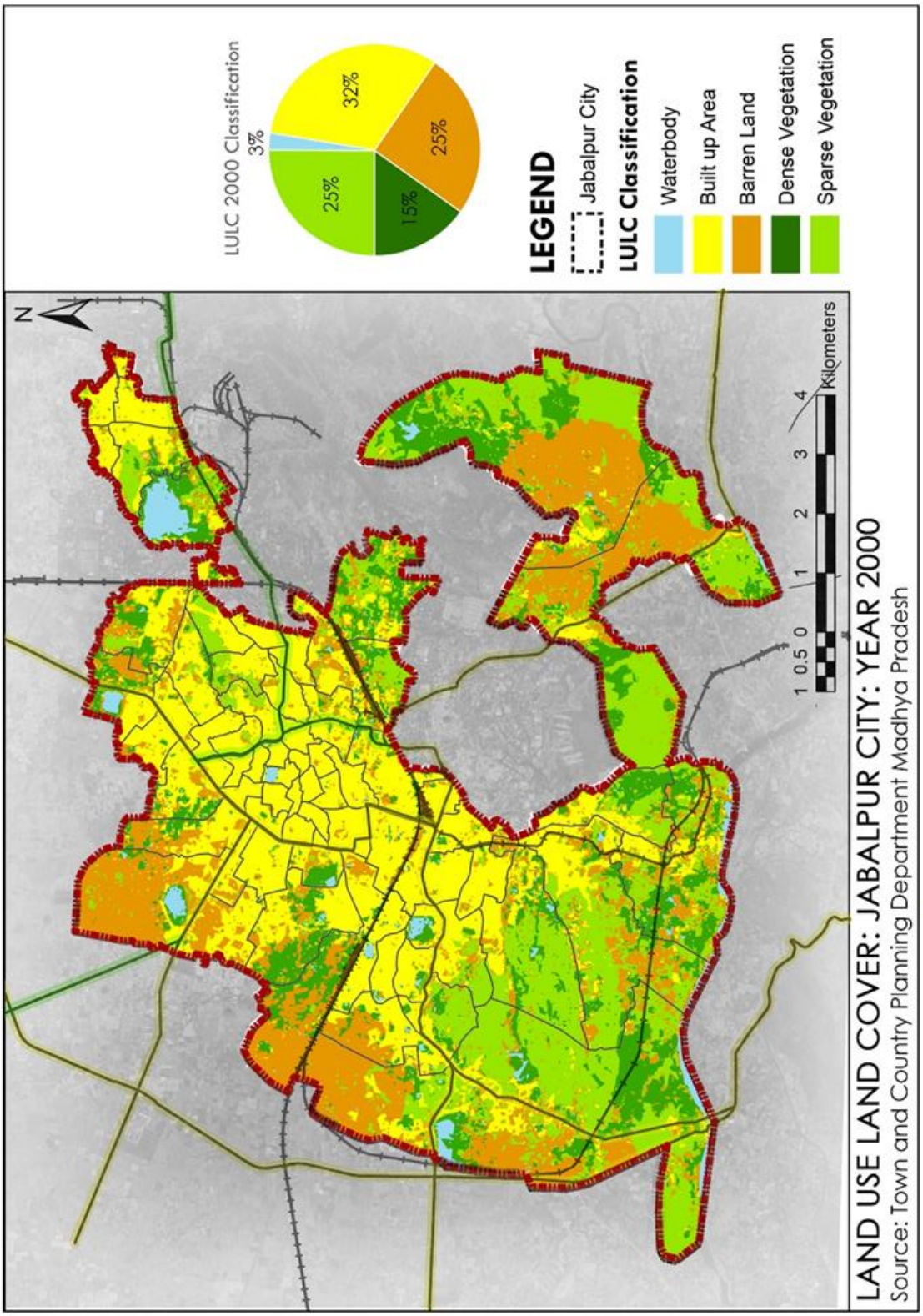


Figure 3.5: Land Use and Land Cover of Jabalpur City: Year 2000

Source: Author, Landsat Imagery [USGS], 2020

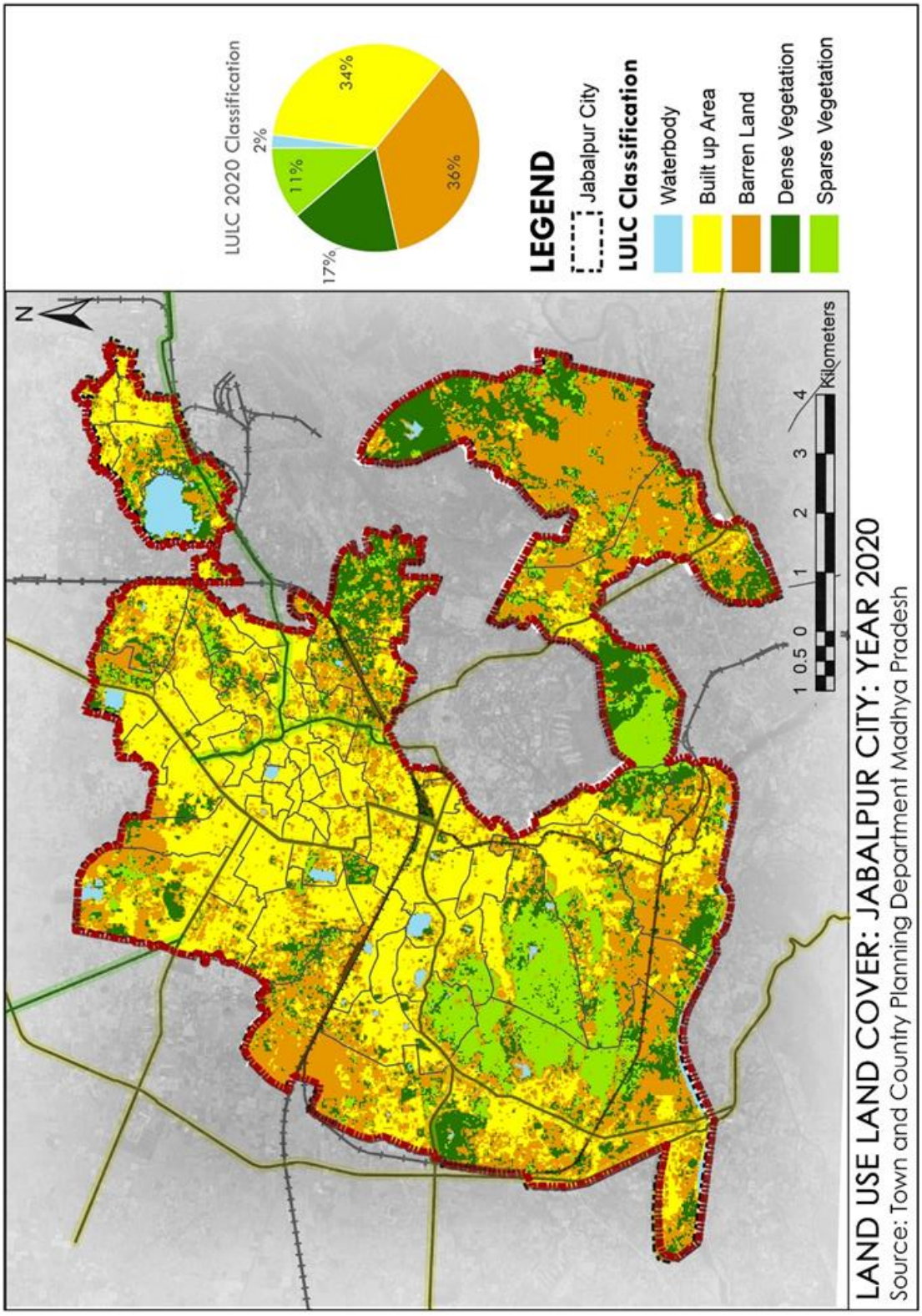


Figure 3.6: Land Use and Land Cover of Jabalpur City: Year 2020

Source: Author, Landsat Imagery [USGS], 2020

Inferences:

In the year 2020, the share of barren land was 36% (max) followed by the built-up area i.e., 34% to the total geographical area. Due to rapid urban sprawl towards the north and south, the area of sparse vegetation was shrunk. Eutrophication led to the death of a few water bodies, which was in turn linked to the increase in barren land (11%) and reduction in the sparse vegetation from 2000 to 2020. Hilly areas of the city have retained the dense vegetation (17%) due to less anthropic intervention.

Table 3.3: Land cover change detection

Land Cover	Year 2000		Year 2020		% Change
	Area (km^2)	%	Area (km^2)	%	
Water body	2.94	2.6	2.28	2	-0.6
Built up	36.57	32.1	38.77	34	1.9
Barren Land	28.70	25.2	41.05	36	10.8
Dense Vegetation	17.26	15.1	19.38	17	1.9
Sparse Vegetation	28.55	25.0	12.54	11	-14
Total	114.02	100	114.02	100	-

Source: Author, 2020 with reference to QGIS

3.1.3.2 NDWI

The map below shows the NDWI analysis that was conducted for Jabalpur city. It can be seen from the maps that there is a clear shrinkage in the surface water bodies, as well as the health of the water bodies, has deteriorated which can be attributed to the increased encroachment of the area. It is also observed that the small water bodies have almost vanished from the city within two decades.

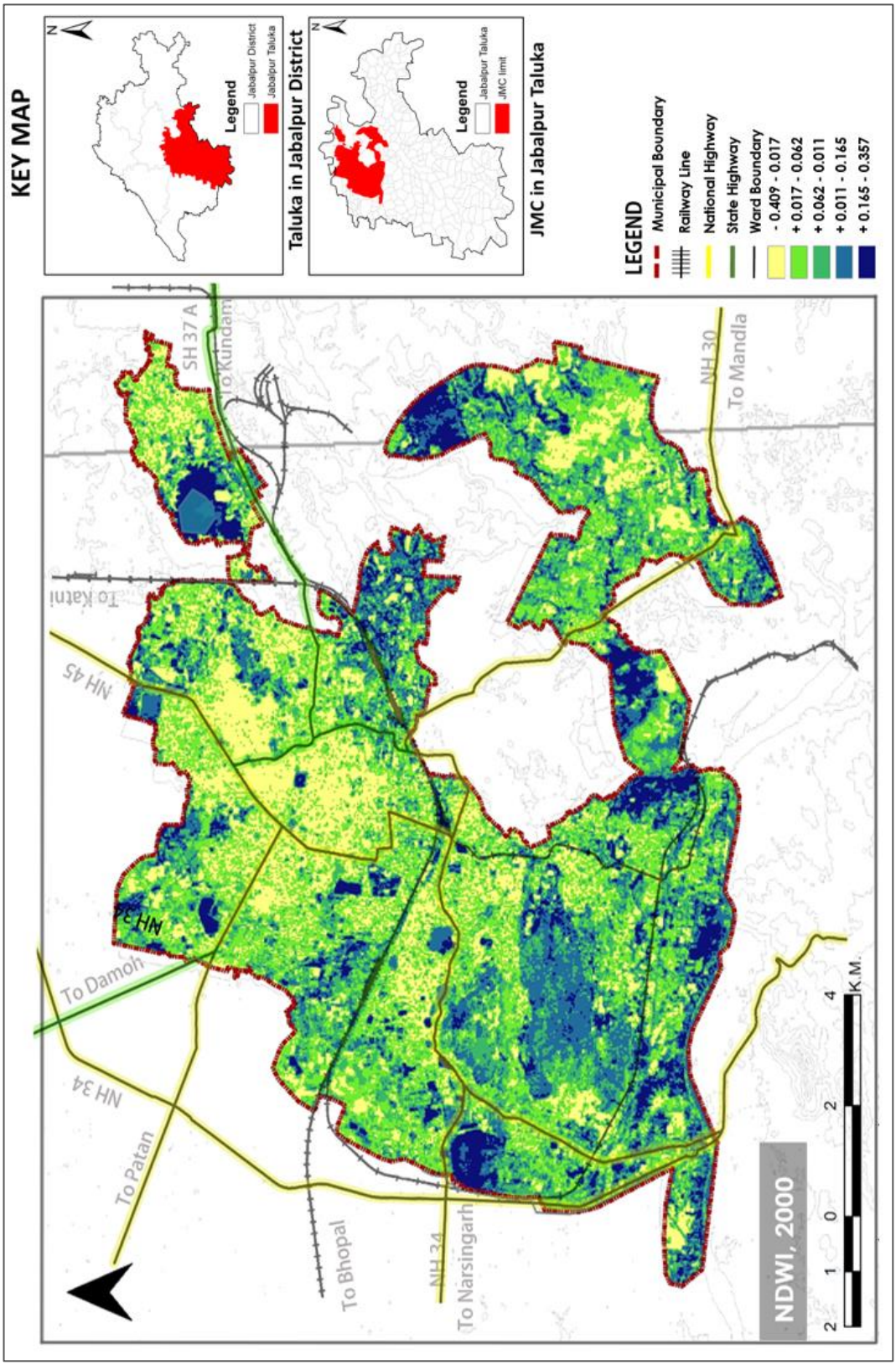


Figure 3.7: Normalized Difference Water Index of Jabalpur City, 2000

Source: Author, 2020

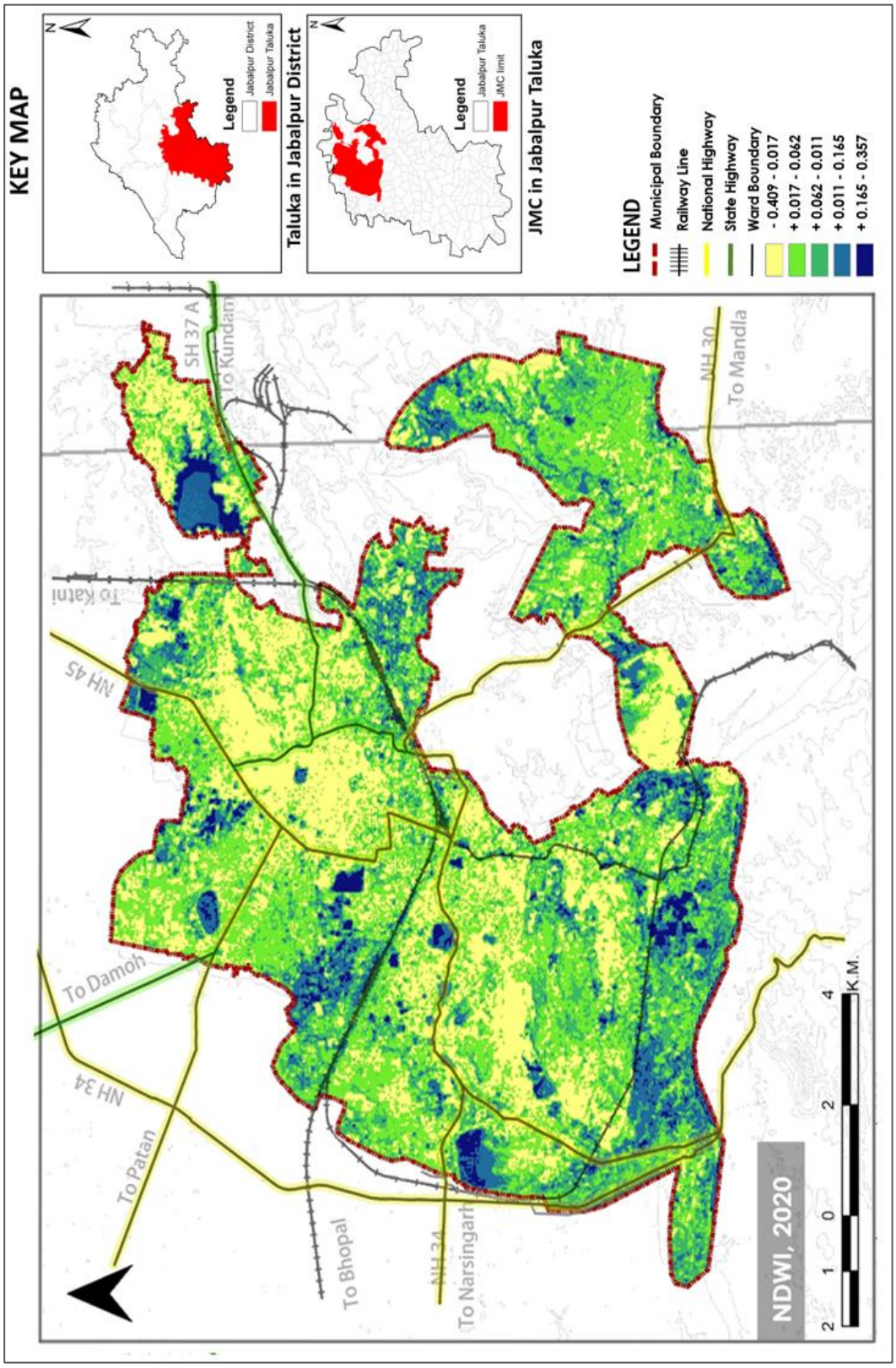


Figure 3.8: Normalized Difference Water Index of Jabalpur City, 2020

Source: Author, 2020

CHAPTER 4 DATA COLLECTION AND ANALYSIS

This chapter concludes the research by emphasizing the detailed implementation of data analysis techniques using collected data.

So, the requisite data required for the thesis was collected through primary & secondary sources. Data was collected from the Municipal corporation of Jabalpur (JMC), Jabalpur smart city (JSC) Madhya Pradesh pollution control board (MPPCB), etc.

1. Phase 1- As stated in objective 1, the existing situation of Jabalpur ponds was analyzed through secondary data & primary surveys for better understanding.3 types of surveys were done to get the idea about the existing conditions.
2. Phase 2- Then to achieve objective 2 and objective 3, the reasons for degradation, its impact on the ponds, and quantification of Cultural ecosystem services were analyzed through a household survey

4.1 Data Collection Tools & Techniques

4.1.1 Phase 1

Phase 1 will result in finding the final ponds which will have all the criteria required for the detailed analysis. Waterbodies with an area below 8 hectares and provide the maximum of cultural ecosystem services.

4.1.1.1 Selection of waterbodies

As of now, Jabalpur city has 36 water bodies in total. We have collected the general information about all the water bodies such as location, area authority which manage them. Table 4.1 is the table with the details and the map showing the location of all the 36 water bodies.

Table 4.1: List of all 36 waterbodies present in Jabalpur city

DETAILS OF THE WATERBODIES			
S.no.	Name	Managed by	Area (hectare)
1	Bijori Taal	Private	1.19
2	Phool Taal	Private	0.67
3	Kakrahi Talaiya	Private	2.85
4	Mahanadda	Private	5.86
5	Sagra Taal	Private	1.54
6	Gopal Bagh Taal	Private	2.79
7	Cheri Taal	Private	1.61
8	Bhita Taal	Private	4.03
9	Kanchanpur Taal	Private	2.14
10	Jindahai ki Taliya	Private	0.15
11	Madkai Taal	Nagar Nigam Jbp	0.91
12	Suraj Taal	Nagar Nigam Jbp	5.5
13	Baksera Taal	Nagar Nigam Jbp	2.93
14	Hanuman Taal	Nagar Nigam Jbp	6.33
15	Imarti Taal	Nagar Nigam Jbp	179
16	Shahi Taal	Nagar Nigam Jbp	1.55
17	Garha Taal	JDA	2.89
18	Dev Taal	JDA	1.53
19	Kola Taal	JDA/ Osho Ashram	1.08
20	Gaurav Taal	JDA	2.21
21	Maharaj sagar	JDA	1.23
22	Thakur Taal	MP Forest	4.37
23	Pandu Taal	MPEB	0.4
24	Jalpari	MPEB	0.35
25	Awasthi Taal	Medical College	0.86

26	Gullu ki Tallaiya	Medical College	0.64
27	Adhar Taal	Agriculture Dept.	16.18
28	Madho Taal	JDA	16.99
29	Gokalpur Taal	Government	122.49
30	Ramnagar Taal	Government	8.31
31	Sangram Sagar	Government	15.85
32	Khandari	Nagar Nigam Jbp	157.80
33	Rani Taal	Nagar Nigam Jbp	10.25
34	Supa Taal	Nagar Nigam Jbp	9.58
35	Ganga Sagar	Nagar Nigam Jbp	18.63
36	Bal Sagar	Medical College	23.05

