

**CLUSTER INNOVATION CENTRE
UNIVERSITY OF DELHI**

DEVELOPING A SYSTEM FOR GREEN RATING OF COLONIES

PROJECT REPORT



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We would also like to extend our thankfulness to The Energy & Resource Institute (TERI) Department and Library at India Habitat Center (IHC) for allowing us to access their library.

Our team-work has enabled the successful completion of this project and so we would also like to thank each other for our respective contributions to the project.

We are also thankful to our college, Cluster Innovation Center for providing us with the opportunity to work on this project.

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ABSTRACT

“What gets measured, gets managed”

This project is centered on rating colonies, both quantitatively as well as qualitatively, on the basis of their environmental and general performance. As a part of the study sample, five types of colonies have been identified in South Delhi. These are:

1. Government Colonies
2. Resettlement Colonies
3. Urban Villages
4. Private flat colonies
5. Multistoried apartment colonies

After having studied extensive literature, a list of performance parameters was made under the able guidance of the mentor. After which, a survey of two colonies of each of the type identified above was conducted. The results obtained from the collection of the primary data have been documented and represented pictorially. They have also been studied further to draw inferences that would serve as the basis for providing recommendations to the concerned authorities. The motive that has been fulfilled by undertaking this project was to analyze the relation between the price of the property and the provision of various amenities by the colony in the light of making recommendations for improving quality of life in the various colonies of Delhi.

1. INTRODUCTION

1.1 GREEN BUILDINGS

Green building (green construction or sustainable building) refers to a structure using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.

Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

A similar concept is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials those are available locally. Sustainability may be defined as meeting the needs of the present generation without compromising the ability of future generations to meet their needs.

Green building guidelines offer recommended measures for conserving natural resources, using water and energy wisely, improving indoor air quality, and planning for livable and vibrant communities. Building with these measures helps to create healthy, durable buildings that reduce environmental impacts and cost less to operate and maintain.

1.2 ENVIRONMENTAL IMPACT

Green building practices aim to reduce the environmental impact of building. The first rule is that the greenest building is the building that doesn't get built. The second rule is that every building should be as small as possible. The third rule is not to contribute to sprawl, even if the most energy-efficient, environmentally sound methods are used in design and construction. The International Energy Agency released a publication that estimated that existing buildings are responsible for more than 40% of the world's total primary energy consumption and for 24% of global carbon dioxide emissions.

1.3 GOAL

The green building movement originated from the need and desire for more energy efficient and environmentally friendly construction practices. There are a number of motives for building green, including environmental, economic, and social benefits. However, modern sustainability initiatives call for an integrated and synergistic design to both new construction and in the

retrofitting of existing structures. Green building aims to reduce and ultimately eliminate the impacts of buildings on the environmental and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic equipment, and using plants and trees through green roofs, rain gardens, and reduction of rainwater run-off. Many other techniques are used, such as using low-impact building materials or using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water.

On the aesthetic side of green architecture or sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site.

1.4 LIFE CYCLE ASSESSMENT (LCA)

A life cycle assessment (LCA) assesses a full range of impacts: from extraction of raw materials through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. Impacts taken into account include embodied energy, global warming potential, resource use, air pollution, water pollution, and waste.

1.5 SITING AND STRUCTURE DESIGN EFFICIENCY

The foundation of any construction project is rooted in the concept and design stages. The concept stage has the largest impact on cost and performance. The objective is to minimize the total environmental impact associated with all life-cycle stages of the building project.

1.6 ENERGY EFFICIENCY

Green buildings often include measures to reduce energy consumption – both the energy required to extract, process, transport and install building materials and operating energy to provide services such as heating and power for equipment.

Power generation is generally the most expensive feature to add to a building. The idea is to use renewable sources of energy and optimize the position and design of the building to generate maximum efficiency from the energy investment.

1.7 WATER EFFICIENCY

Reducing water consumption and protecting water quality are key objectives in sustainable building. The critical problem is that the demands on the supplying aquifer exceed its ability to replenish itself. Increasing dependence on water that is collected, used, purified, and reused on-site can be of great value. Waste-water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads. Water quality and energy efficiency while reducing the amount of water in circulation constitute the main objective.