Source: Author, Jabalpur k sarovar, Prof. Sanjay Verma

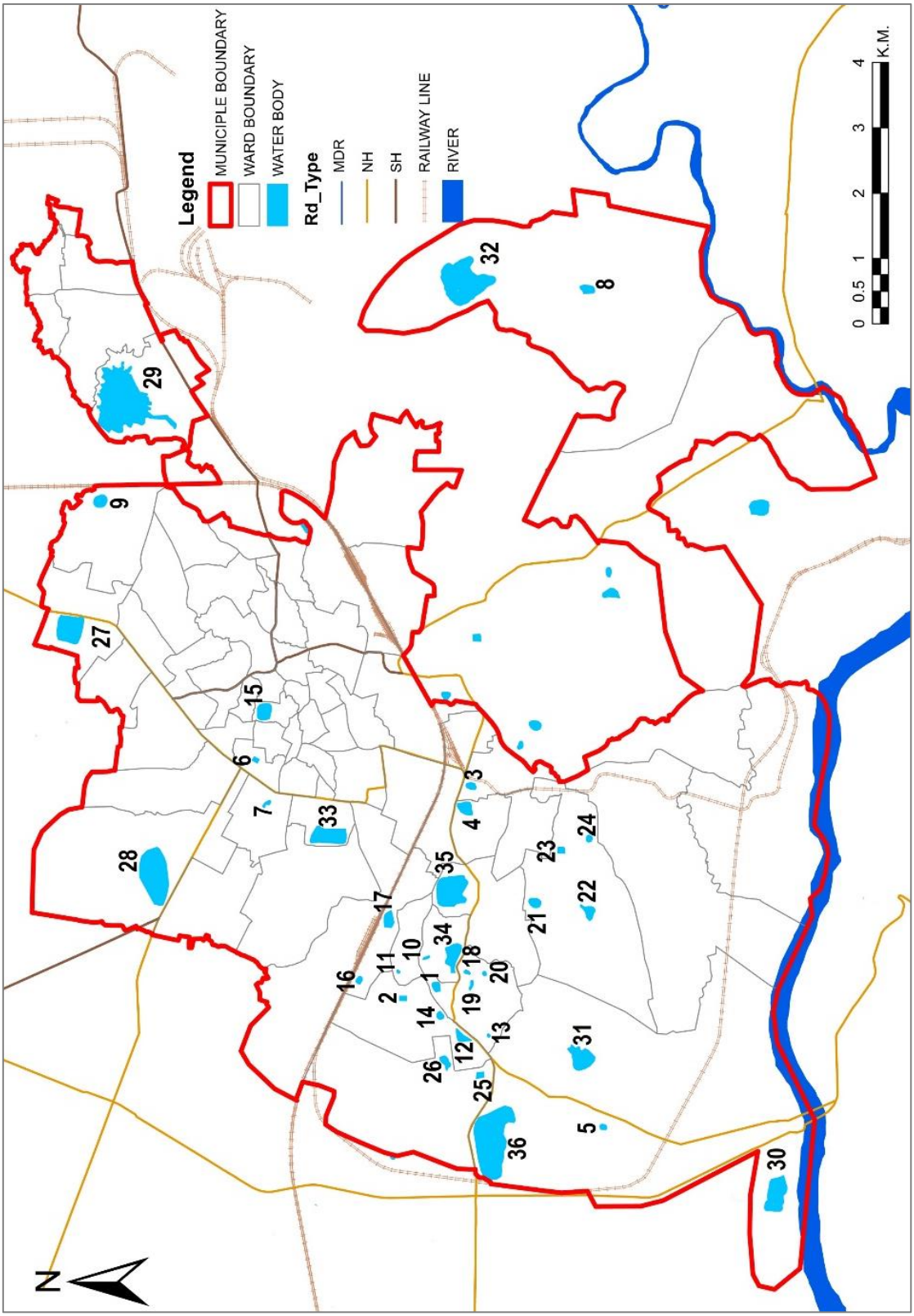


Figure 4.1: Map showing location of all 36 waterbodies in Jabalpur city

Source: Author, Jabalpur k sarovar, Prof. Sanjay Verma

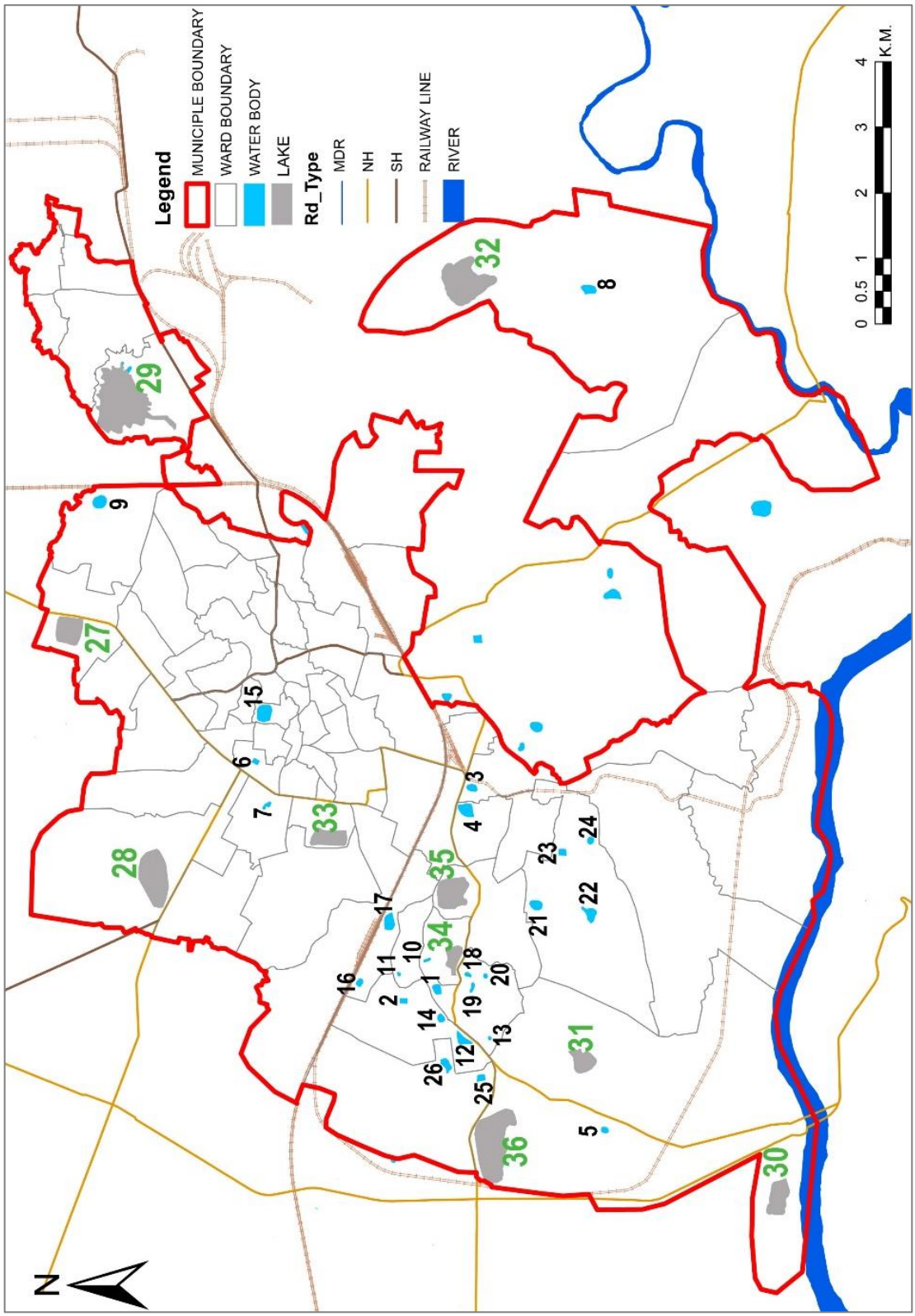


Figure 4.2: Map showing location of 26 ponds and 10 lakes of Jabalpur city

Source: Author, Jabalpur k sarovar, Prof. Sanjay Verma

The table above shows all the 36 water bodies. As per the Ramsar wetland convention, we have an area of 8 hectares as the above limit to be known as a pond. Thus, among all, we have 26 water bodies to be called ponds. Also, the image is showing the location of these 26 ponds with blue and 10 lakes with grey.

4.1.1.2 Selection of ponds providing cultural ecosystem services

To finalize the ponds that provide cultural ecosystem service we had surveyed all 26 ponds. The photographic survey, Questionnaire survey, Stakeholder survey was done for the same. The stakeholders for this survey were - Water management authority (JMC), local people (30 from each taal). With this, we have come up with a table where we have classified them in the services they provide.

Table 4.2: List of all 26 ponds with the ecosystem service they provide.

S.no.	Name	ES	Majorly used for
1	Bijori Taal	PES	Fishing and Water chest nut Farming
2	Phool Taal	PES	Lotus plantation
3	Hathitaal	RES	Water regulation, Climate regulation
4	Mahanadda	PES	Fishing and Water chestnut Farming
5	Sagra Taal	PES	Fishing and Water chestnut Farming
6	Gopal Bagh Taal	PES	Cooking, bathing, washing clothes
7	Cheri Taal	RES	Water regulation, Climate regulation
8	Bhita Taal	RES	Water conservation, Climate regulation
9	Kanchanpur Taal	PES	Water conservation, Climate regulation
10	Jindahai ki Taliya	RES	Water conservation, Climate regulation
11	Madkai Taal	RES	Water conservation, Climate regulation
12	Suraj Taal	PES	Pottery, Water chestnut farming
13	Baksera Taal	RES	Water conservation, Climate regulation
14	Imarti Taal	PES	Cooking, Drinking water (if needed)
15	Hanuman Taal	CES	Religious, Recreational, Identification, Education
16	Shahi Taal	CES	Religious, Recreational, Aesthetic value, Identification

17	Garha Taal	CES	Recreational, Aesthetic value, Identification, Mental inspiration
18	Dev Taal	CES	Religious, Aesthetic value, Recreational, Identification, Education, Mental inspiration
19	Kola Taal	CES	Religious, Aesthetic value, Recreational, Identification, Education, Mental inspiration
20	Maharaj Sagar	CES	Aesthetic value, Recreational, Identification, Education, Mental inspiration
21	Gaurav Taal	CES	Recreational aspect
22	Thakur Taal	CES	Aesthetic value
23	Pandu Taal	CES	Aesthetic value, Mental inspiration
24	Jalpari	CES	Aesthetic value, Recreational, Identification
25	Awasthi Taal	CES	Religious, Recreational
26	Gullu ki Tallaiya	PES	Pottery, Water chestnut farming

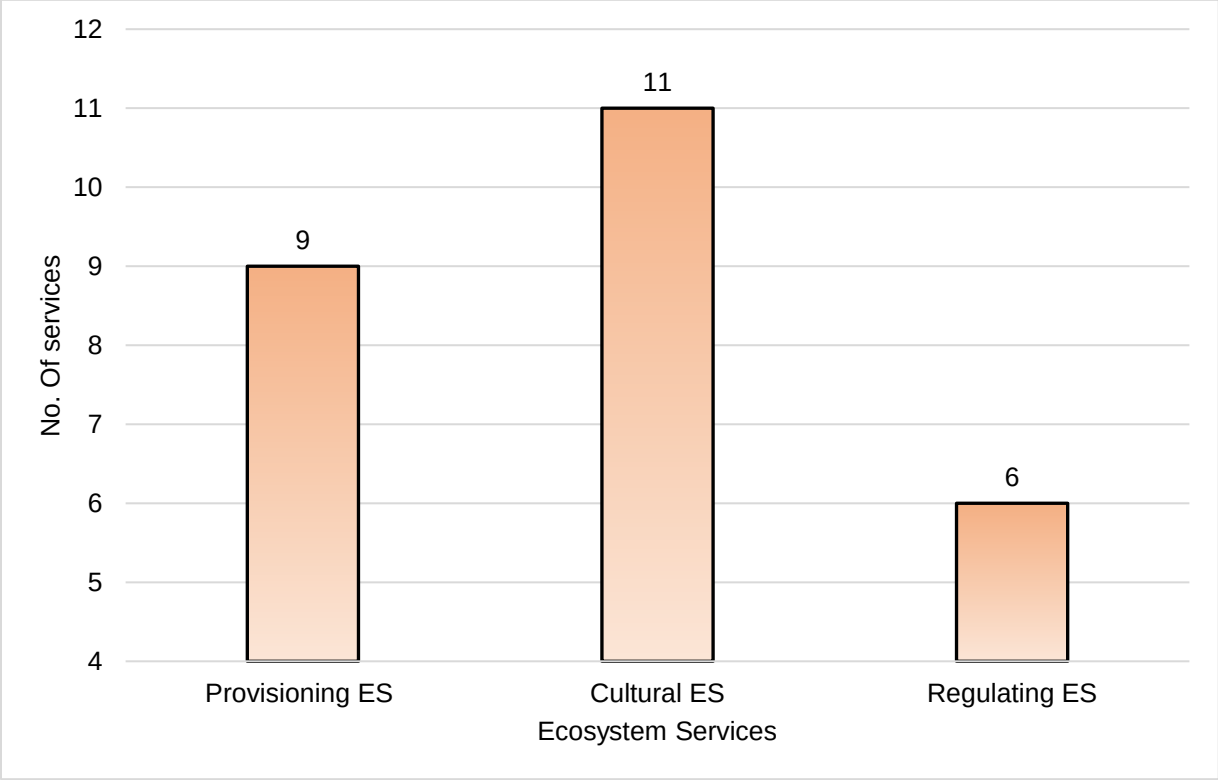


Figure 4.3: No. of ponds providing different ES

Herewith this table, we can infer that 11ponds are providing cultural services which are highest followed by provisioning services and regulating services. Now we will analyze these 11 ponds and see which services under cultural they are providing and which of them are providing the maximum no of services. The pond with more than 3 services would be selected for the detailed analysis.

S.No.	Name of ponds	Area (hectare)	Religious /Spritual values	Aesthetic value	Identification	Recreation / Tourism	Education/ Training value	Mental, spiritual and artistic inspiration	No. of service pond provide
15	Hanuman Taal	6.33							5
16	Shahi Taal	1.55							2
17	Garha Taal	2.89							4
18	Dev Taal	1.53							6
19	Kola Taal	1.08							6
20	Maharaj sagar	1.23							5
21	Gaurav Taal	2.21							1
22	Thakur Taal	4.37							2
23	Pandu Taal	0.4							2
24	Jalpari	0.35							3
25	Awasthi Taal	0.86							3

Figure 4.4: Matrix table showing the No. of cultural services provided by the 11 ponds

So, with this matrix table we have finalized the 5 ponds for the detailed analysis.

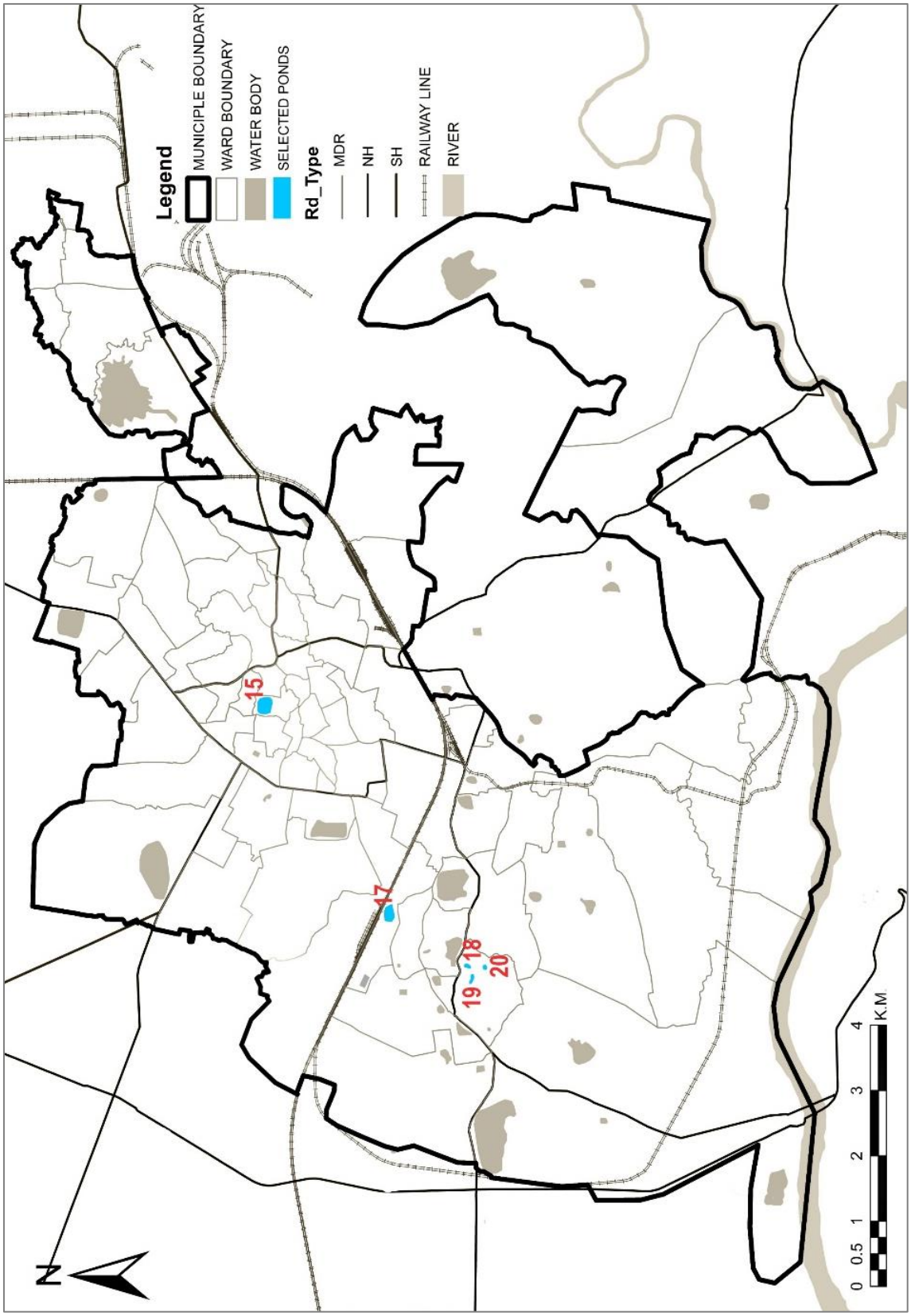
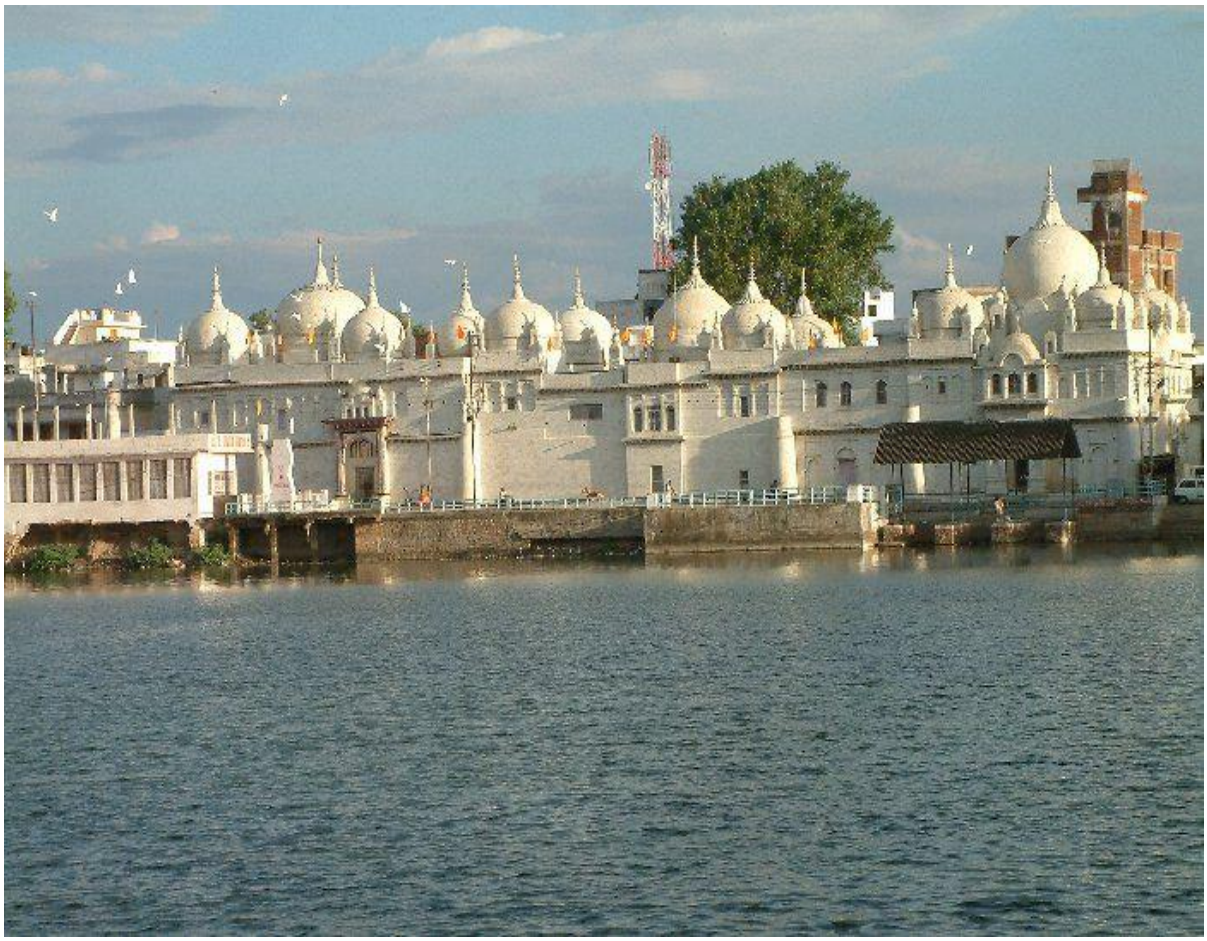


Figure 4.5: Map showing the 5 selected ponds

4.1.1.3 Site selected

With the above analysis, the 5 ponds that have selected for the final study are as follows –

1. Hanuman taal - Hanuman taal is situated at ward 20- Hanuman taal ward, highest dense ward. The area of this taal is 6.33 hectares. This was constructed in the year 1794. It is surrounded by various temples. A floating shower is enhancing the beauty of this pond.



2. Garha taal - Garha taal is situated at ward 55- Garha ward. The area of this taal is 2.89 hectares. This was recently been developed by JMC by fixing the boundary around the taal. This is now maintained by Nagar Nigam Jabalpur.

3. Dev taal - Dev taal is situated in Rani Durgavati ward no. 58. Area of Devtaal is 1.53 hectare. It is maintained by the JMC. It has 16 temples around the taal. In ancient days this taal is known as Vishnu taal.

4. Kola taal - Kola taal is situated in Rani Durgavati ward no. 58, near the campus of Osho Ashram with an area of about 1.08 hectares. It is maintained by the ashram and also by JMC. It gives beauty and a soothing environment to the ashram especially for meditation.

5. Maharaj Sagar taal - Maharaj Sagar taal is situated inside the campus of Shailparn Udhyan (Garden). With an area of about 1.23 hectares. It is maintained by the JMC. The natural beauty of this pond makes the area so much beautiful. Also, it is the calmest area even after situating on a highway and high traffic area.

With this, we have ended up with our first objective and had complete our phase 1 survey and come up with our 3 sites for the detailed analysis in which we try to get the reasons for degradation of the water body and itz impact on the cultural sevices.

4.1.1 Phase 2

Phase 2 will result in finding the reasons for the ponds degradation due to cultural services and also to find their impacts on cultural services. It is finding interrelationships between the reasons for the degradation and the cultural ecosystem services.

The 5 selected ponds are divided into 3 sites for the detailed analysis.

Site 1 – Hanuman taal

Site 2 – Garha taal

Site 3 – Dev taal, Kola taal, Maharaj sagar taal

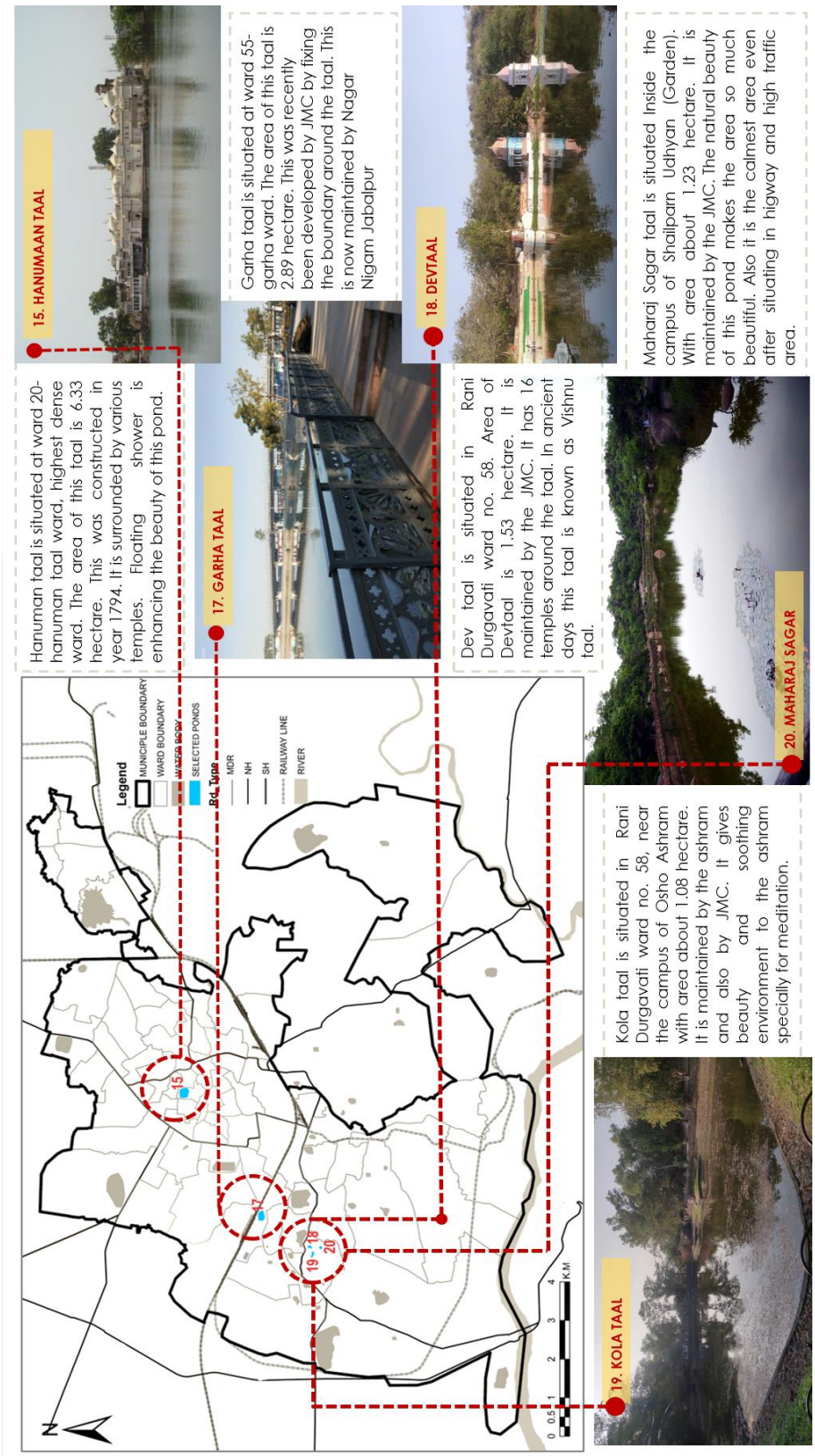


Figure 4.6: Details of selected 5 ponds

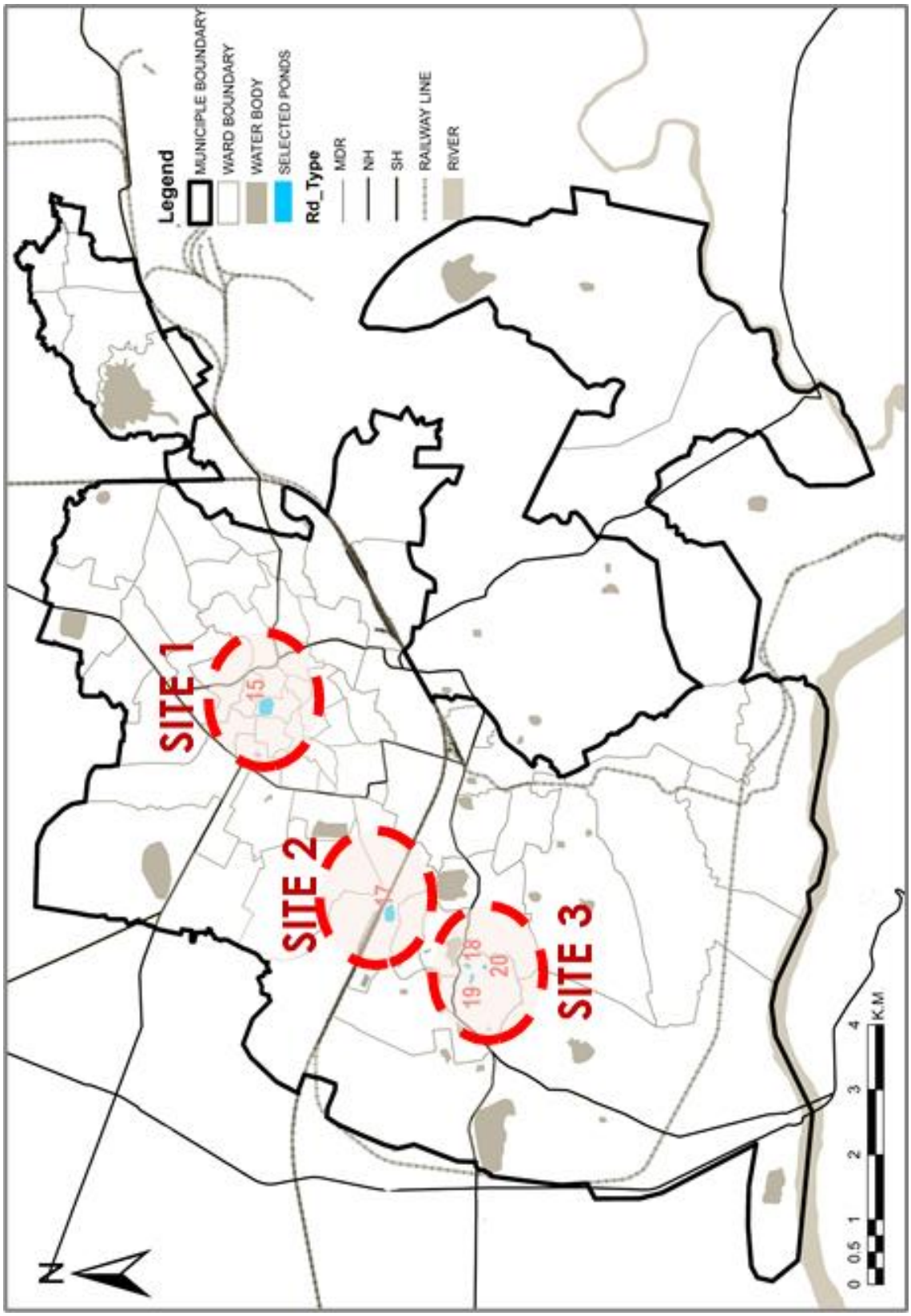


Figure 4.7: Map showing the 3 sites for the survey.

4.1.1.1 Primary survey

Perception survey, Questionnaire survey, and Photographic survey were done. The sites are divided into further 2 proximity areas one is of 0.5km radius and the other is of 0.75 km of radius.

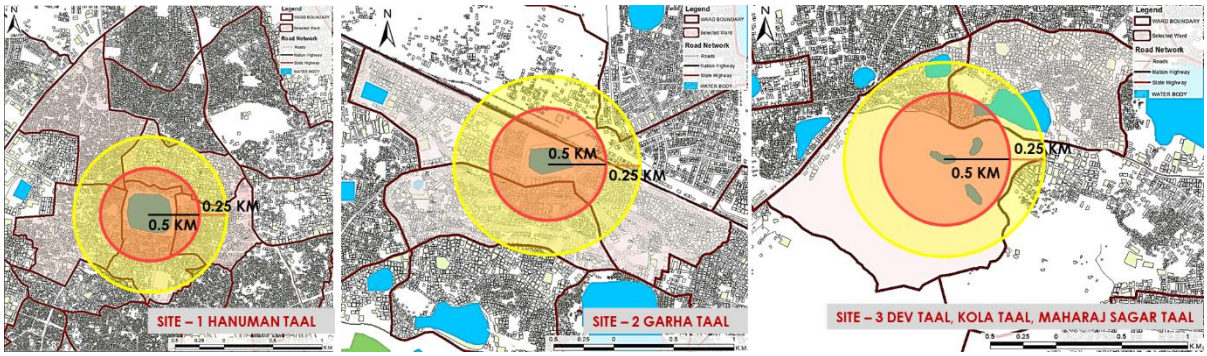


Figure 4.8: Image of wards selected for a survey on 3 sites

4.1.1.2 Sample size

The total population was taken as the combination of the 3 sites. And as per the total population, the sample size has been calculated, and then as per the percentage of the population of site it will be divided among the 3.

Table 4.3: Table showing the area and population of the wards of 3 selected sites

Site	Ward	Name	Area	Population
Site - 1	Ward No - 19	Khermai Ward	17	11920
	Ward No - 20	Hanuman Tal ward	23	8600
	Ward No - 22	Sardar Vallabh Bhai Patel Ward	24	8802
	Ward No - 26	Govind Vallabh Pant Ward	28	12674
	Ward No - 27	Mohm. Abdul Kalam Azaad Ward	18	13567
Site - 2	Ward No - 54	Veer Sawarkar Ward	91	18375
	Ward No - 55	Garha Ward	181	25946
Site - 3	Ward No - 57	Indira Gandhi ward	54	16000
	Ward No - 58	Rani Durgavati Ward	64	17707

Site 1 has 55563 population in 5 wards whereas **Site 2** has 44320 in 2 wards and **Site 3** has 33707 2 wards. In total, the population among the 9 wards is 133590.

The sample size is now calculated with this population by taking 90% of confidence level and confidence interval as 5%

Total population ---------- 133590

Confidence level ---------- 90%

Confidence interval ---------- 5%

Sample size ---------- 285

The sample size from each site is now divided by the percentage and then further divided into 60% and 40% as per proximity area.

Table 4.4: Distribution of sample size ward-wise

Site	Ward No.	Population		Total Population %	Sample Size	60%	40%
Site - 1	19	11920	55563	42%	119	71	47
	20	8600					
	22	8802					
	26	12674					
	27	13567					
Site - 2	54	18375	44320	33%	95	57	38
	55	25945					
Site - 3	57	16000	33707	25%	72	43	29
	58	17707					

4.2 Data analysis

4.2.1 Site 1 analysis

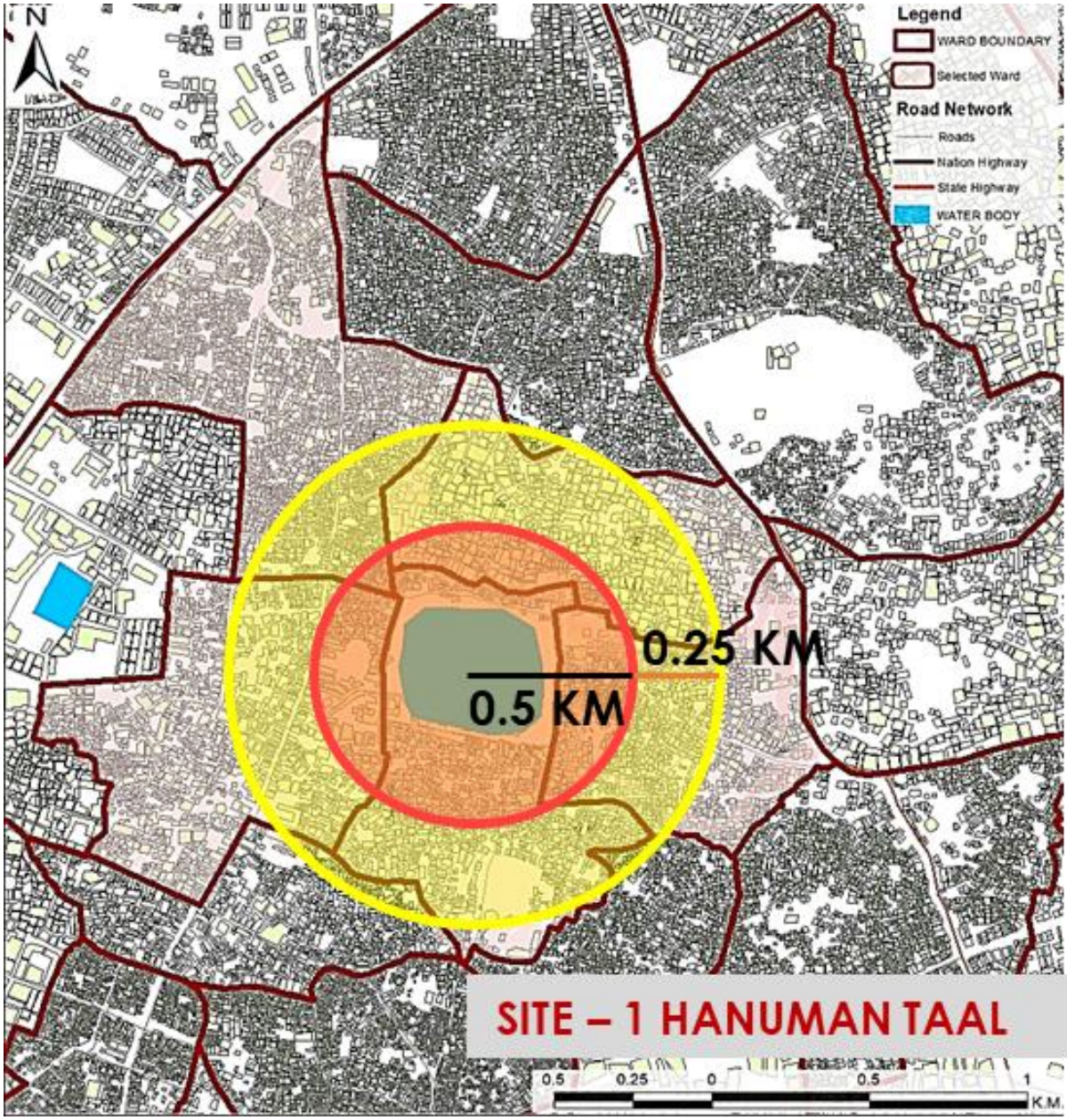


Figure 4.9: Image of selected wards with proximity area for site 1 Hanuman taal

The Hanuman taal has several diffuse point sources that bear discharges from irrigation channels. Solid waste dumping and the disposal of sacred relics are also

issues that this lake faces. This lake has a huge issue with idol immersion during the Durgotsav and Ganeshotsav festivals.

The major reason for degradation come out from the survey are cultural misuse with 40% followed by sewage disposal 30%, garbage disposal 20%, and improper management 10%.

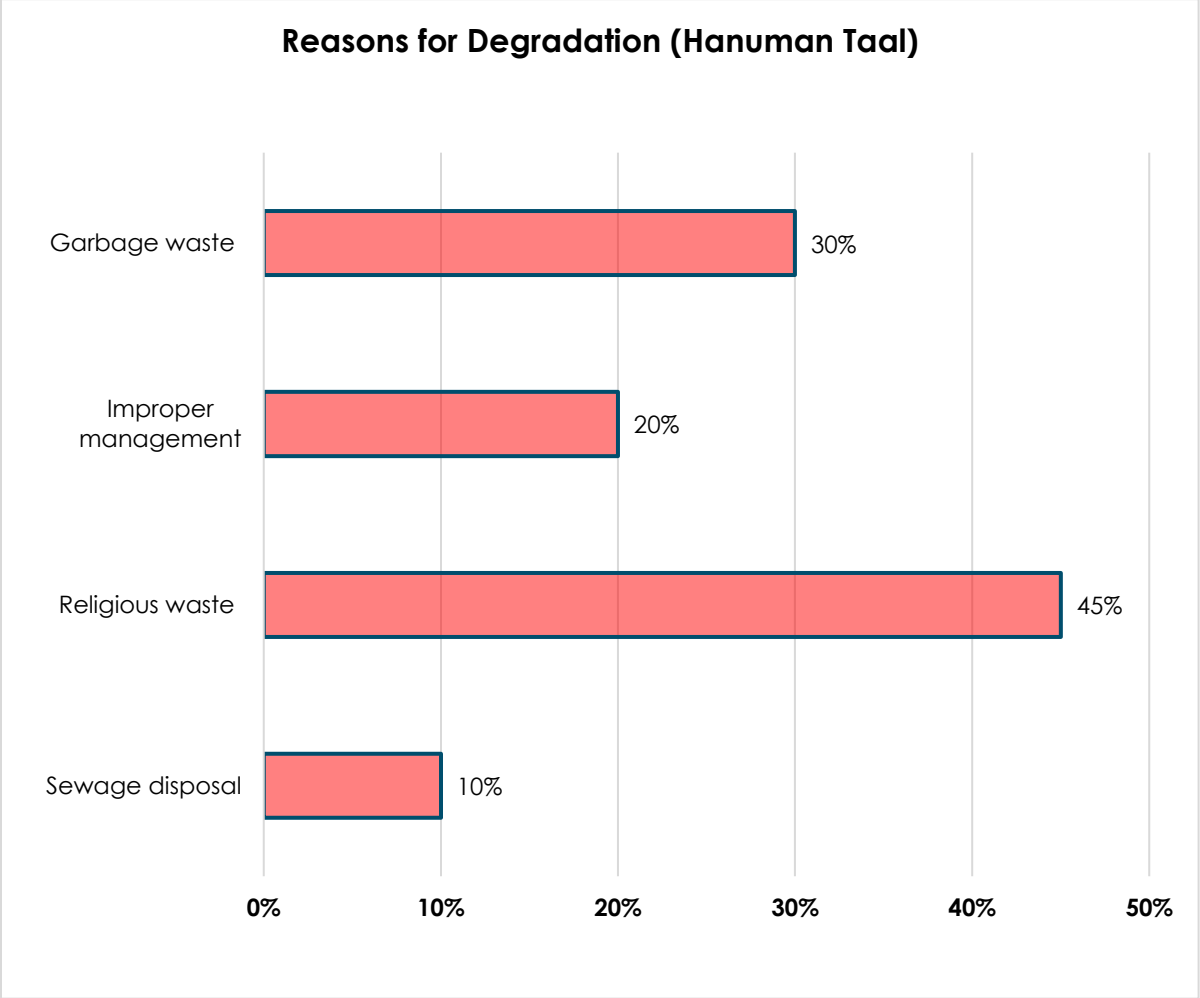


Figure 4.10: Graph showing reasons for degradation (Hanuman taal)

Figure 4.11: Image of degraded condition of Hanuman taal

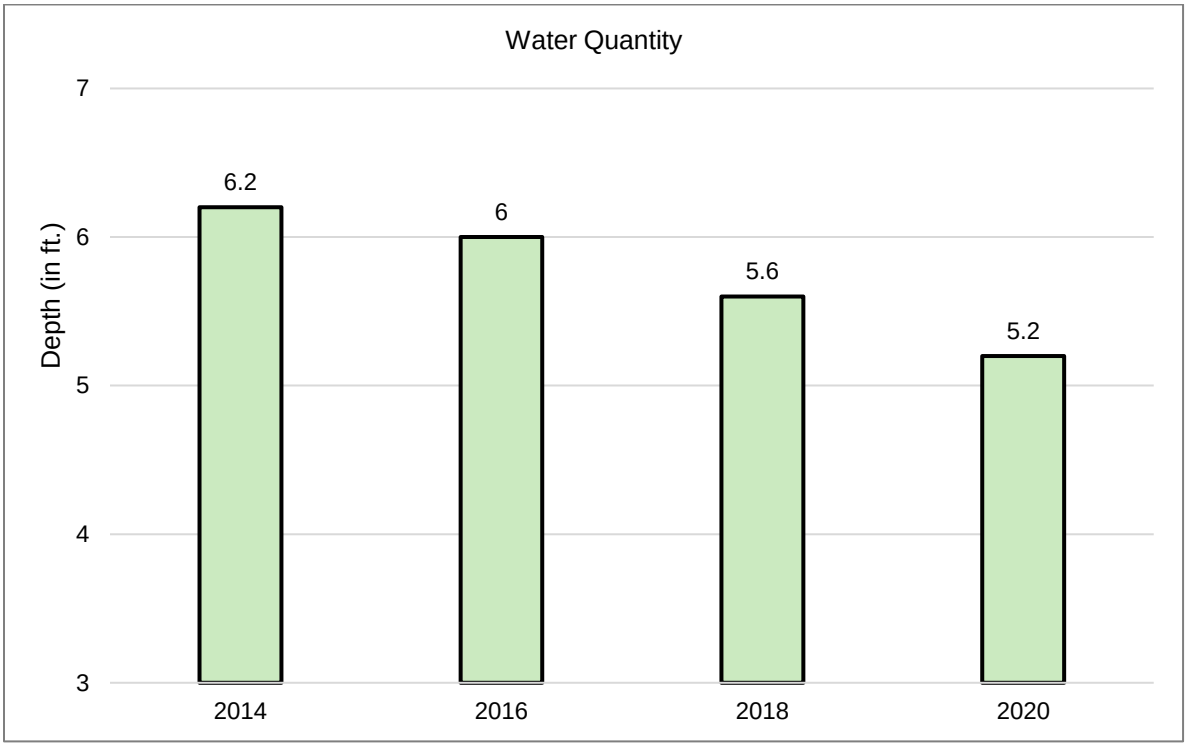


Figure 4.12: Graph showing the decrease in water quantity.

Source: Jabalpur municipal corporation (JMC)

Also, we have found that the quantity of water in depth has been decreased from 6.2 feet to 5.2 feet in 7 years.

Table 4.5: Table showing the water quality of Hanuman taal

Water Quality	Standards	2017	2018	2019
pH	6.5- 8.5	8.4	8.5	8.7
Turbidity NTU	5 to 10	36	42	58
Conductivity mS/cm	< 1	0.623	0.774	0.89
TDS Mg/l	500 max.	126	128	131
Nitrates Mg/l	20	1.16	1.38	1.54

Source: Jabalpur municipal corporation (JMC)

Water quality is not visually good. The sewage water is not only spoiling its color but also it is smelly near the sewer outlet.

Inferences

1. Water quality degradation is one of the most significant effects of sewage and garbage disposal, which not only reduces visitor but also degrades the pond's aesthetic value.
2. Earnings of vendors and shopkeepers are reduced as footfall decreased.
3. Undeveloped surrounding do not fascinate the people to enjoy the space.
4. Water quality degradation is one of the most significant effects of sewage and garbage disposal, which not only reduces visitor but also degrades the pond's aesthetic value.
5. Earnings of vendors and shopkeepers are reduced as footfall decreased.
6. Undeveloped surrounding do not fascinate the people to enjoy the space

Activity mapping

During the survey, the activity mapping has been done in the morning and evening on the weekends and the weekdays.