1.8 MATERIAL EFFICIENCY

Building materials should be extracted and manufactured locally to the building site to minimize the energy used in their transportation. Wherever possible, building elements should be manufactured off-site and delivered to site, to maximize benefits of off-site manufacture including minimizing waste, maximizing recycling (because manufacture is in one location), high quality elements, less noise and dust.

2. GREEN BUILDING RATING SYSTEM

It is an evaluation tool that measures the environmental performance of a building through the course of its life cycle. It includes various criteria related to design, construction and operation of a green building. Each criterion has pre-assigned points.

Benefits of green rating include:

- Reduced energy consumption without sacrificing the comfort levels (lower operational costs)
- Reduced water consumption
- Reduced system sizes (HVAC, transformers) for optimal performance at local conditions
- Reduced investment (lifecycle cost)
- Reduced destruction of natural areas, habitats and biodiversity; reduced soil loss from erosion
- Reduced air, water pollution (health benefits)
- Limited waste generation (recycle and reuse)
- Reduced pollution loads
- Increased user productivity
- Enhanced image and marketability (influence property rates)
- Landscape design, solar passive design and architecture, building energy system, renewable energy and plumbing engineering

2.1 EXISTING GREEN RATING SYSTEMS

2.1.1 GRIHA (Green Rating for Integrated Habitat Assessment)

The system has been developed to help ‘design and evaluate’ new buildings. A building is assessed based on its predicted performance over its entire life cycle – inception through operation. The stages of the life cycle that have been identified for evaluation are:

- Pre-construction stage
- Building planning and construction stages
- Building operation and maintenance stage

The rating system is based on accepted energy and environment principles through a balance between established practices and emerging concepts, both national as well as international.

A green building:

- Minimizes demand of non-renewable resources
- Maximizes the utilization efficiency of these resources
- Maximizes reuse, recycling, and utilization of renewable resources
- Maximizes the use of efficient building materials and construction practices
- Uses minimum energy to power itself
- Uses efficient equipment to meet its lighting, air conditioning and other needs
- Maximizes the use of renewable sources of energy
- Uses efficient waste and water management practices
- Provides comfortable and hygienic indoor working conditions
- Green Building Design
- Site Planning
- Building envelope design
- Building system design (HVAC – heating, ventilation and air conditioning; lighting, electrical and water heating)
- Integration of renewable energy sources to generate energy on site
- Water and waste management
- Selection of ecologically sustainable materials (with high recycled content, rapidly renewable resources with low emission potential)
- Indoor environment quality (maintains indoor thermal and visual, comfort and air quality)

2.1.2 CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)

It was adopted in 2001 in Japan. The CASBEE major categories of criteria include:

- Building Environment Quality and Performance
Indoor environment (noise and acoustics, thermal and visual comfort, and indoor air quality)
- Quality of Services (functionality and usability, amenities, durability and reliability, flexibility and adaptability)
- Outdoor environment on site (preservation and creation of biotope, townscape and landscape, local characteristic and outdoor amenities)
- Building Environmental Loadings
- Energy (building thermal load, utilization of natural energy, efficiency in building service systems, and efficient operations)
- Resources and materials (water conservation, materials of low environmental loads)

- Off-site environment (air pollution, noise and vibration, odor, sunlight obstruction, light pollution, heat island effect, and load on local infrastructure)

Every criterion is ranked at a scale from level 1 to level 5.

Level 1: Meeting minimum requirements

Level 3: Meeting typical technical and social levels

Level 5: High level of achievement

CASBEE results are presented as a measure of eco-efficiency or BEE (Building Environmental Efficiency). Results are plotted on a graph with environmental load on one axis and quality on the other axis; the best buildings fall in the section representing lowest environmental load and highest quality.

2.1.3 GB Tool (Green Building Tool)

It was developed by the International Framework Committee for the Green Building Challenge, and international project with more than 25 countries involved.

GB Tool major categories of criteria:

- Energy consumption is assessed through total use of non-renewable energy (embodied and operational), electrical demand, usage of renewable energy and commissioning.
- Resource consumption is assessed through materials used -salvaged, recycled, bio-based and sustainably harvested, locally produced, designed for disassembly, reuse or recycling and water use for irrigation, building systems and occupant use.
- Environment loading includes Green House Gas (GHG) emissions, other atmospheric emission, solid wastes, waste water, site impact, and other local and regional impacts.
- Indoor environment quality is assessed through indoor air quality, ventilation, temperature and relative humidity, daylight and illumination, noise and acoustics.
- Other criteria include selection of appropriate site (in terms of land use, brown fields, access to transportation and amenities), project planning, urban design (density, mixed uses, compatibility, native species and wildlife corridors), building controls, flexibility and adaptability, maintenance of operating performance and a few social and economic measures.

2.1.4 LEED (Leadership in Energy & Environmental Design)

LEED is a green building tool that addresses the entire building lifecycle recognizing best-in-class building strategies. At its core, LEED is a program that provides third-party verification of green buildings. Within each of the LEED credit categories, projects must satisfy prerequisites and earn points. The number of points the project earns determines its level of LEED certification.

Main credit categories

- Sustainable sites credits encourage strategies that minimize the impact on ecosystems and water resources.
- Water efficiency credits promote smarter use of water, inside and out, to reduce portable water consumption.
- Energy & atmosphere credits promote better building energy performance through innovative strategies.
- Materials & resources credits encourage using sustainable building materials and reducing waste.
- Indoor environmental quality credits promote better indoor air quality and access to daylight and views.

2.1.5 GNH (Gross National Happiness)

The concept of GNH in Bhutan is a novel and innovative way of measuring how happy the people are. This happiness quotient depends on multidimensional factors other than the family income, which is most commonly looked as the source of “happiness”. The following table represents the evaluation scheme of GNH.

	Domain	Indicators
1	Psychological wellbeing	4
2	Health	4
3	Time use	2
4	Education	4
5	Cultural diversity and resilience	4
6	Good Governance	4
7	Community vitality	4
8	Ecological diversity and resilience	4
9	Living standards	3
	Total	33

Table 1: Overview of GNH domains and breakdown of indicators

2.2 LIST OF COMMON CRITERIA

After having studied the various global and local green rating systems, we prepared a small list of common criteria across all these rating systems, they are:

- Preserve and protect landscape during construction
- Soil conservation
- Renewable energy based hot water system
- Waste water treatment

- Water reuse and recycle (rainwater)
- Storage and disposal of wastes
- Sustainable site planning
- Water management
- Energy optimization
- Sustainable building materials
- Innovation
- Building operation and maintenance
- Health and well-being
- Waste management
- Education
- Amenities such as market connectivity
- Proximity to health care centers
- Security
- Satisfaction

The intention of studying this literature extensively was to create a list of parameters that would serve specifically for our project. On the basis of these parameters we prepared a survey. This survey would facilitate the collection of primary data which would later be studied and analyzed to fulfill the objectives of the project.

3. OBJECTIVES

- To study the existing green rating systems across the world and identify their relevance to the context of the ongoing project
- To enlist relevant parameters for assessing the environmental performance and quality of pre-selected colonies under the purview of the project
- To develop an Environmental Performance & Quality Index (EPQI) for green rating of colonies in Delhi
- To survey ten colonies under five urban environments and rate them using the aforementioned EPQI

4. METHODOLOGY

After an extensive study of literature concerning green buildings and the various rating systems developed in order to measure their environmental performance, we proceeded to make our own list of parameters which broadly covered not only the environmental performance parameters but also the general performance parameters.

On the basis of these parameters we prepared questions that were to be a part of our survey. This survey was a result of continuous efforts of structuring and re-structuring the questions to increase the degree of their relevance.

Once the survey was in place, we undertook field trips to the target areas to collect the primary data. This data collected was then recorded for further analysis. On the basis of this analysis, we rated the performance of the colonies numerically as well as qualitatively through a star rating system that we have developed. We pictorially represented this result and discussed it in order to arrive on a conclusion and a set of recommendations that our study had enabled us to make.

QUESTIONNAIRE

This Survey is being carried out by students pursuing B.Tech in Innovation with Mathematics & IT from Cluster Innovation Center, University of Delhi as a prerequisite to develop a system for Rating the performance of Colonies in South Delhi as a part of Semester Long Project.