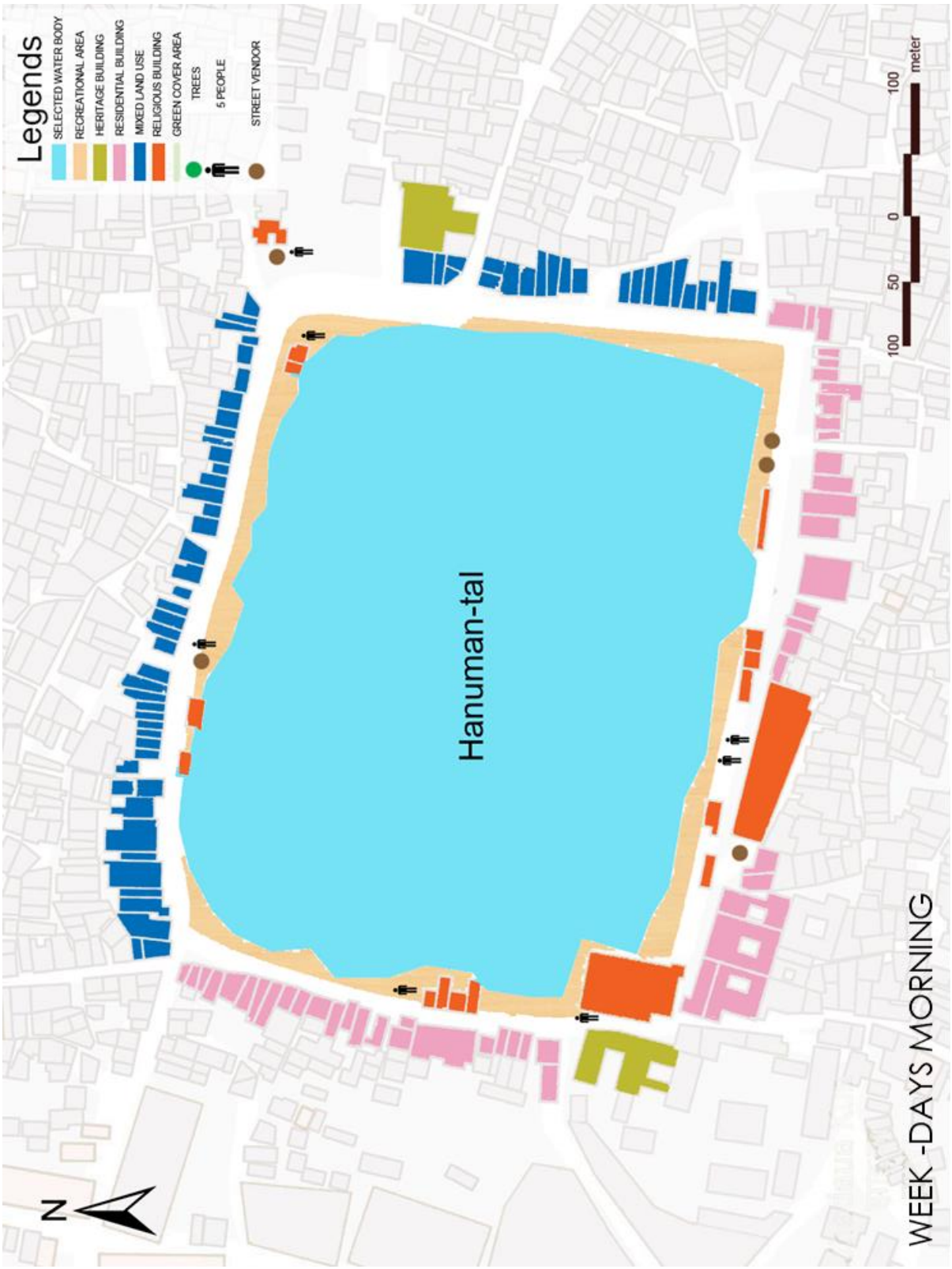


Figure 4.13: Activity mapping is done for Hanuman taal - morning of a weekday

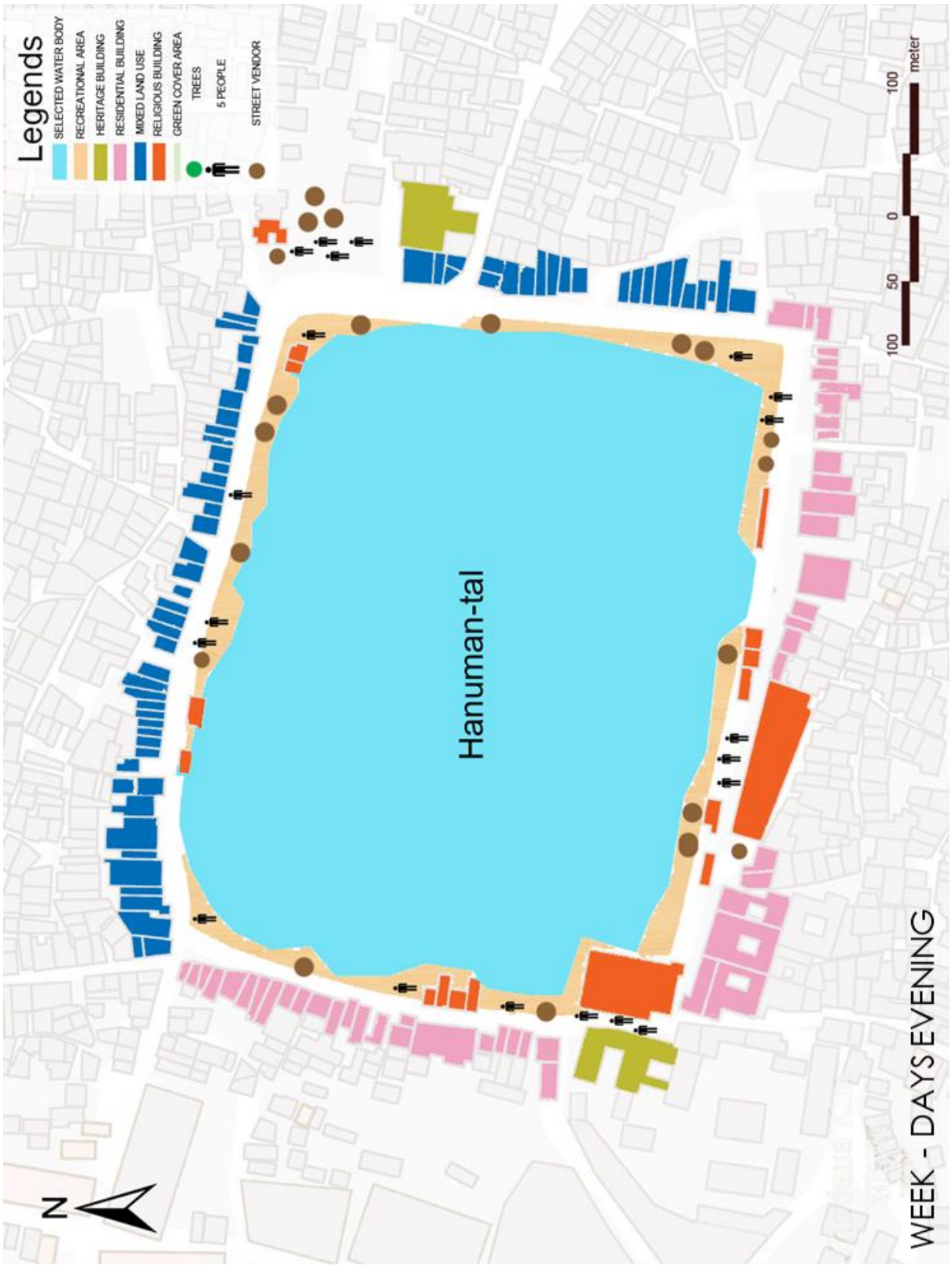


Figure 4.14: Activity mapping is done for Hanuman taal - evening of a weekday

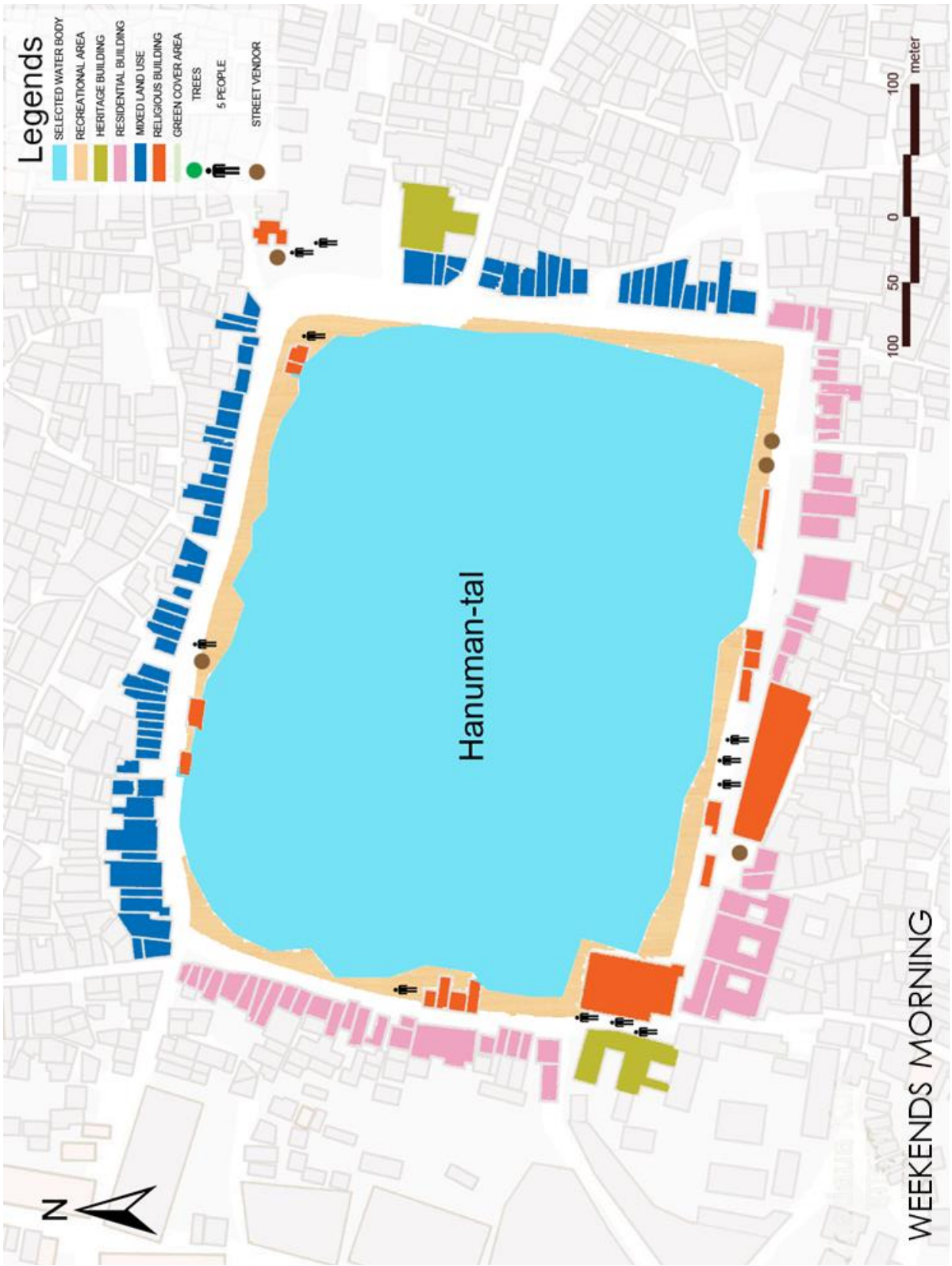


Figure 4.15: Activity mapping is done for Hanuman taal - morning of weekends

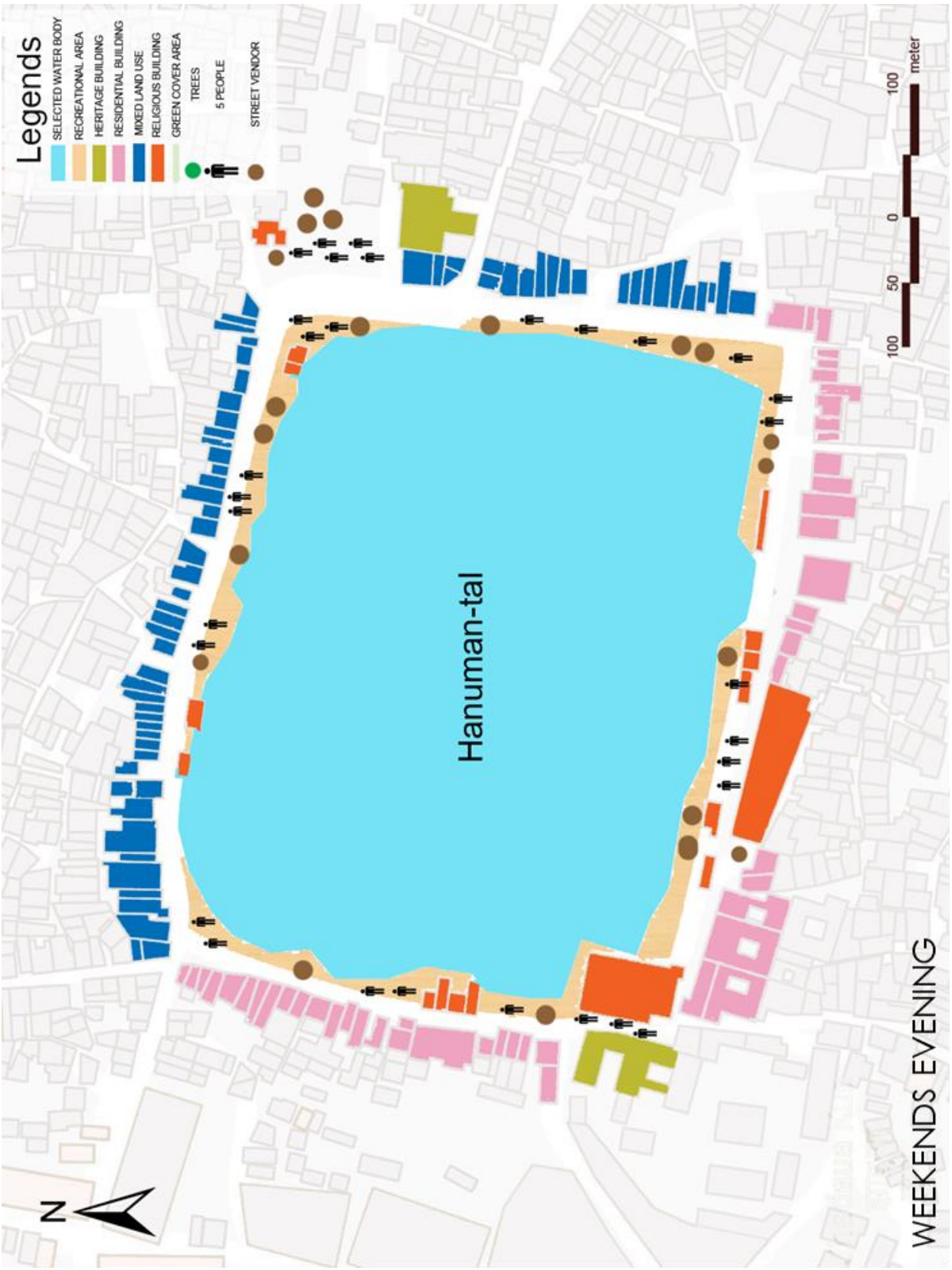


Figure 4.16: Activity mapping is done for Hanuman taal - evening of weekends

Inferences

1. Because of the warmer days and the lack of shaded areas, there are fewer people in the morning.
2. Evenings are crowded because of the vendors and shops. Senior citizens also gather for spending time.
3. Weekends have comparatively more rush with the local people.
4. There is no availability of parking, toilets, seating area near the ponds for the public.
5. Less people from city comes here as the accessibility is not easy.

Figure 4.17: Photos showing the activity happening around Site 1- Hanuman taal

4.2.2 Site 2 analysis

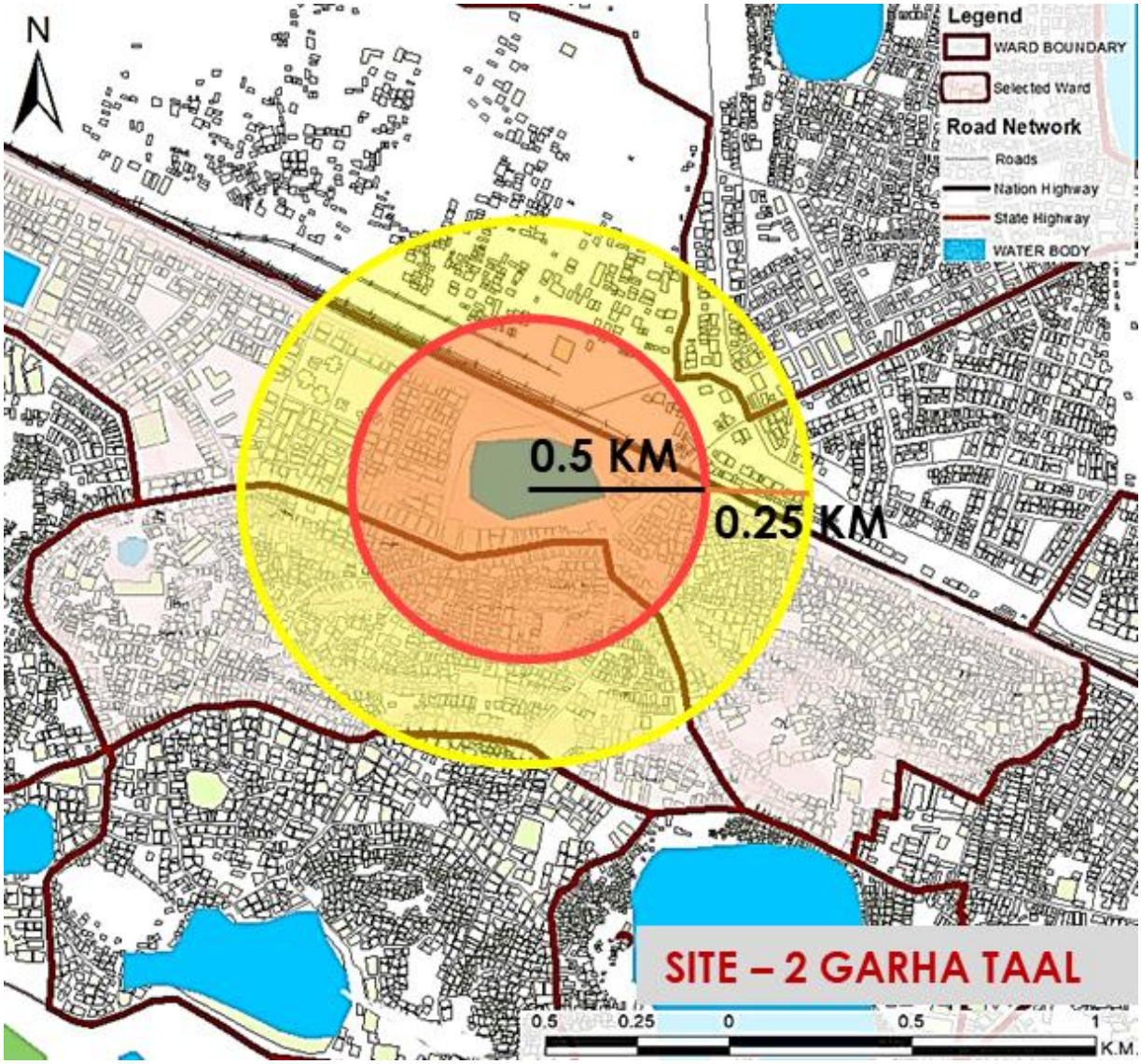


Figure 4.18: Image of selected wards with proximity area for site 2 Garha taal

Garha taal has one diffuse point source which carries discharges from drainage channels. Garbage dumping is another problem of this pond as now the visitors are allowed to take eatable inside.

During the survey, the reasons found for the degradation of Garha taal are encroachment with 40% followed by garbage disposal 25%, sewage disposal 20%, and improper management 15%.

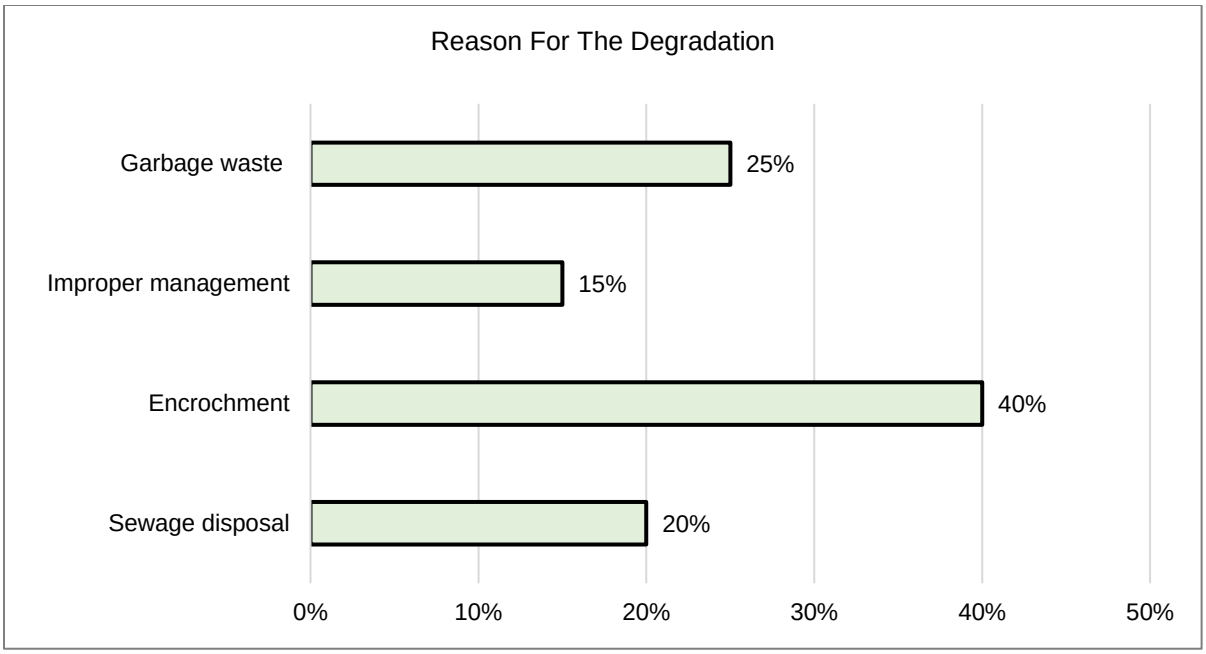


Figure 4.19: Graph showing reasons for degradation (Garha taal)

Figure 4.20: images showing degraded condition of Garha taal

The quantity of water in depth has found to be decreased from 6.4 feet to 5.8 feet in the past 7 years.

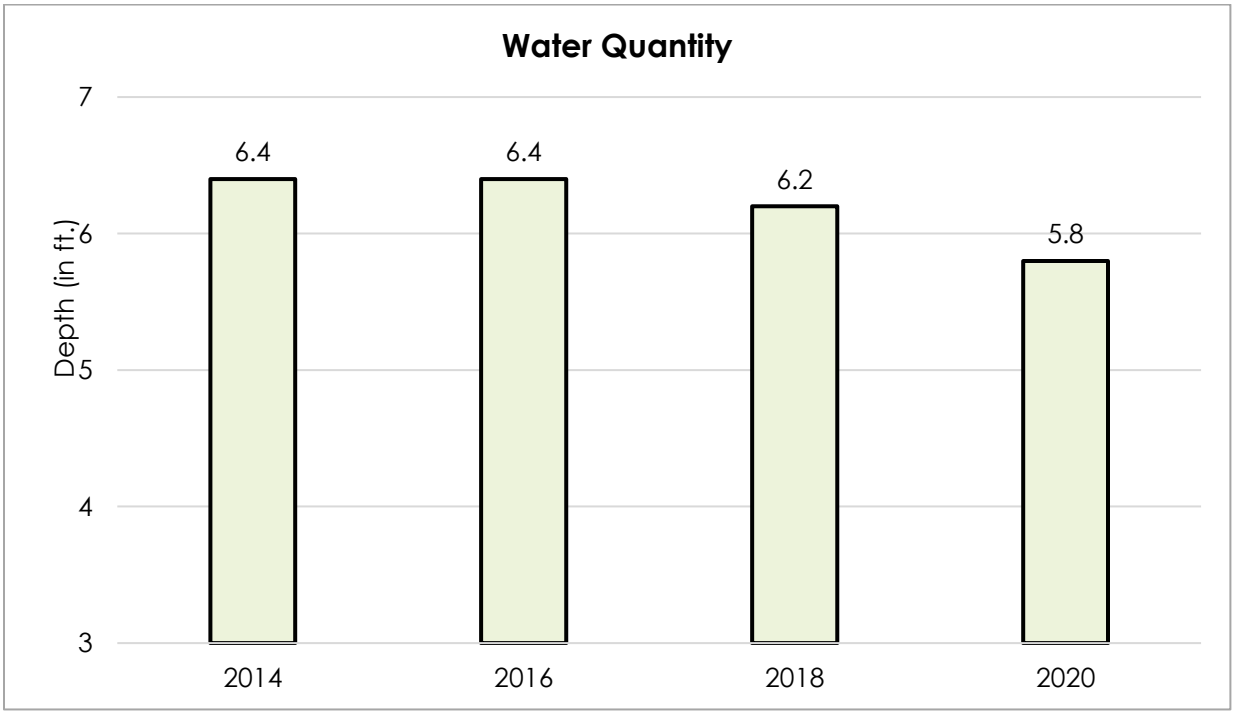


Figure 4.21:Graph showing the decrease in water quantity.

Source: Jabalpur municipal corporation (JMC)

Table 4.6: Table showing the water quality of Garha taal

Water Quality	Standards	2017	2018	2019
pH	6.5- 8.5	8.4	8.42	8.56
Turbidity NTU	5 to 10	56	60	63
Conductivity mS/cm	< 1	0.68	0.37	0.57
TDS Mg/l	500 max	183	296	348
Nitrates Mg/l	20	1.06	1.25	1.381

Source: Jabalpur municipal corporation (JMC)

Inferences

1. Garbage waste collection are causing mosquitoes and smell around the area which is the reason visitors are not coming.
2. Also one side encroachment not only degrading the pond but also spoiling its aesthetic view.
3. Improper management result in spitting in the pond, polluting it by troughing packages.
4. Garha taal has one diffuse point sources which carry discharges from drainage channels results in smelly surrounding.

Activity mapping

During the survey, the activity mapping has been done in the morning and evening on the weekends and the weekdays.