S.No.	Parameter	Maximum Points
1	Public Parks /Green Areas	5
1.1	Are there Green Areas (parks/gardens) in your colony?	1
1.2	Are these green areas properly maintained?	2
1.3	Are the trees concretized?	2
2	Parking Space	2
2.1	Are there enough parking spaces in your colony?	1
2.2	Is there a reserved parking space/basement available?	1
3	Water Supply	3
3.1	What is the duration of water supply in a day?	2
3.2	Recycle/Reuse of water	1
4	Waste	4
4.1	Is the system of waste collection in your colony efficient?	1
4.2	How many <i>dhallaons</i> are there in/near your colony?	1
4.3	Are these <i>dhallaons</i> well maintained?	2
5	Efficiency of Sewage System	4
5.1	Is the sewage system of your colony efficient?	2
5.2	Is the sewage system equipped to deal with the monsoon downpour?	2
6	Connectivity to public transport and market	3
6.1	Is your colony well connected to public transport and market?	1
6.2	Proximity to nearest bus stand(within 1 km or more than 1 km)	1
6.3	Proximity to nearest metro station (within 1 km or more than 1 km)	1
7	Civic Amenities	3
7.1	Proximity of your colony to a hospital or a PHC (Public Health Center)?	1
7.2	What is the proximity of your colony to a fire station?	1
7.3	How frequently does your colony face power-cut in a month?	1
8	Mixed Land Use	2
8.1	Is there any mixed-land use in the colony?	2
9	Security	3
9.1	Does your colony have security guards or gates/fencing?	2
9.2	CCTV/ intercom/ personal guards	1
10	Happiness	4
10.1	Cultural Diversity (Interaction/cultural events/Harmony)	1
10.2	How secure do you feel in your house? (Very secure/ Secure/Unsecure)	1
10.3	Crime in Colony (theft/steal/robbery/pick pocket)	1
10.4	How satisfied are you with your living? (Job/ housing/access to basic services) (very satisfied/ satisfied/ unsatisfied)	1
11	Sustainability	5
11.1	Is your colony leaving scope for more green spaces?	5

OUR OBSERVATIONS

1. How many parks are there in the colony?
Less than, equal to 2 or more
2. Is adequate parking space available in the colony?
Yes or No
3. Does an efficient sewage system exist in the colony?
Yes or No
4. Is the colony clean?
Very clean, clean or untidy
5. How many dhallaons are there? Are they well maintained?
1 or 2 or more than 2 and Yes or No
6. Are utilities (connectivity to market etc.) available?
Yes or No
7. Is public transport available?
Yes or No
8. Are auto-rickshaws available for commuting to nearby place?
Yes or No
9. How far is the daily necessity and chemist shop?
At less than 2 km. or more than 2 km.
10. How many street lights are there in the colony?
Less than 10 or more than 10
11. What quality infrastructure does the colony have?
Very good, good or poor quality
12. Is the colony an Urban Village?
Yes or No
13. Does the colony have a gate?
0 Gate or 1 Gate or More than 1 gate
14. Does the colony have a security system in place?
Yes or No
15. What is the approximate number of trees?
Less than, equal to 15 or more than 15
16. Is there adequate spacing between these trees?
Less than, equal to 1m or more than 1m

5. RESULTS

The ten colonies that were surveyed have been illustrated in Figure 1.