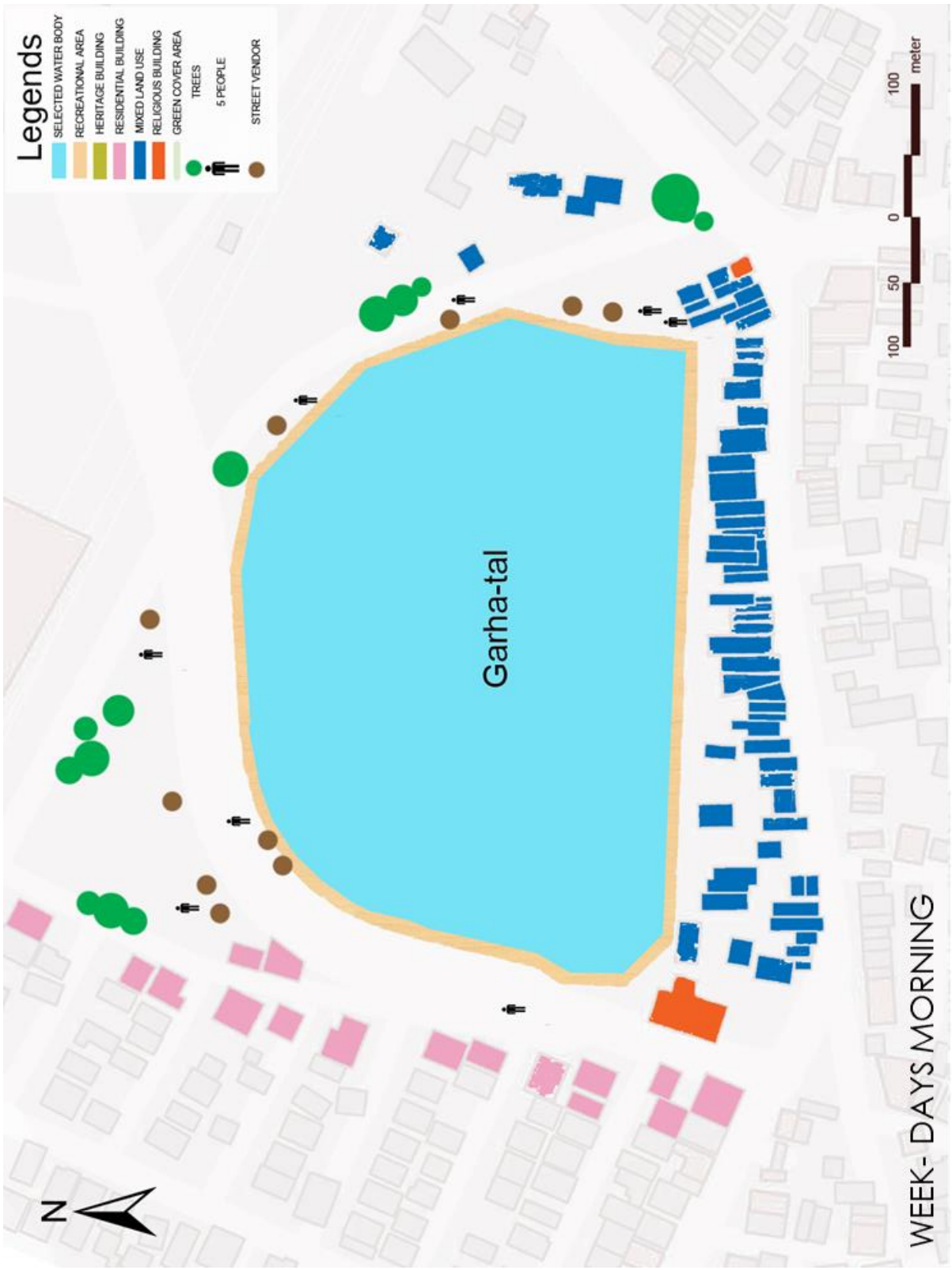


Figure 4.22: Activity mapping is done for Garha taal - morning of weekdays

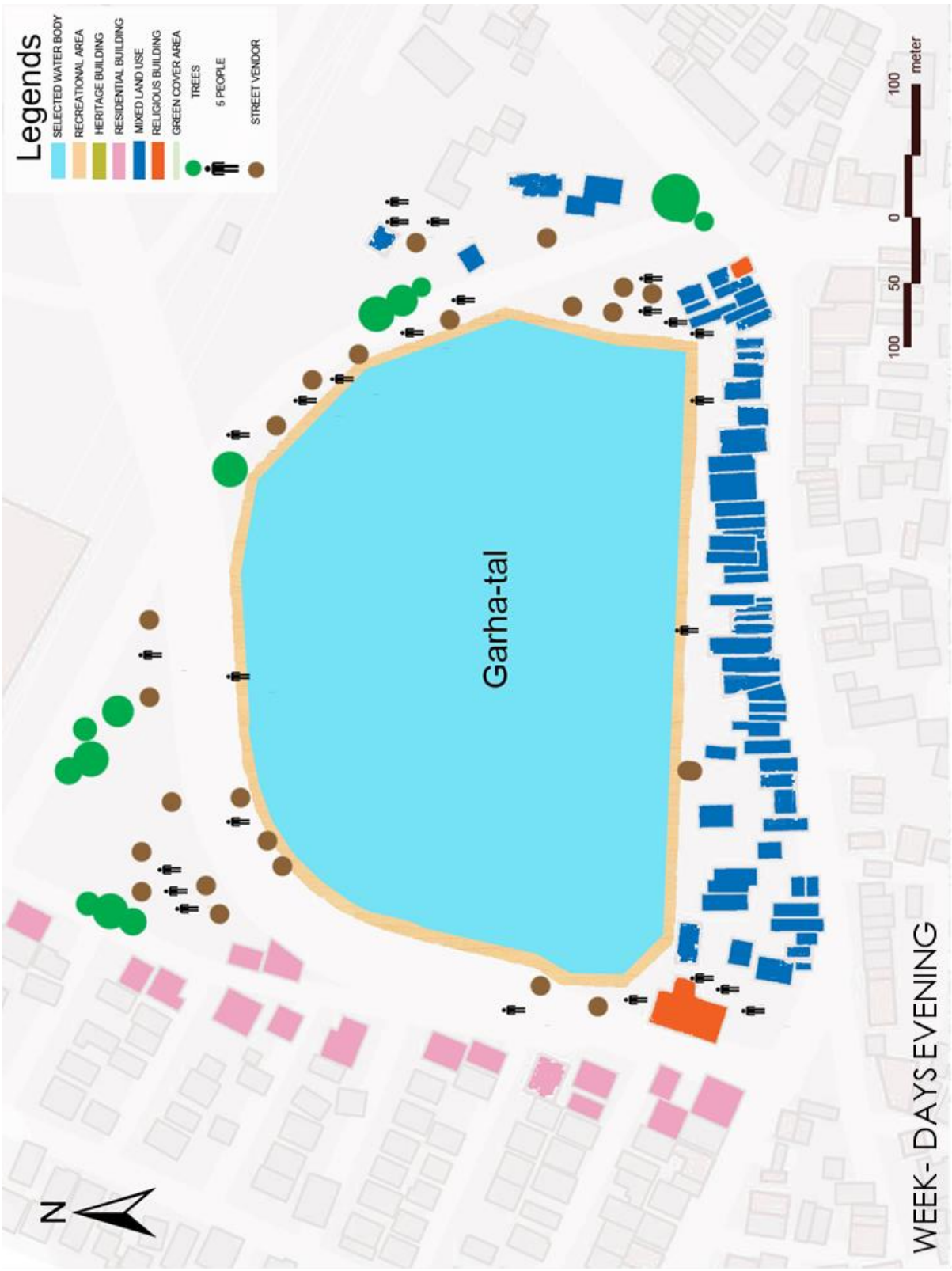


Figure 4.23: Activity mapping is done for Garha taal - evening of weekdays

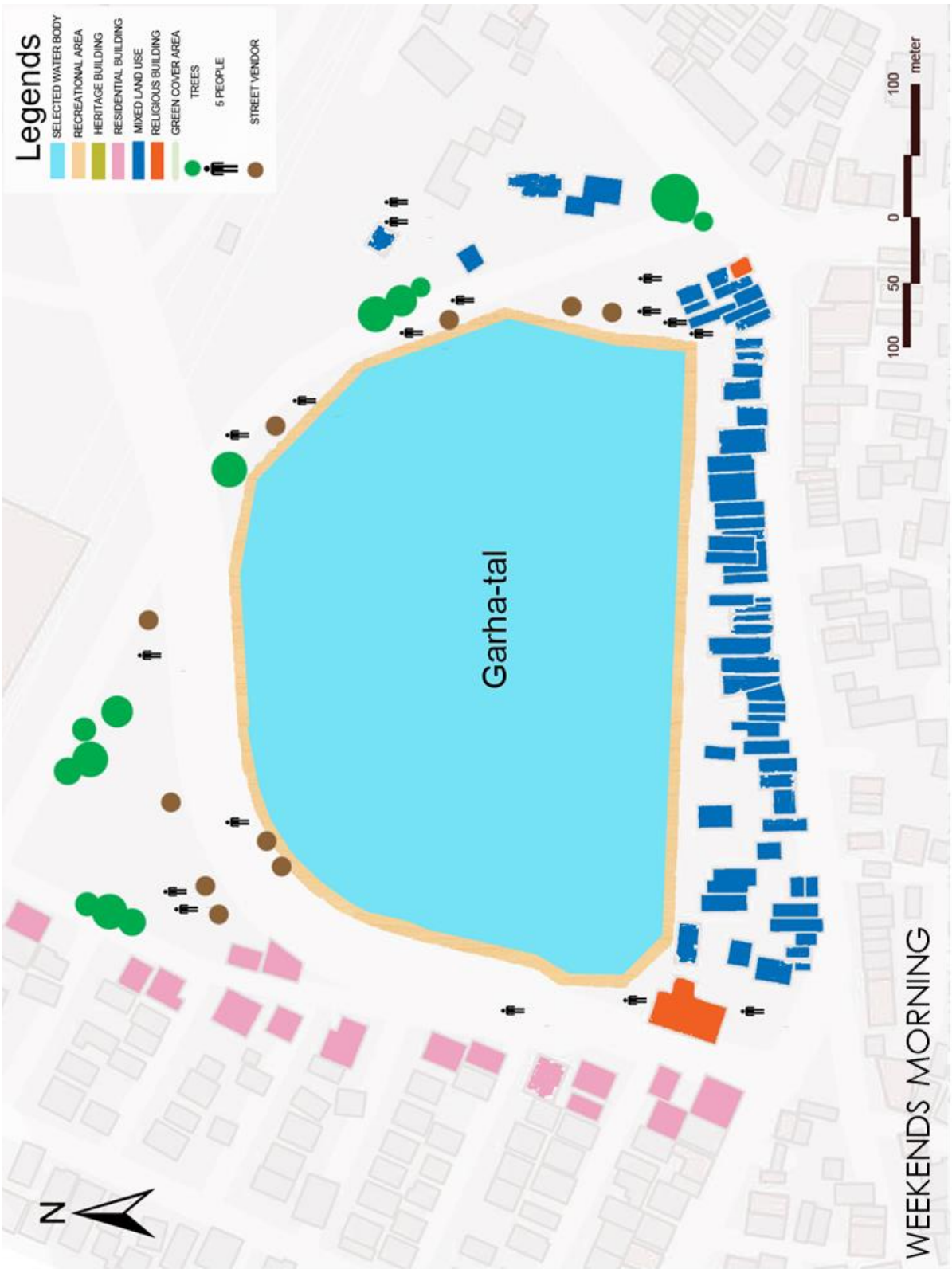


Figure 4.24: Activity mapping is done for Garha taal - morning of weekends

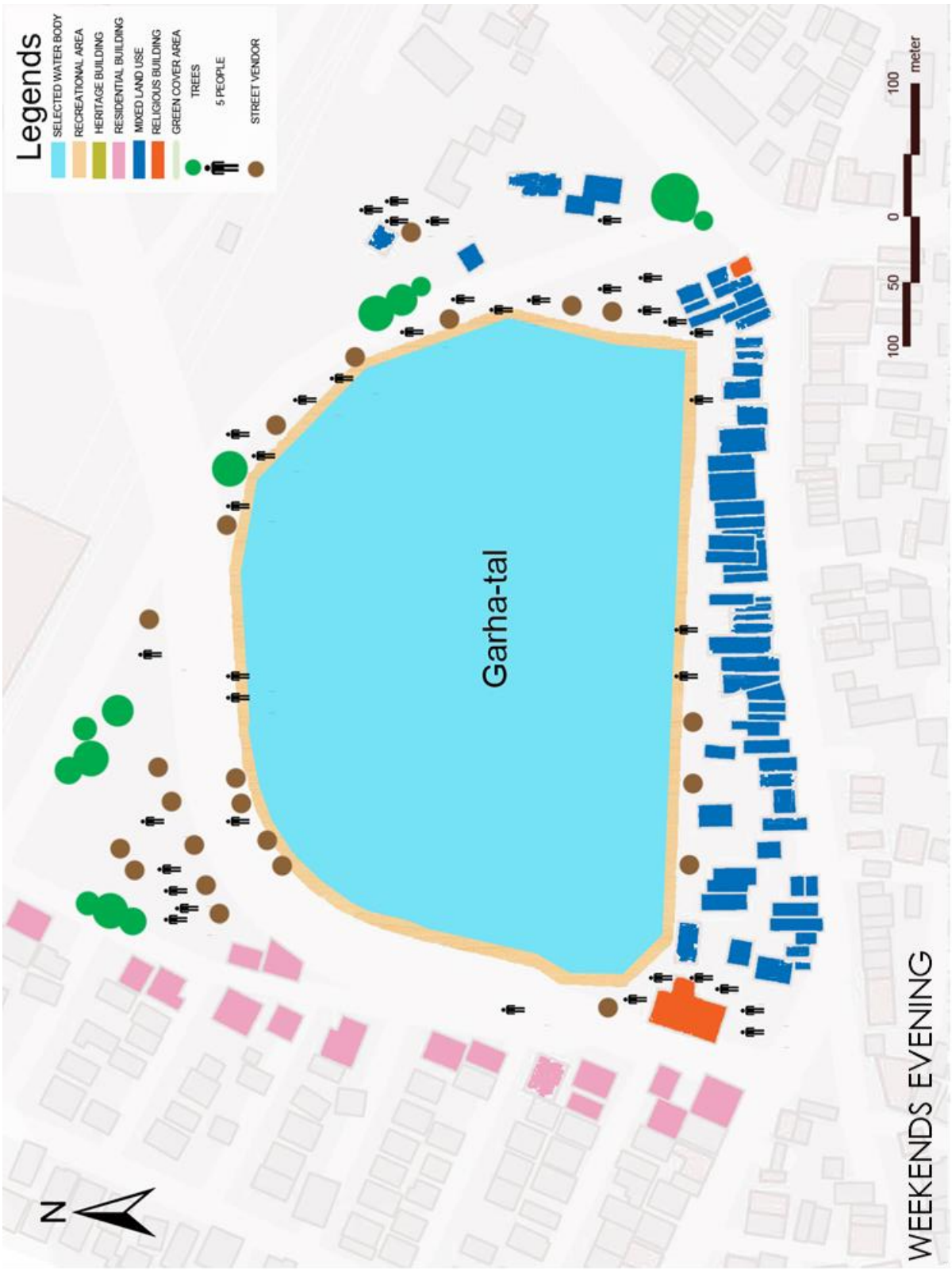


Figure 4.25: Activity mapping is done for Garha taal - evening of weekends

Inferences

1. After the development it is a known place to the city. Morning and evening walks are the most seen activity around this pond.
2. Evenings are crowded because of the vendors and food stalls.
3. This is the place where 75% are group of youth.
4. Easy accessibility and spacious calm surrounding.
5. South part of the pond is not much fascinate because of the backyard view of the nearby residence and thus less explored

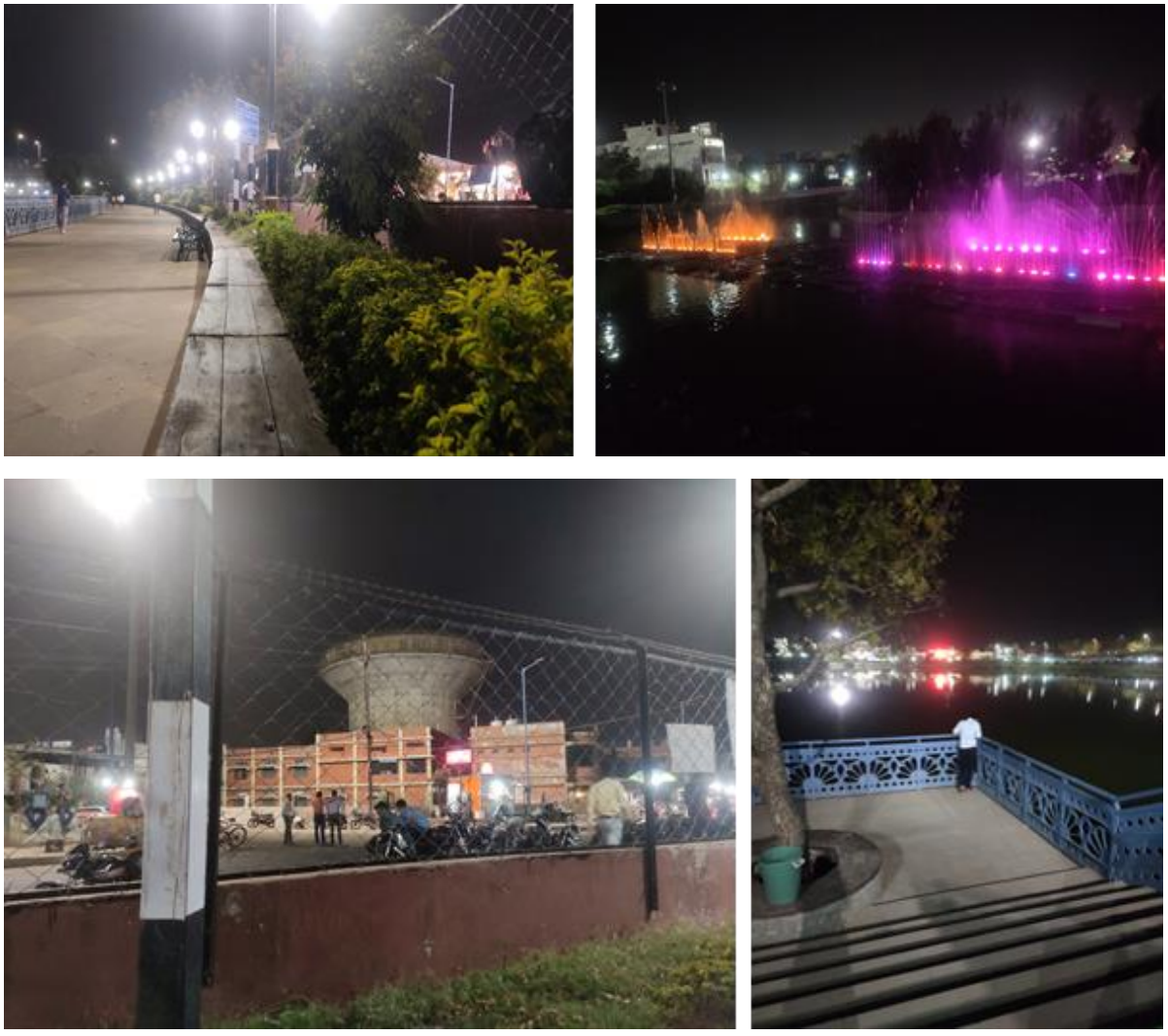


Figure 4.26: Photos showing the activity happening around Site 2 - Garha taal

4.2.3 Site 3 analysis

4.2.3.1 Site 3(a) analysis

The third site is further divided into 3 parts as it combinedly contains 3 selected ponds. They are – 3(a) – Dev taal, 3(b) – Kola taal, 3(c) – Maharaj sagar taal.

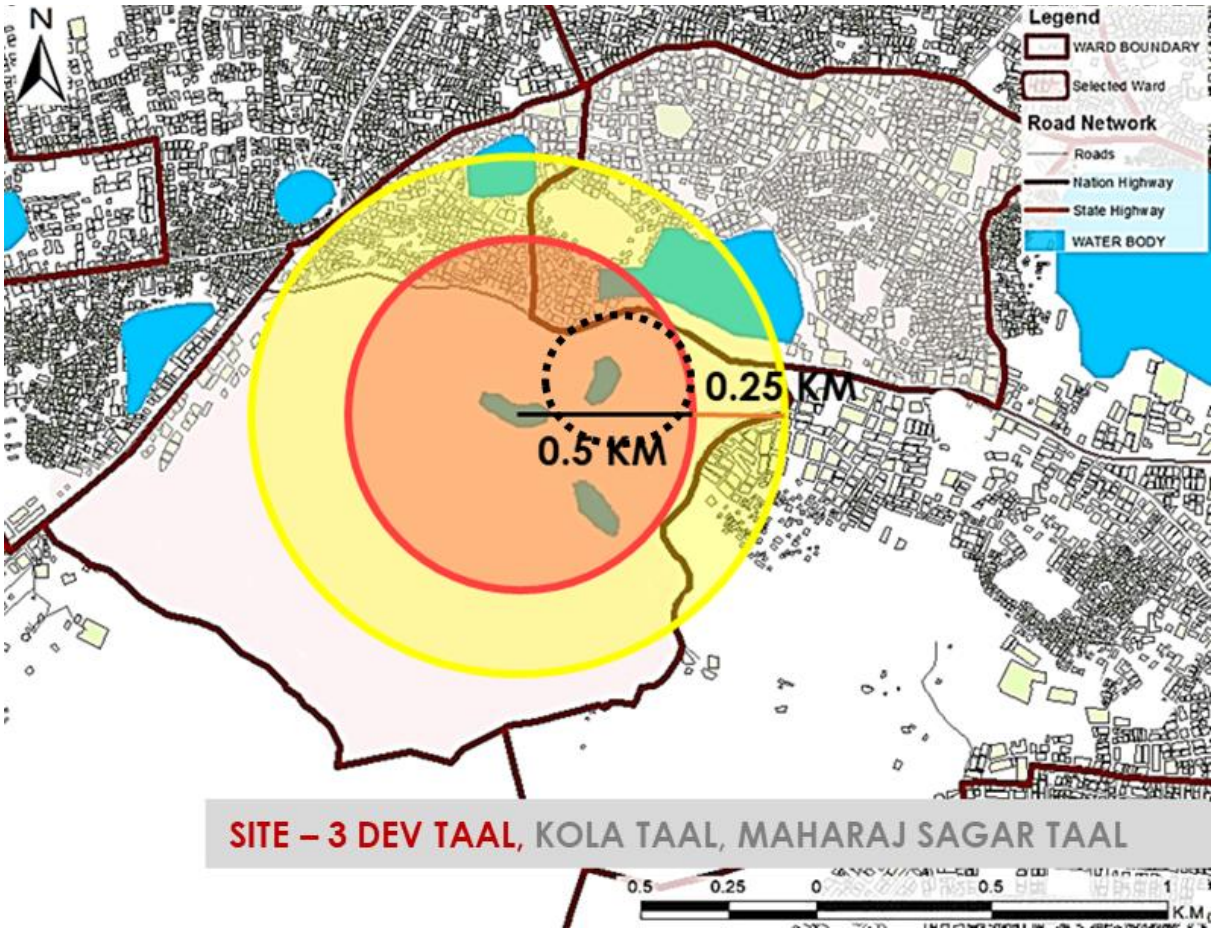


Figure 4.27: Image of selected wards with proximity area for site 3(a) Dev taal

Several ancient temples exist on the bank of Dev Tal lake. The temple has religious importance. Immersion of idols during festivals and disposal of religious remains occurs in this lake. Presently lake is being used for washing/bathing and other nistar activities affecting the water quality of the lake.

Bathing and washing clothes, cultural misuse, improper management, eutrophication are the reasons that have been found in the survey.

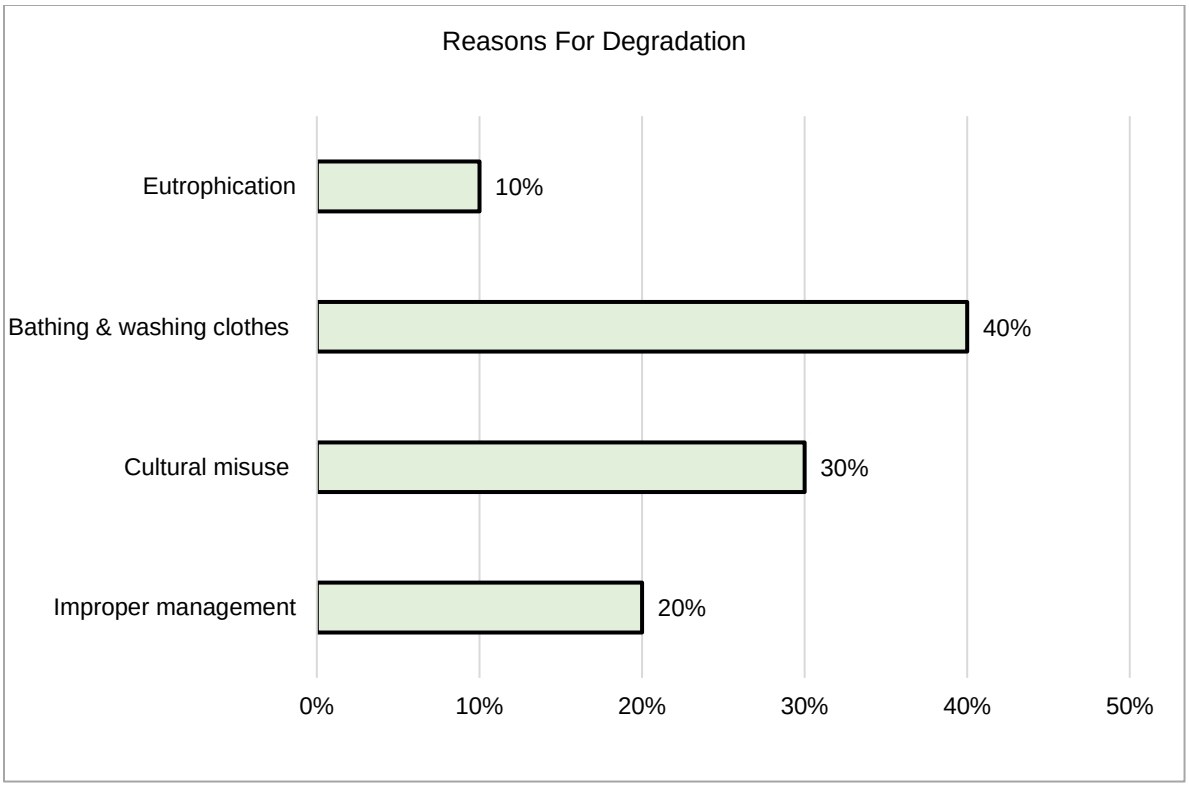


Figure 4.28: Graph showing reasons for degradation (Dev taal)

Figure 4.29: Images showing the degraded condition of Dev taal

In the past 7 years, the quantity of water in depth has also found to be decreased from 6.4 feet to 5.8 feet

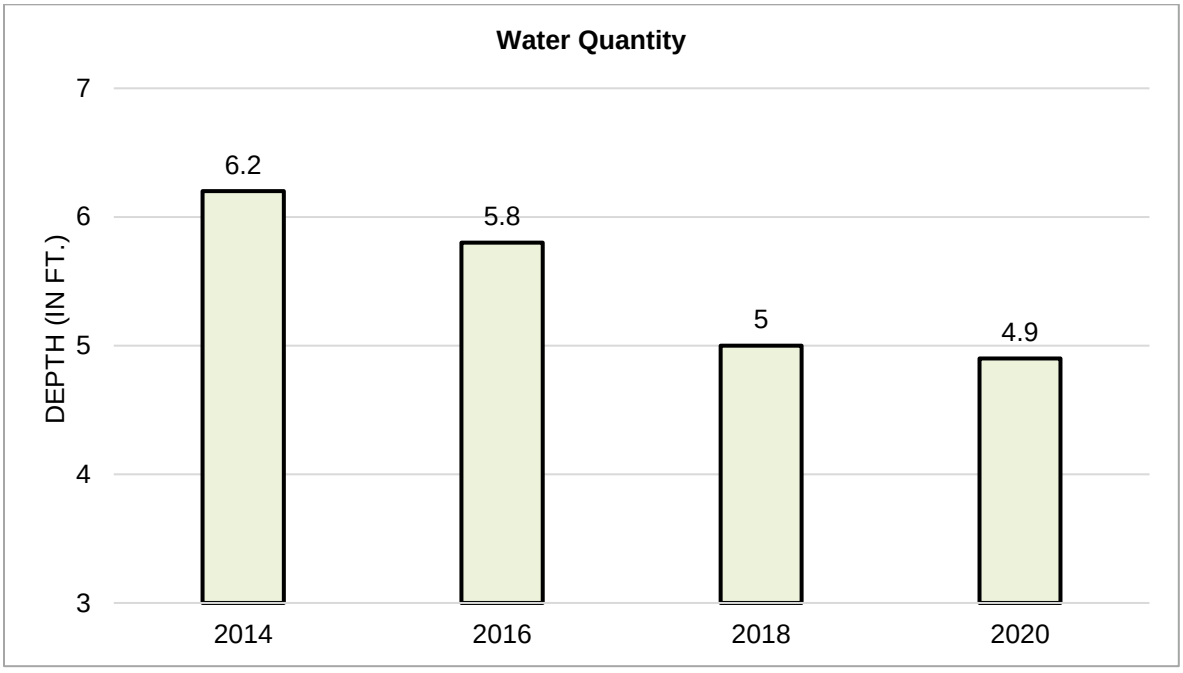


Figure 4.30: Graph showing the decrease in water quantity.