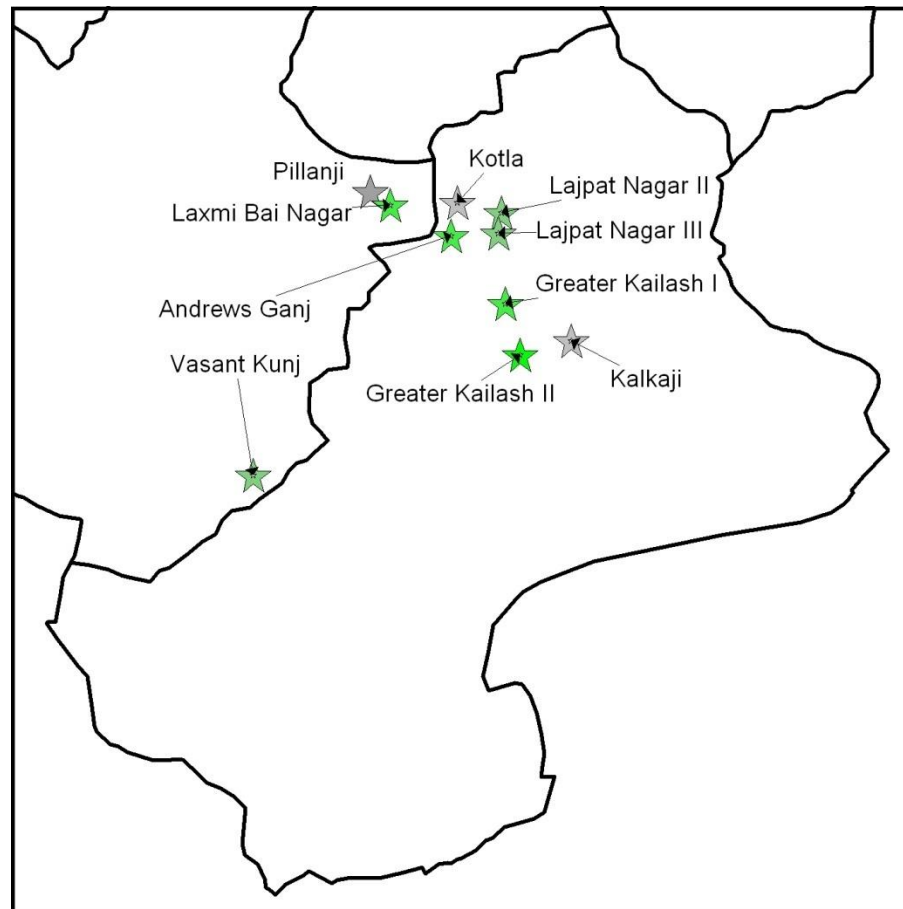
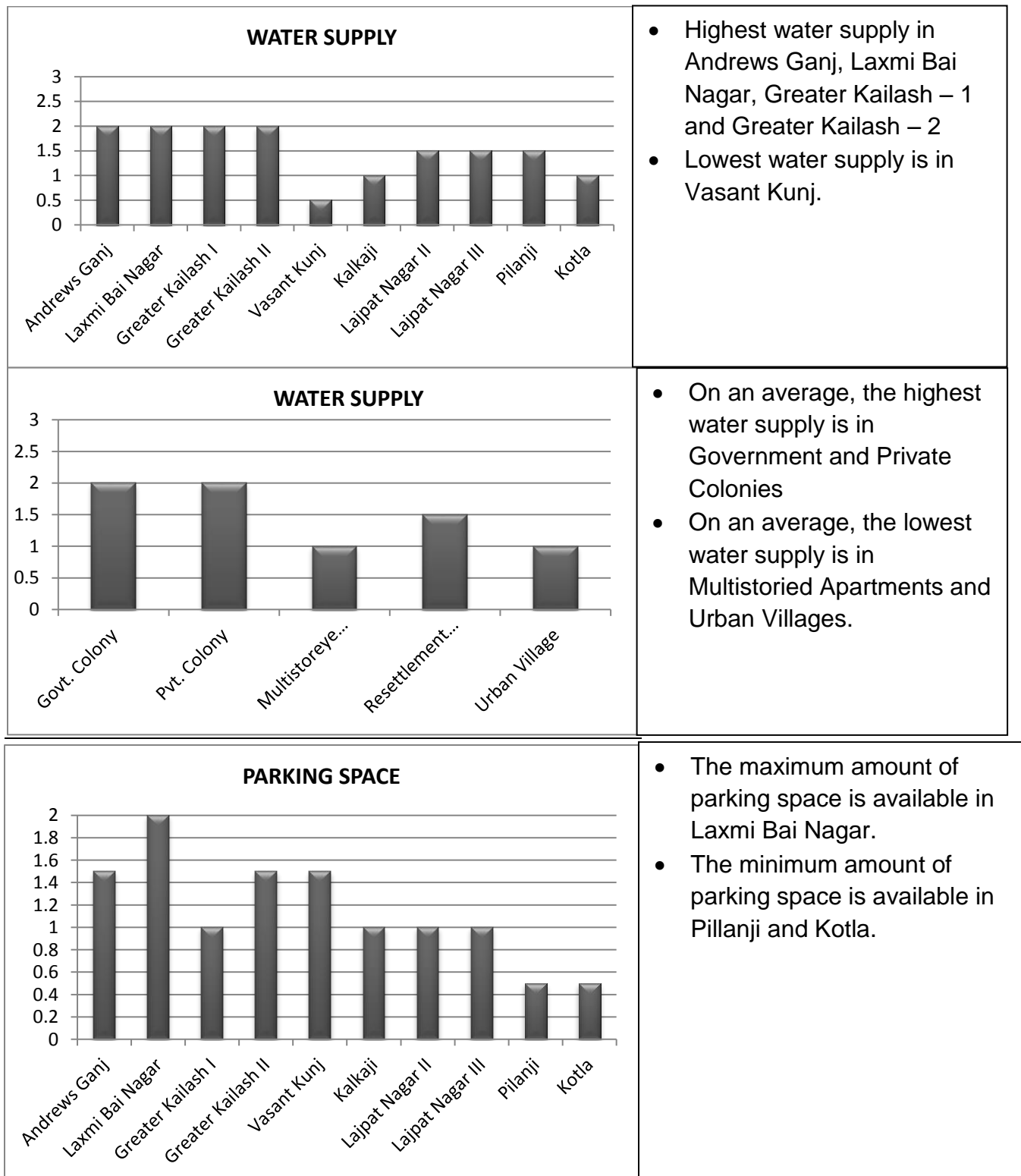
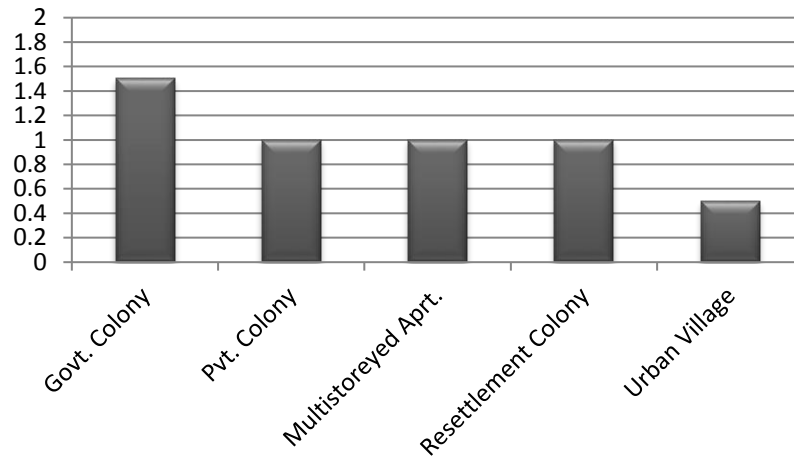