Source: Jabalpur municipal corporation (JMC)

Table 4.7: Table showing the water quality of Dev taal

Water Quality	Standards	2017	2018	2019
pH	6.5- 8.5	8.5	8.5	8.54
Turbidity NTU	5 to 10	89	92	109
Conductivity mS/cm	< 1	0.27	0.32	0.36
TDS Mg/l	500 max	196	204	220
Nitrates Mg/l	20	1.42	1.49	1.57

Source: Jabalpur municipal corporation (JMC)

Inferences

1. The activity around the pond does not allow to enjoy the space more like washing clothes and bathing.
2. Religious waste from temples and houses are thrown to this taal as it has spiritual values.
3. No proper management and security in this place results in illegal activities.
4. Even after having very easy accessibility footfall has been observed because of undeveloped area.

4.2.3.2 Site 3(b) analysis

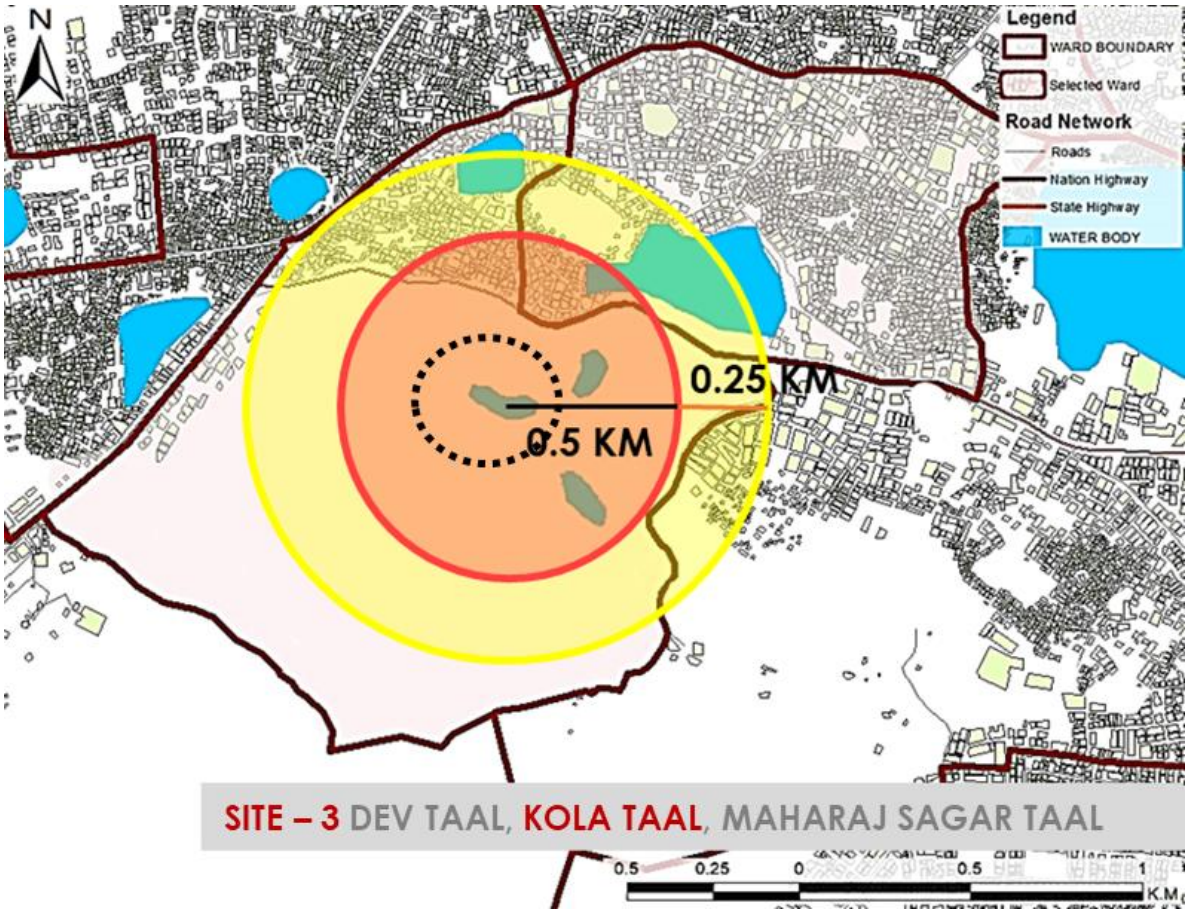


Figure 4.31: Image of selected wards with proximity area for site 3(b) Kola taal

A beautiful pond that is now a part of Osho ashram is known as kola taal. This site -3 is having a very soothing environment as it is covered with a major forest area. But now because of improper management visitors won't come to this place.

The major reason for degradation that come out from the survey is improper management with 40% followed by eutrophication 30%, garbage disposal 20%, and illegal construction 10%.

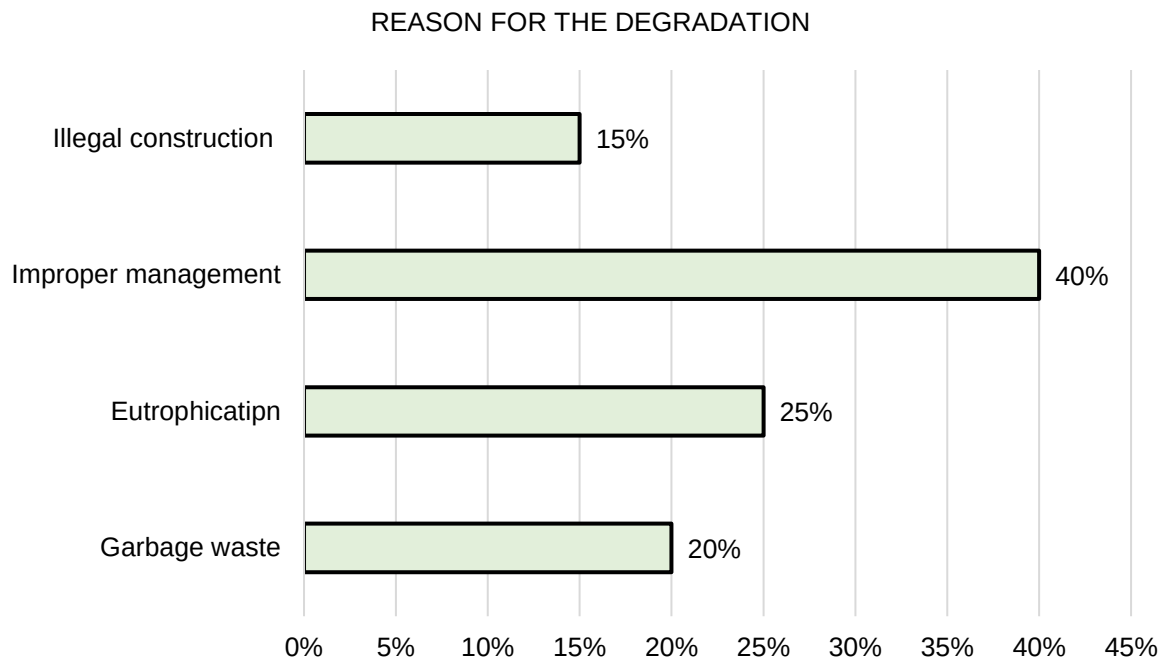


Figure 4.32: Graph showing reasons for degradation (Kola taal)

Figure 4.33: Image of degraded condition of Kola taal

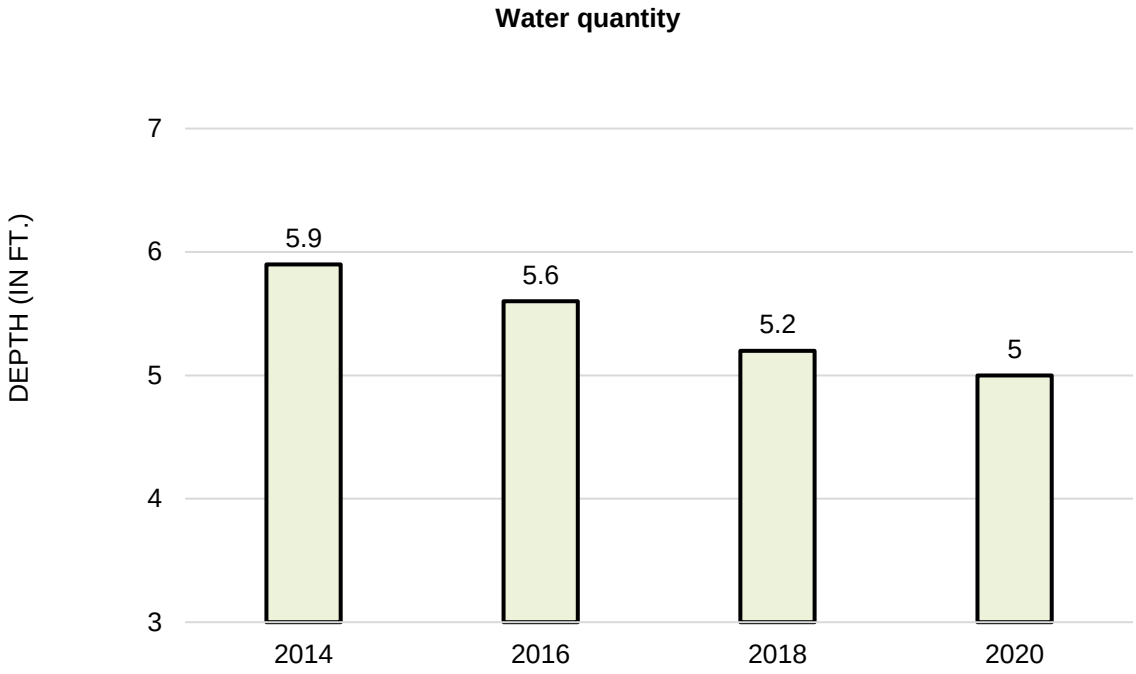


Figure 4.34: Graph showing the decrease in water quantity.

Source: Jabalpur municipal corporation (JMC)

Also, we have found that the quantity of water in depth has been decreased from 5.9 feet to 5 feet in 7 years.

Table 4.8: Table showing the water quality of Kola taal

Water Quality	Standards	2017	2018	2019
pH	6.5- 8.5	8.5	8.5	8.56
Turbidity NTU	5 to 10	75	80	84
Conductivity mS/cm	< 1	0.62	0.79	0.96
TDS Mg/l	500 max	280	324	386
Nitrates Mg/l	20	1.02	1.09	1.26

Source: Jabalpur municipal corporation (JMC)

Inferences

1. Less use of the pond results in eutrophication.
2. Improper management is the biggest issue found in this pond.
3. The aesthetic beauty of the pond is not maintained which don't allow people to attract. Broken grill, unclean water are the examples.
4. No night light and safety is being provided so all activities end up at around 6-7 pm max.
5. Even after such scenic beauty this pond is not attracting the vistors.

4.2.3.3 Site 3(c) analysis

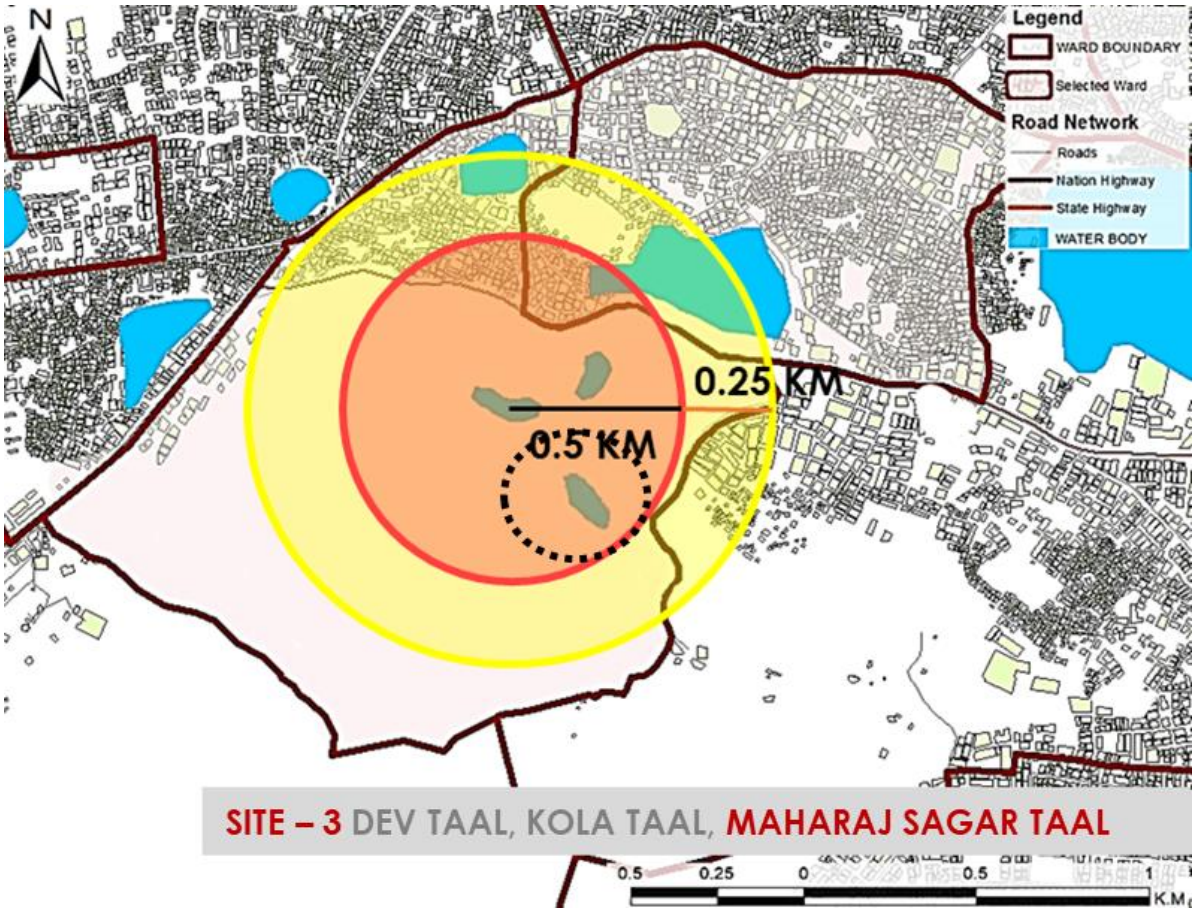


Figure 4.35: Image of selected wards with proximity area for site 3(c) Maharaj Sagar taal

This taal is a part of Shailparn Udhyan which is a completely green area. This taal has lotus plants which beautify it. In the rainy season, the water from the hills comes in this taal which increases its aesthetic value.

During the survey, the reasons found for the degradation of garha taal are encroachment with 40% followed by garbage disposal 25%, sewage disposal 20% and improper management 15%.

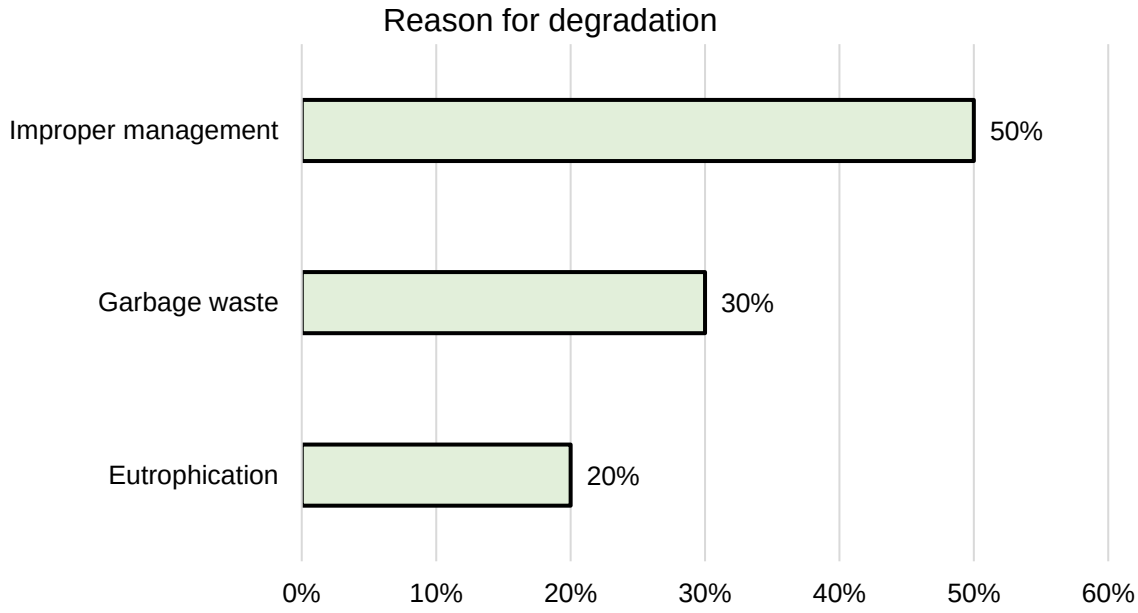


Figure 4.36: Graph showing reasons for degradation (Maharaj sagar taal)

Figure 4.37: Images showing the degraded condition of Kola taal

The quantity of water in depth has found to be decreased from 6.4 feet to 5.8 feet in the past 7 years.

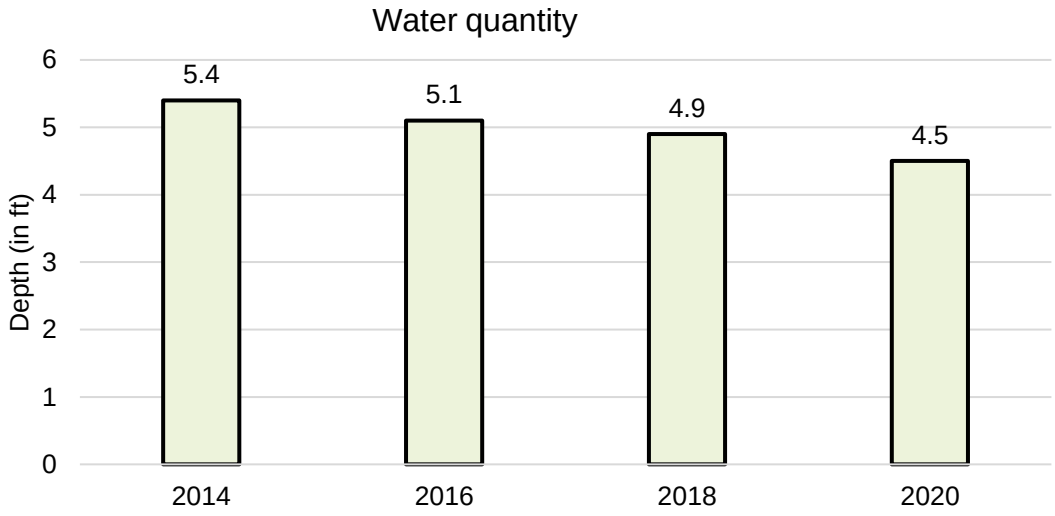


Figure 4.38: Graph showing the decrease in water quantity.

Source: Jabalpur municipal corporation (JMC)

Table 4.9: Table showing the water quality of Maharaj sagar taal

Water Quality	Standards	2017	2018	2019
pH	6.5- 8.5	7.9	8.43	8.48
Turbidity NTU	5 to 10	24	30	36
Conductivity mS/cm	< 1	0.76	0.8	0.85
TDS Mg/l	500 max	480	501	519
Nitrates Mg/l	20	0.87	0.91	0.98

Source: Jabalpur municipal corporation (JMC)

Inferences

1. The main reason for the footfall of this space is less exploration of this place.
2. Also the maintenance and amenities are not there which results is less attraction.
3. Less use and maintenance of water cause eutrophication.
4. People who came for picnic to this area left the waste here only.
5. No extra visitors attraction is available such as food stalls, shops etc

Activity mapping

During the survey, the activity mapping has been done in the morning and evening on the weekends and the weekdays.

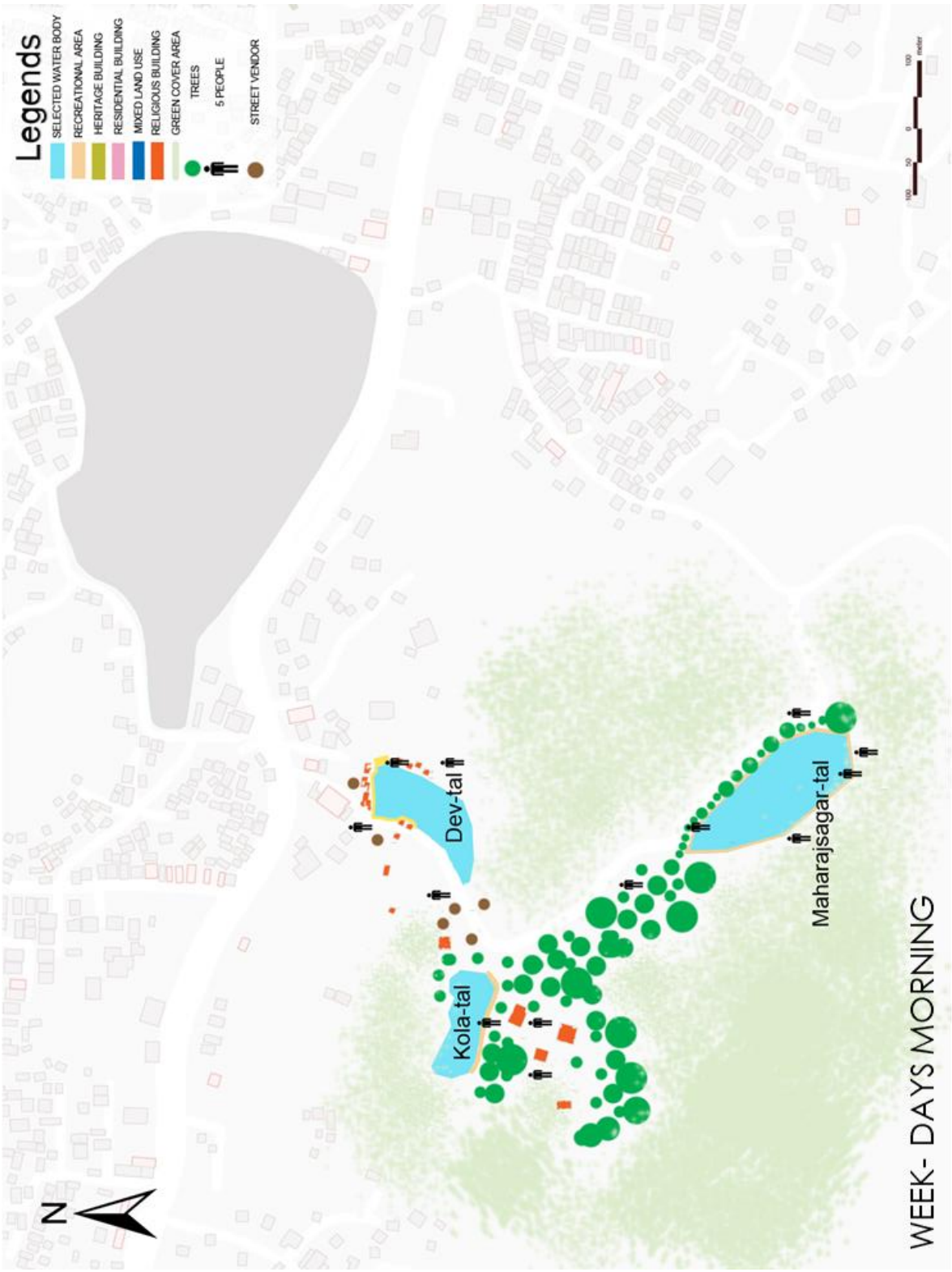


Figure 4.39: Activity mapping is done for site 3 - the morning of weekdays

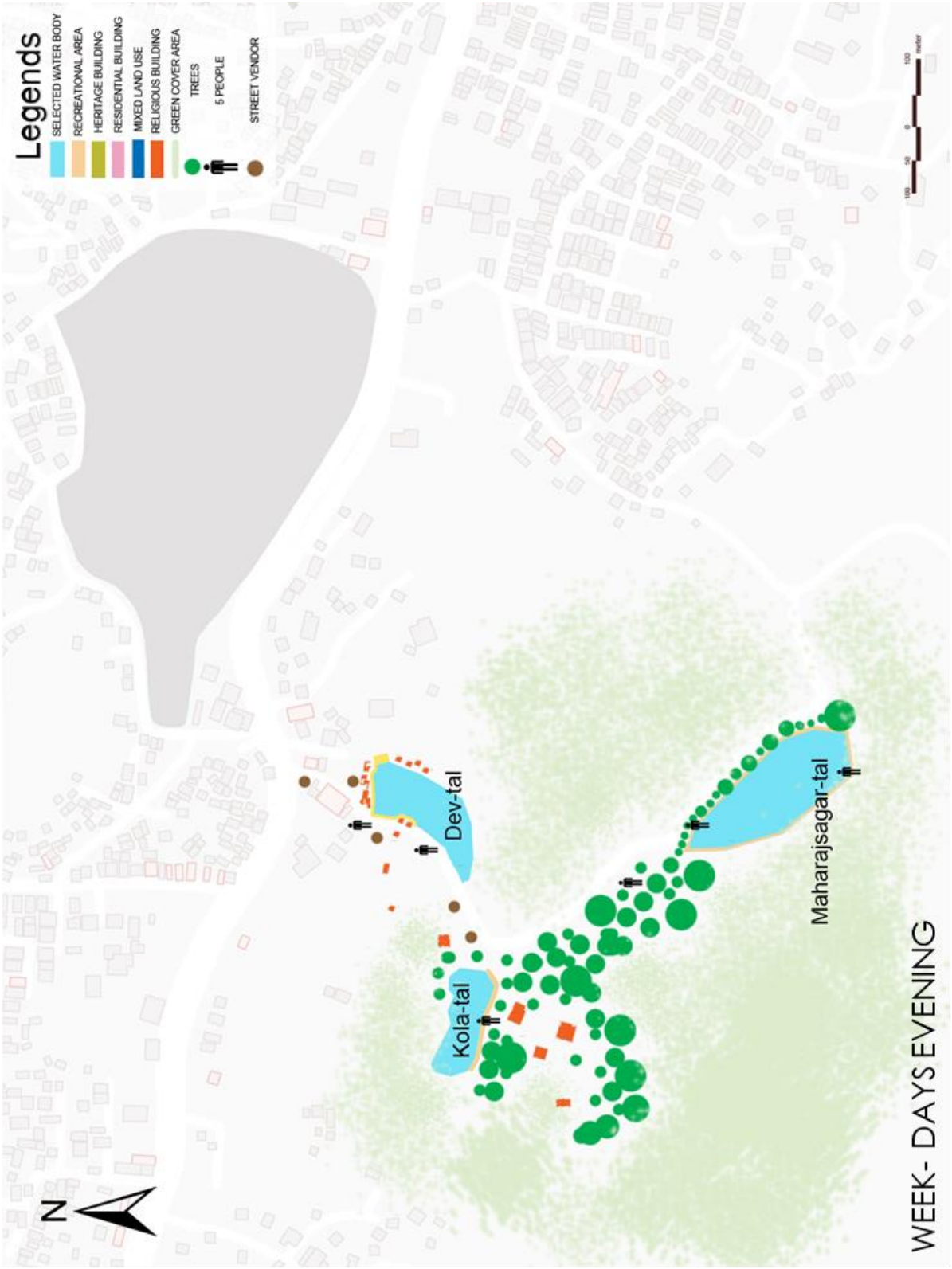


Figure 4.40: Activity mapping is done for site 3 - an evening of weekdays

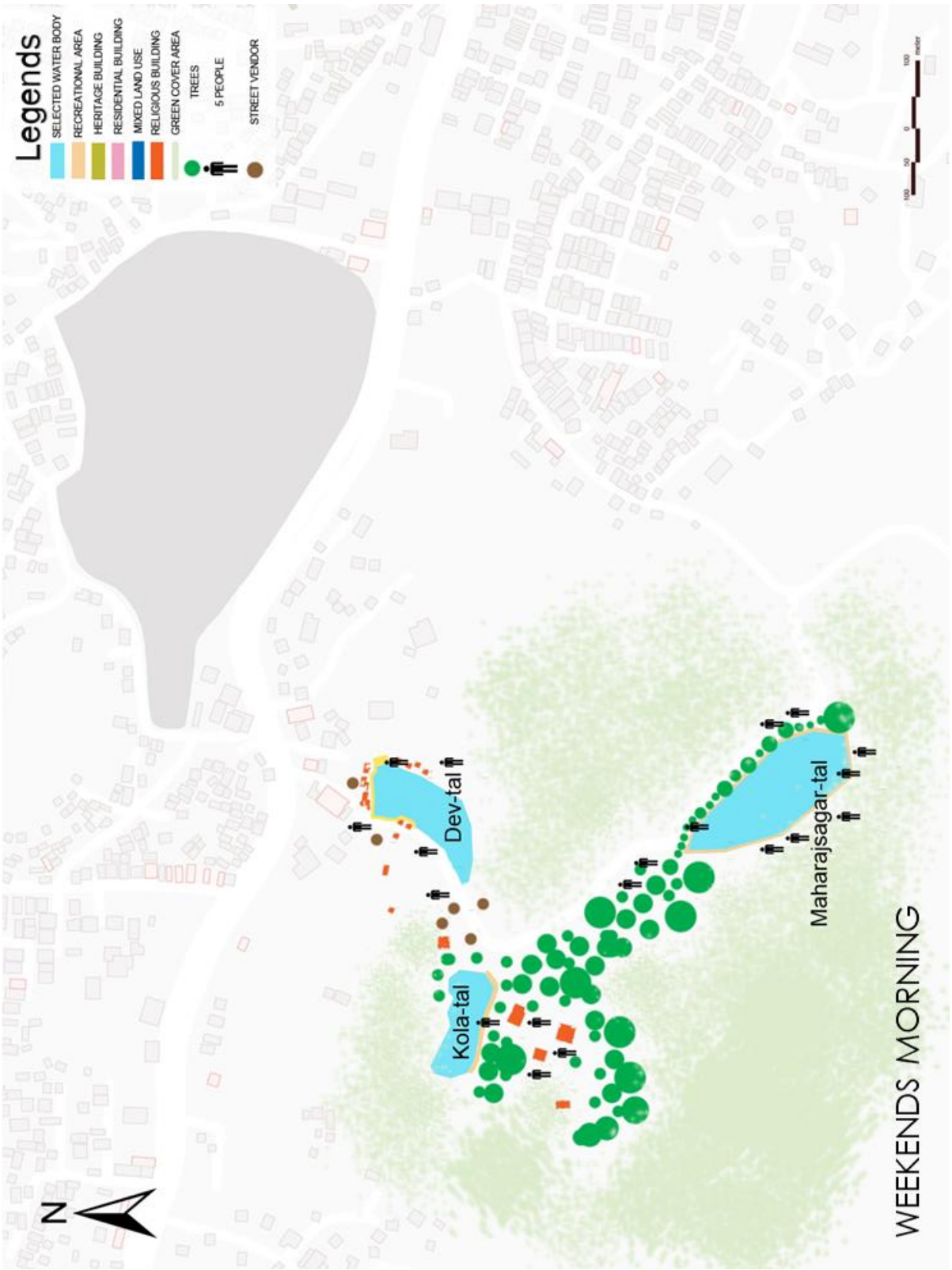


Figure 4.41: Activity mapping is done for site 3 - the morning of weekends

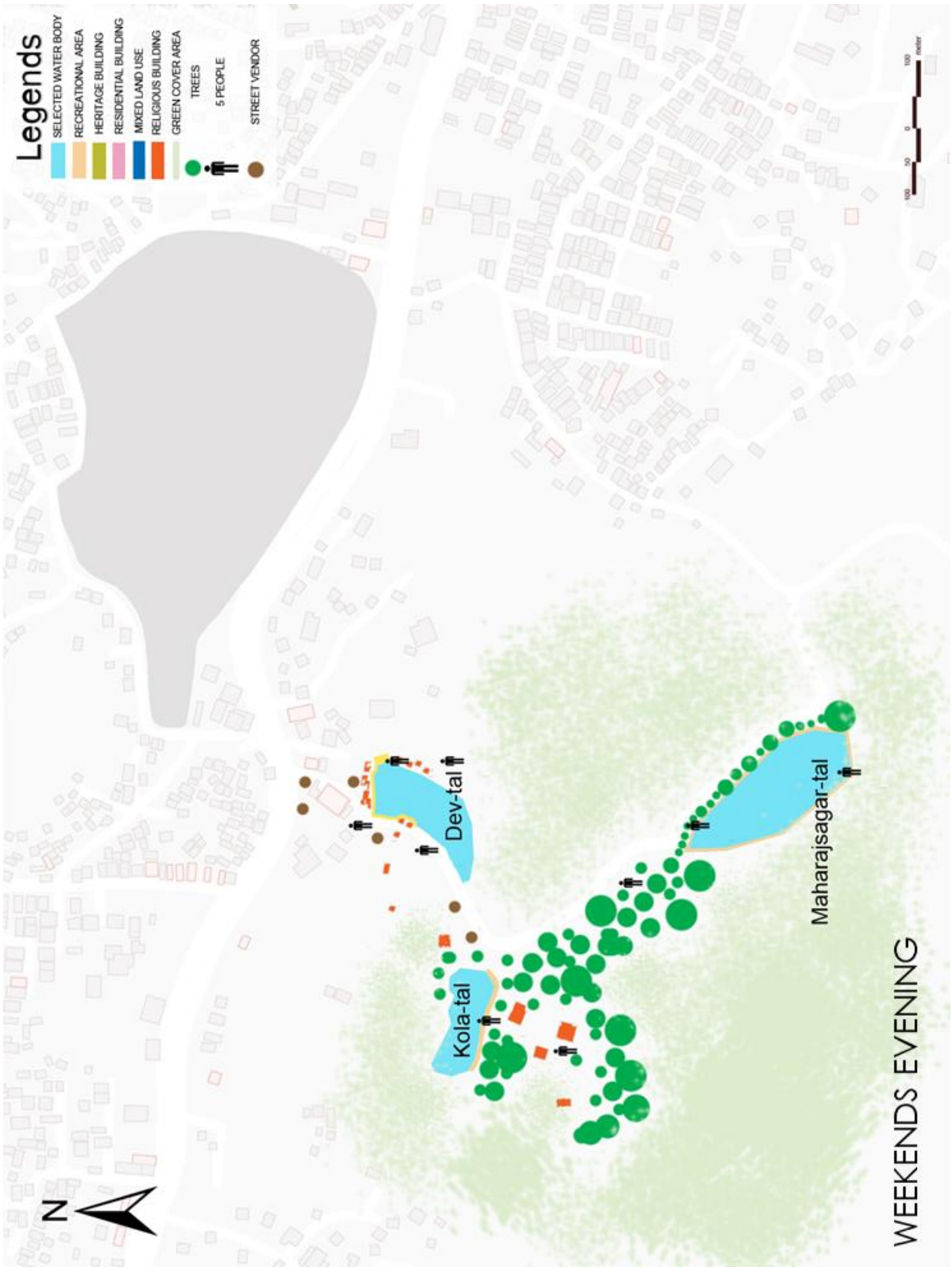


Figure 4.42: Activity mapping is done for site 3 - an evening of weekends

Inferences

1. Least visitors come to this taal even after having such a beautiful environment.
2. Maximum of them come to morning as there is no security or street lights available in this area.
3. No public amenities are provided which attract visitors.
4. Only group of people are found to be here maximum of which are youngsters.
5. Even after located in the main city area and side to the NH-34 less awareness of this place.

Figure 4.43: Photos showing the activity happening around the Site 3 - Dev taal, Kola taal, Maharaj sagar taal.

4.2.4 Quantification of the ecosystem services.

To quantify the CES in non-monetary terms, we surveyed a household survey in which we asked people to rate the different services provided by each pond from best to worst.

Recreation services rank highest in Garha taal, Kola taal, and Maharaj Sagar, while religious or spiritual services rank highest in Hanuman taal and Dev taal.

These preferences should also be taken into account when recommending strategies and projects that should be prioritized for implementation based on these preferences as this was a public need.

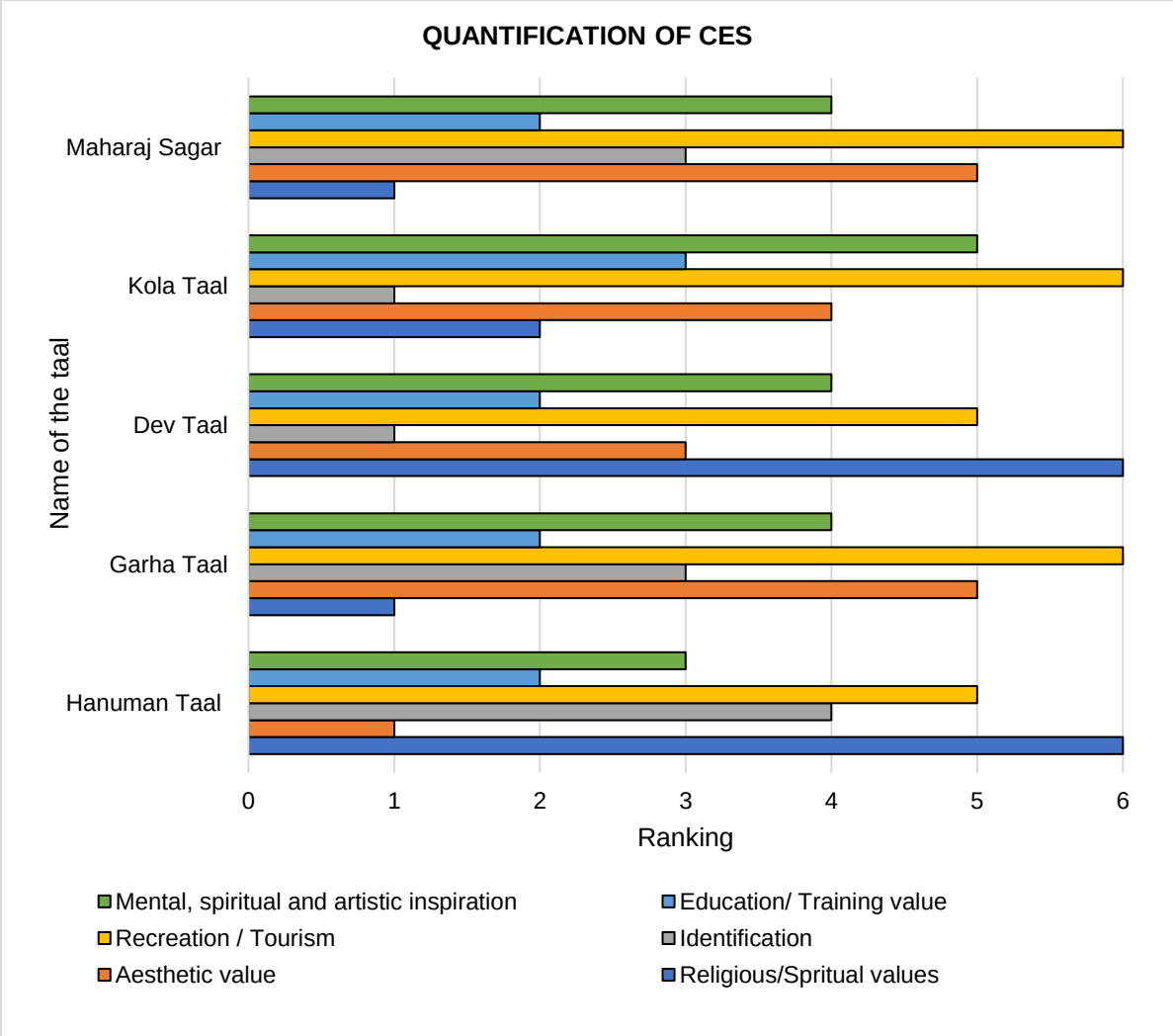


Figure 4.44: Graph showing the ranking of different services of each pond.

CHAPTER 5 STRATEGIES AND RECOMMENDATIONS

This chapter reflects on the numerous proposals that should be made, as well as the strategies and initiatives that should be implemented to improve the situation in the study area.

Now comes the swot analysis of these ponds, which was carried out to prioritize services and determine the strengths and opportunities that should be pursued. Also, weaknesses and threats that the strategies should eliminate.

5.1 SWOT analysis

SITE 1 - Hanuman taal

1. Strength

It is the oldest taal with religious and heritage buildings around. It is a sacred water body. In the heavily populated region, it serves like a puncture.

2. Weakness

It is located in a congested area. It has undeveloped surroundings. It has Polluted water.

3. Opportunity

It has the potential to be redeveloped as a heritage-tourism destination. It has the potential to generate revenue.

4. Threats

It has poor accessibility. The space around the pond is limited for development.

Inferences –

It can be built as a religious recreational space with the requisite leisure facilities, as it is the only comfortable space for the gathering of nearby people. Purification of water is required and must be preserved. Surrounded by a market area, proper stall area distribution should be performed to reduce congestion.

SITE 2- Garha taal

1. Strength

It has easy accessibility.It is a development project under Jabalpur smart city.

2. Weakness

It has an entrance fee that limits tourists. It is located in an unappealing environment.

3. Opportunity

It has the potential to become a leisure area for the surrounding community. A variety of activities, such as open gym, swimming, and boating, can be included.

4. Threats

The noxious odor makes the environment toxic**.** Residents' backyards prevent them from using the whole reservoir.

Inferences –

A pond with enough space and aesthetic elegance could be created as a local leisure area. It is possible to recommend walking trails, a bike track, and a yoga practice room in open areas. It is important to improve the consistency of the water. Food stalls, bars, stores, and other amenities may be provided to tourists if the area is created as a leisure zone.

SITE 3 - Dev taal, Kola taal, Maharaj Sagar Taal

1. Strength

It has a strategic location. It has a relaxing ambiance. There is good traffic and quick connectivity in this region. The landscape and nature are the main attractions.

2. Weakness

It has not a well-known area because of improper management . This place has a lack of government attention . It has a lack of infrastructure facility

3. Opportunity

It has the potential to be established as an eco-tourism destination. Improvements to the infrastructure would boost its appeal. May be used as a multi-purpose zone.

4. Threats

Development can be a high-cost project.

Inferences –

This place, among all others, has the most potential for development as a tourist destination, from an aesthetic standpoint to usability. It has degraded due to poor administration, which must be addressed. It is possible to suggest a multi-functional field.

We have attempted to identify the primary causes of degradation and their effect on cultural impacts. We discovered that in three of the sites, the main reasons for water degradation are garbage, solid waste, and offerings disposal to the water. The second big cause is poor management of the water body. As a result, the pond's facilities, such as dirty and noisy surroundings, are not drawing tourists, resulting in lower footfall, which has an indirect effect on the local vendors' economy.

And though the reasons for pond degradation differ, the effects are the same in all three locations.

• As a result of the waste disposal, the water quality is declining.

• Footfall is reduced because degraded and undeveloped ponds do not draw tourists.

• Because of the low volume of visitors, the local essential carts generate a low amount of revenue.

Thus, the proposal should be so that they –

- Increase the water quality.
- Attract the visitors.
- Economy generation.

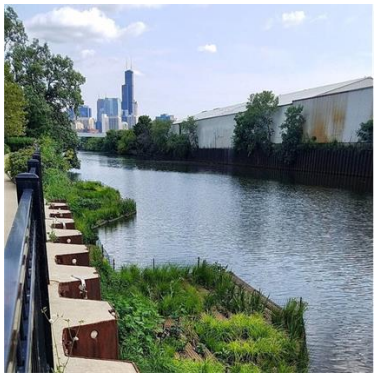
5.2 Strategies proposed for the sites

5.2.1 Strategies for water quality enhancement

- Phytoremediation at the pond's edge works to clear up polluted water conditions while still preventing pollutants from being carried downstream from the site by groundwater flow to nearby locations or deeper underground. This often prevents people from coming into close contact with the lake, preventing the pond from being polluted by religious offerings and solid waste disposal.

This is both attractive and environmentally conscious. This technique is also the most cost-effective because it does not require costly or highly skilled labor.

- Aeration in the pond helps to disinfect the air by improving the water quality; additionally, floating fountain aerators are attractive enhancements to every waterbody. It aids in the reduction of algae and the removal of phosphorus. It will also break down unwanted bacteria, assist with insect issues, and eliminate noxious odors from a pond, all of which contribute to a more pleasant and relaxing environment.



5.2.2 Strategies to attract visitors or local citizen

- A pond development program is suggested, which includes a proper walking path and a spot to rest. Small shaded areas will be offered in the religious nearby areas for festival sitting. Walking trails and a yoga meditation center in open spaces will benefit both individual wellness and group experience. With enough available, cycle tracks may be added to the walking trails.
- The presence of large trees and flower plantations not only adds to the taal's charm but also encourages tourists to spend more time here during all seasons.
- The construction of a park with proper management in site -3 will play a significant role in growing its appeal to tourists. Boating, among other water sports, will add to the natural beauty of the region. Visitors to a developed area should be able to enjoy a variety of attractions such as shops, boating, cycling, restaurants, and so on.



5.2.3 Strategies for economic generation

- The surrounding area could be built as a chowpatty or food zone, which would support the stalls' economy while also allowing tourists to enjoy the vicinity.
- The flowers used in temple offerings may be used to make incense sticks. The majority of the jobs will go to local women, and this will be a small-scale sector.
- The building would boost government revenue from retail, hotels, sporting events, tourism, boating, and other sports, as well as the property value of the surrounding neighborhood.



5.3 Site-specific proposal

Site 1 - Hanuman taal

The upper zone should be devoted entirely to leisure. The lower zone, which contains the majority of old and popular temples, can be entirely devoted to regional and heritage tourism. Parking is available for all tourists and residents of both zones. A flower bed will be supported at the edge of the railing. To improve water quality, an

aerator and water plants have been suggested. For locals, an open area near the mixed land use formed into a food zone. Devotees will be supplied with benches and shade. Visitors should use the open area around the residential property as a vegetable market zone. A separate kund should be given for kali ji visarjan, as this is a well-known practice that takes place in this pond. Nearby buildings/shops may be used for a recreation center, yoga class, cafes, and restaurants. In addition, some of them can be merged to form the flower reuse industry. Image 5.1 below explains the site-specific proposal for Hanuman Taal.

Site 2 – Garha taal

Plantation and screening were used to hide the buildings' backyards. Water plants have been suggested as a means of improving water quality. Aerators also aid in insect control and the removal of foul odors from ponds. Additionally, the pond's charm would be enhanced. Citizens will benefit from a boating and cycling track. The government-owned vacant land in front of the taal could be used as a public park, open gym, or another recreational facility. Nearby buildings can be converted into cafés and restaurants. Vacant land to be transformed into a food zone. Image 5.2 below explains the site-specific proposal for Garha Taal.

Site 3 – Dev Taal, Kola Taal, Maharaj Sagar Taal.

Vehicle parking should be available at the entrance to the city, and cycling should be permitted after that. Pond boating should be offered first, as it allows visitors to see the heritage temples surrounding the pond while learning about the region.

To draw tourists, a nearby restaurant and hotel could be redeveloped. Food stalls at each stop will assist people in seeing the whole city.

A second pond in the area can be used for meditation and yoga. There could be an open gym provision there. A routine Osho center mediation class can also be held near the pond. The third reservoir, which is now part of an undeveloped and deteriorating park, should be built first, along with all required facilities such as street lights, cameras, and public restrooms. Children's playfield with swings and a creative natural park The park's ticket booth is also the park's entrance. Image 5.3 below explains the site-specific proposal for Dev Taal, Kola Taal, Maharaj Sagar Taal.

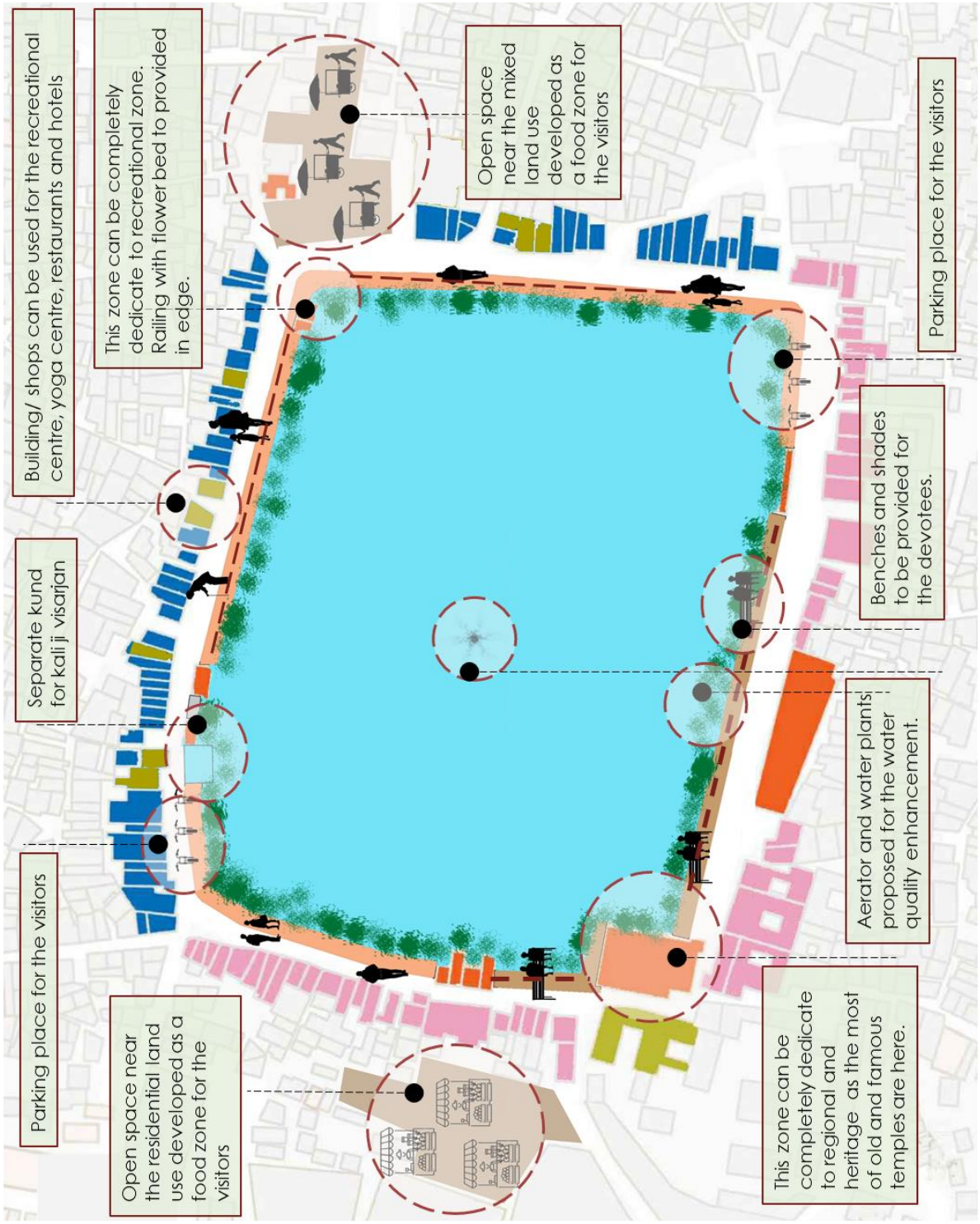


Figure 5.1: Image of site-specific strategies in Hanuman Taal

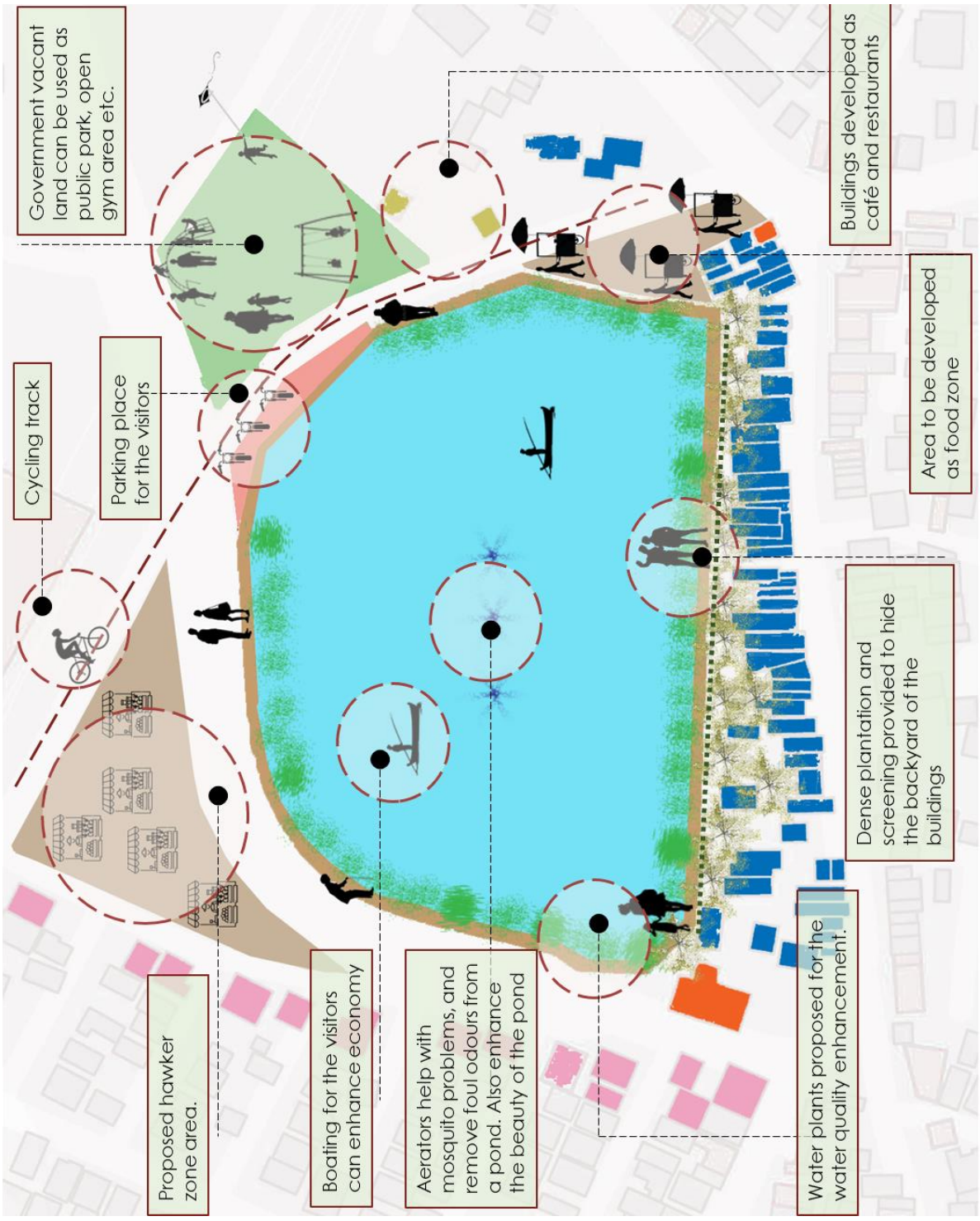


Figure 5.2: Image of site-specific strategies in Garha Taal

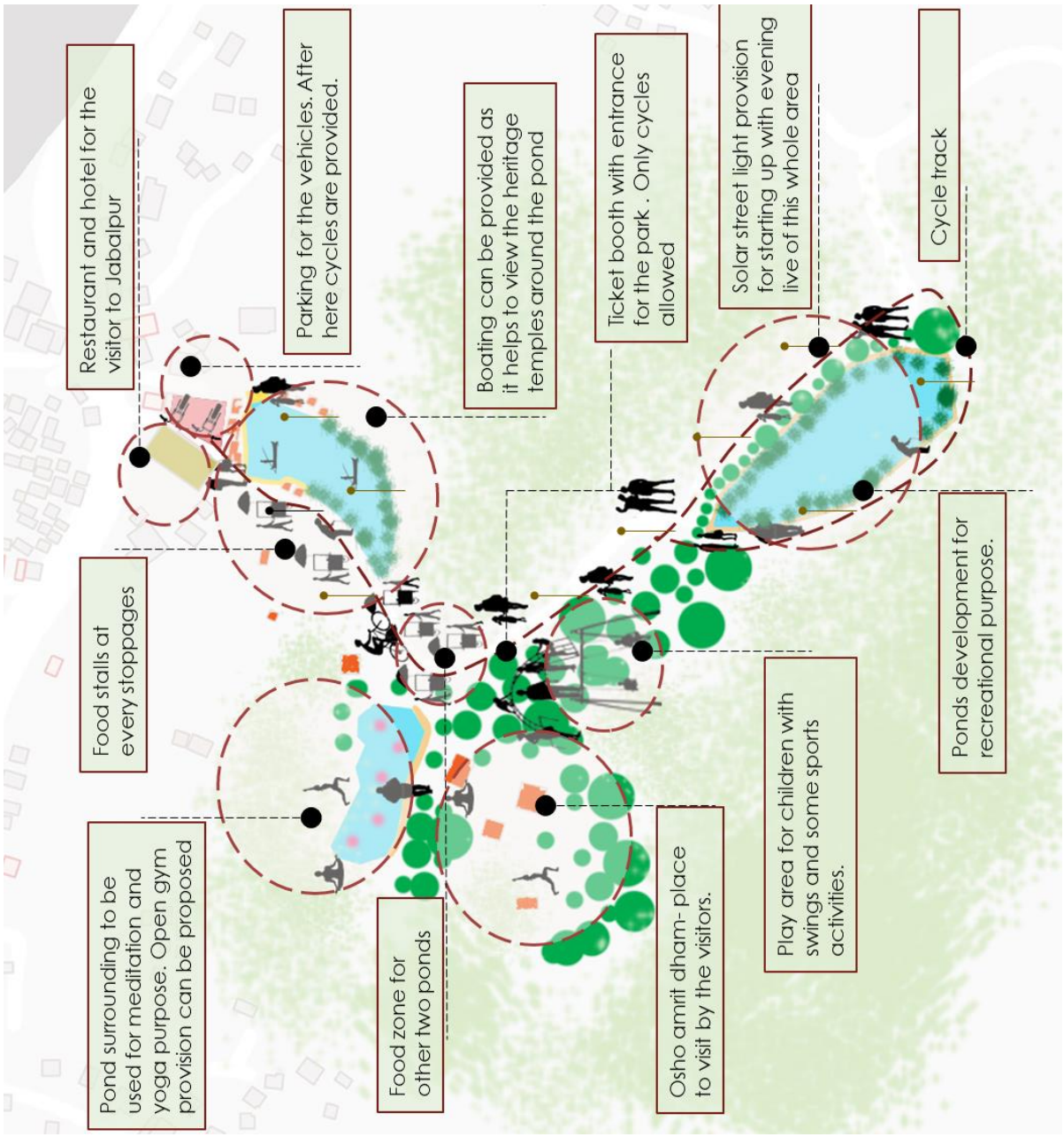


Figure 5.3: Image of site-specific strategies in Dev Taal, Kola Taal, Maharaj Sagar Taal

The strategies will be implemented in different phases and different stakeholders will be involved in the process.

Strategy 1 - Water Quality Enhancement

Pond development and water quality up-gradation will be done in phase 1

Stakeholder involved

- Smart city
- Jabalpur municipal corporation
- Water resource department

Strategy 2 - Attract Visitors

Development of all the necessary amenities will be conducted in this phase-2

Stakeholder involved

- Jabalpur municipal corporation
- Jabalpur development authority
- Public work department

Strategy 3 - Economy Generation

Development helpful for the economy will take place in this phase – 3

Stakeholder involved

- Jabalpur municipal corporation
- Public work department
- Community
- NGOs

Also, community participation and awareness programs, in addition to these strategies, will help improve the situation. Both of these initiators will keep ponds in good condition.

- COMMUNITY PARTICIPATION

Once the pond is built, the community will be responsible for the majority of its upkeep, and the locals will either depend on or leave the area. It is recommended that each pond have a committee that is in charge of the pond's construction and upkeep.

- AWARENESS PROGRAMS

There should be awareness campaigns organized to inform people about the importance of the pond and its progress. For the same reason, social media can be really useful. The reuse of flower offerings can be encouraged so that not only the waste flowers of these taals but also the waste flowers of the entire region, especially those from the Narmada river, are reused.

5.4 Recommendations

1. Efficient facilities for waste disposal (such as urban solid waste and plastic waste) should be provided in compliance with the relevant provisions.
2. Physical disposal of poorly disposed of wastes by the local or municipal authority regularly.
3. Removing nutrients from wetlands regularly improves groundwater recovery potential, removes polluted sediments, and enhances pond holding space.
4. The buffer zone surrounding a reservoir should be kept as a green belt zone or a no-activity zone, with no activity permitted inside it.
5. To meet and maintain delegated water quality levels in water sources, set policy goals and priorities.

5.5 Benefits of the pond rejuvenation

1. Recreational growth around the pond will improve the surrounding area as well as the gatherings of the city.
2. The scenic beauty of the pond contributes to the quality of life for landowners and the entire city.
3. If incorporated properly, recreational events in and near urban wetlands will provide a potential revenue stream for city governments.
4. Open-air social events and yoga meditation centers will benefit both personal wellness and group experience.

And lastly, a generalised framework has been proposed to aid in the further exploration of the same research. It explains which survey should be conducted and which stakeholders should be contacted.

5.6 Generalized framework

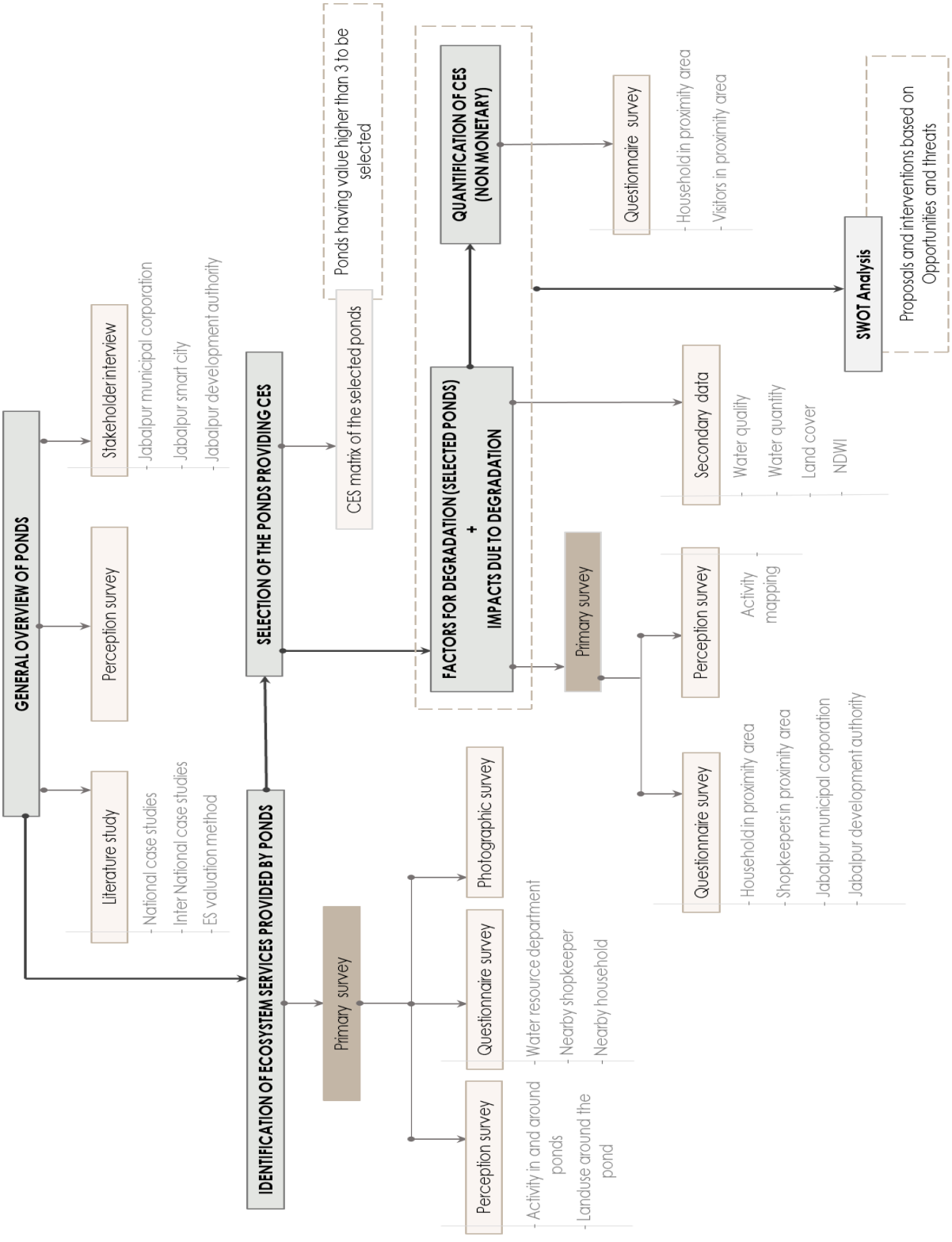


Figure 5.4: Generalized framework for the CES assessment of degraded ponds

CHAPTER 6 References

Biggs, J., von Fumetti, S., & Kelly-Quinn, M. (2017). The importance of small waterbodies for biodiversity and ecosystem services: implications for policy makers. *Hydrobiologia*, *793*(1), 3–39. https://doi.org/10.1007/s10750-016-3007-0

Bingham, T. H., Bondelid, T. R., Depro, B. M., Figueroa, R. C., Hauber, A. B., Unger, S. J., Van Houtven, G. L., & Stoddard, A. (2000). A benefits assessment of water pollution control programs since 1972: Part 1, the benefits of point source controls for conventional pollutants in rivers and streams. *US Environmental Protection Agency*, *68-C6-0021*(January), 1–111.

Brönmark, C., & Hansson, L. A. (2002). Environmental issues in lakes and ponds: Current state and perspectives. *Environmental Conservation*, *29*(3), 290–307. https://doi.org/10.1017/S0376892902000218

Céréghino, R., Boix, D., Cauchie, H. M., Martens, K., & Oertli, B. (2014). The ecological role of ponds in a changing world. *Hydrobiologia*, *723*(1), 1–6. https://doi.org/10.1007/s10750-013-1719-y

Cheng, X., Van Damme, S., Li, L., & Uyttenhove, P. (2019). Evaluation of cultural ecosystem services: A review of methods. *Ecosystem Services*, *37*(June 2018), 100925. https://doi.org/10.1016/j.ecoser.2019.100925

Downing, J. A. (2010). Emerging global role of small lakes and ponds: Little things mean a lot. *Limnetica*, *29*(1), 9–24.

Kumar, M., & Padhy, P. (2015). Environmental Perspectives of Pond Ecosystems: Global Issues, Services and Indian Scenarios. *Current World Environment*, *10*(3), 848–867. https://doi.org/10.12944/cwe.10.3.16

Landuyt, D., Lemmens, P., D'hondt, R., Broekx, S., Liekens, I., De Bie, T., Declerck, S. A. J., De Meester, L., & Goethals, P. L. M. (2014). An ecosystem service approach to support integrated pond management: A case study using Bayesian belief networks - Highlighting opportunities and risks. *Journal of Environmental Management*, *145*(2014), 79–87. https://doi.org/10.1016/j.jenvman.2014.06.015

Rao, V. S. (1971). An ecological study of three freshwater ponds of Hyderabad-India.

I. The environment. *Hydrobiologia*, *38*(2), 213–223. https://doi.org/10.1007/BF00036835

Rustogi, P., & Singh, S. K. (2017). Ecological Benefits of Reviving Urban Water Bodies using Rainwater Harvesting. *International Journal of Advance Research and Innovation*, *5*(2), 283–285.

CHAPTER 7 ANNEXURE

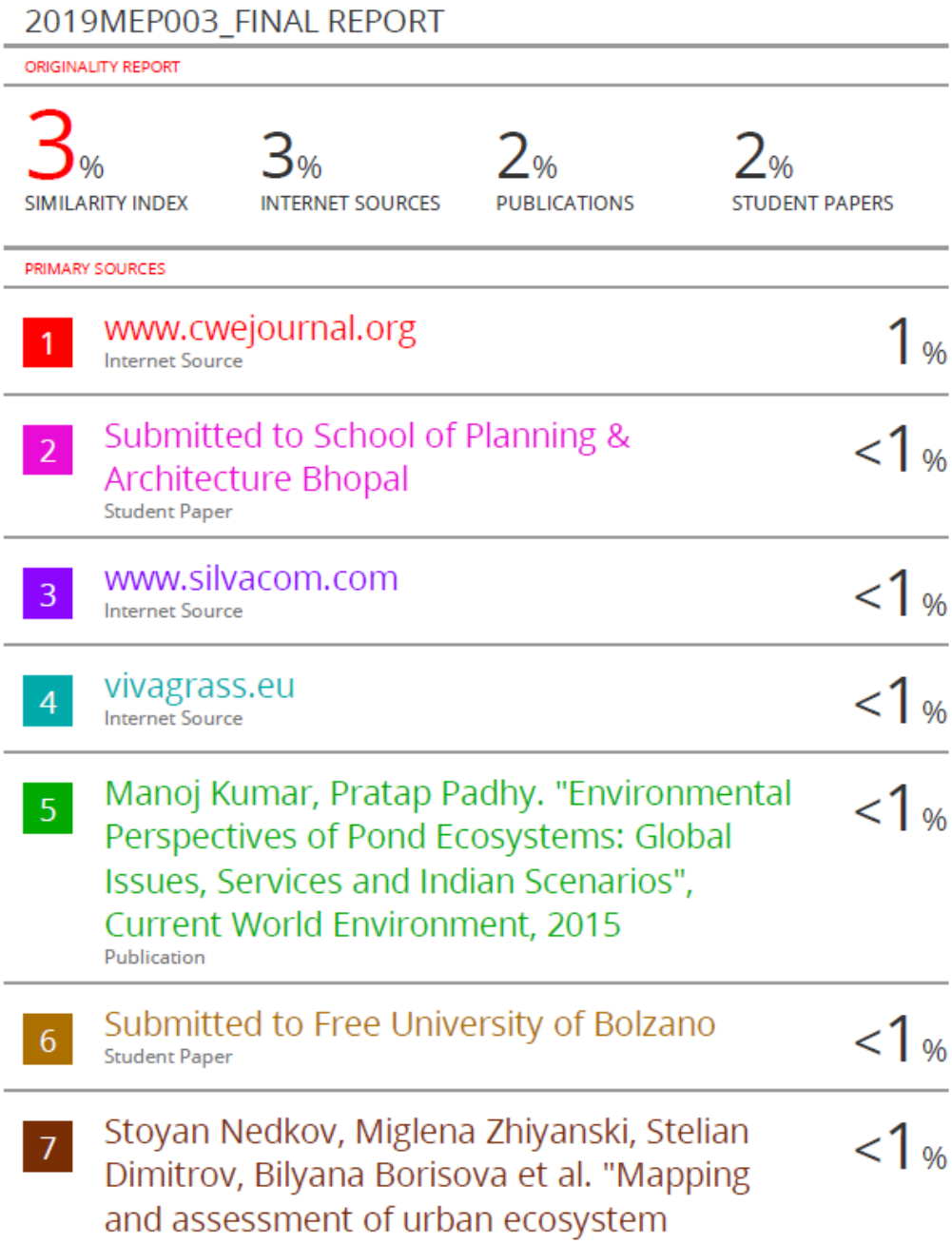


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Figure 7.1: Plagrism report