Figure 1. Map of South Deli district showing the location of the ten colonies surveyed.

After surveying these colonies, we obtained the following results:

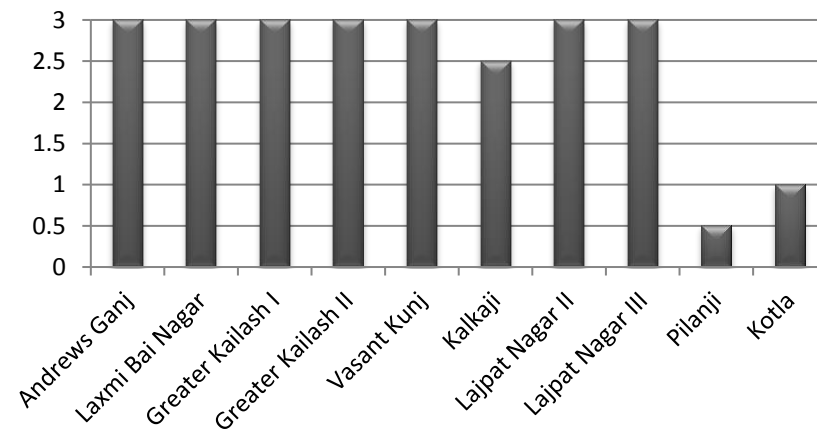


PARKING SPACE



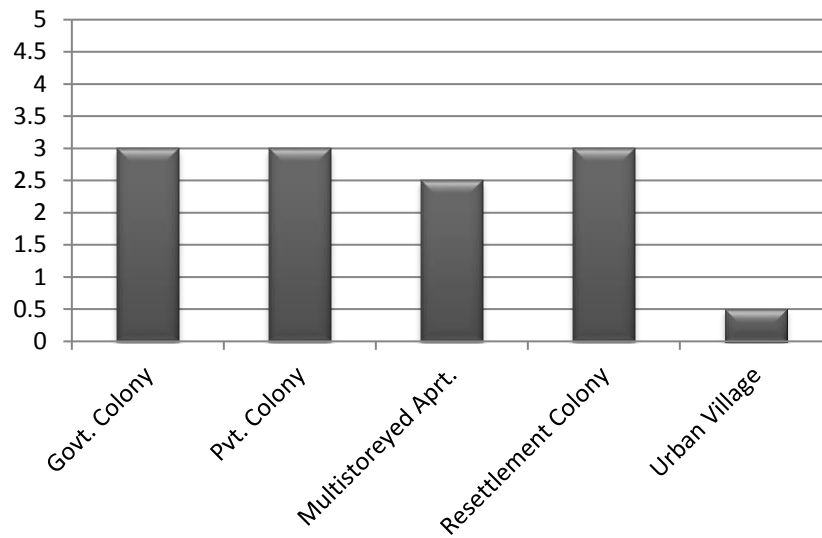
- On an average, the maximum amount of parking space is available in Government Colonies.
- On an average, the minimum amount of parking space is available in Urban Villages.

PUBLIC PARKS/GREEN AREAS



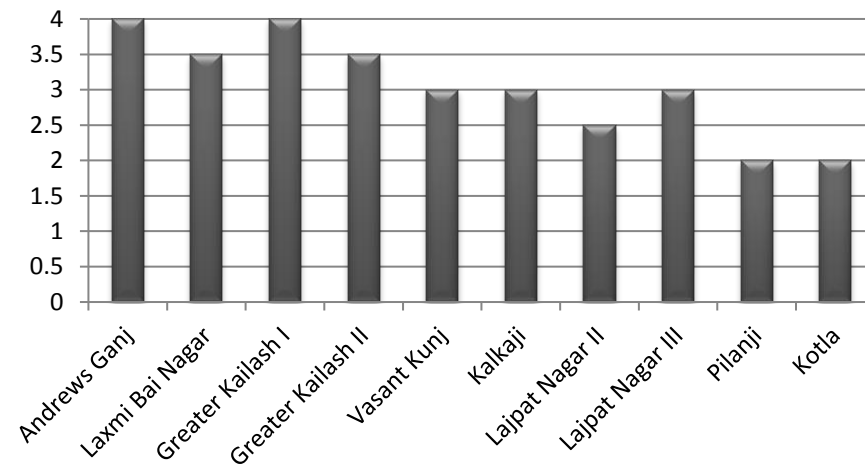
- The maximum green areas can be found in Andrews Ganj, Laxmi Bai Nagar, Greater Kailash – 1, Greater Kailash – 2, Vasant Kunj, Lajpat Nagar – 2 and Lajpat Nagar -3.
- The minimum green areas can be found in Piliangji.

PUBLIC PARKS/GREEN AREAS



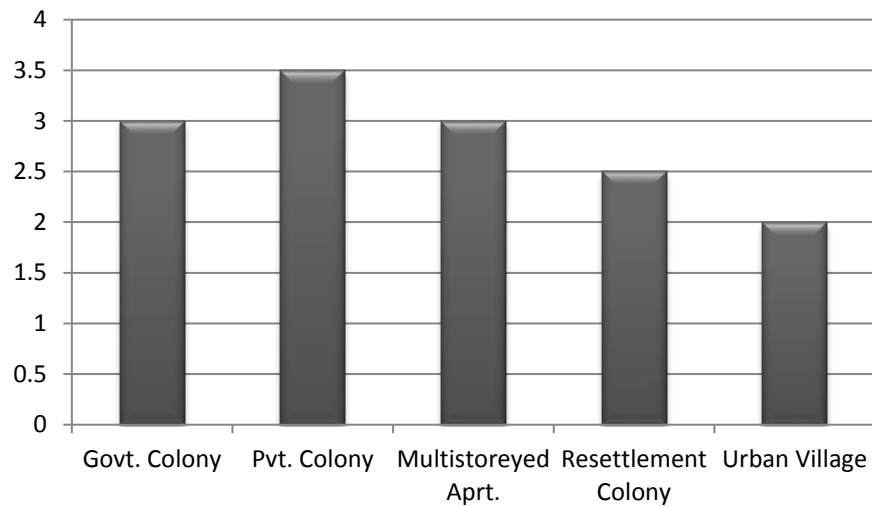
- On an average, maximum green areas can be found in Government, Private and Resettlement Colonies.
- On an average, minimum green areas are found in Urban Villages.

EFFICIENT WASTE DISPOSAL



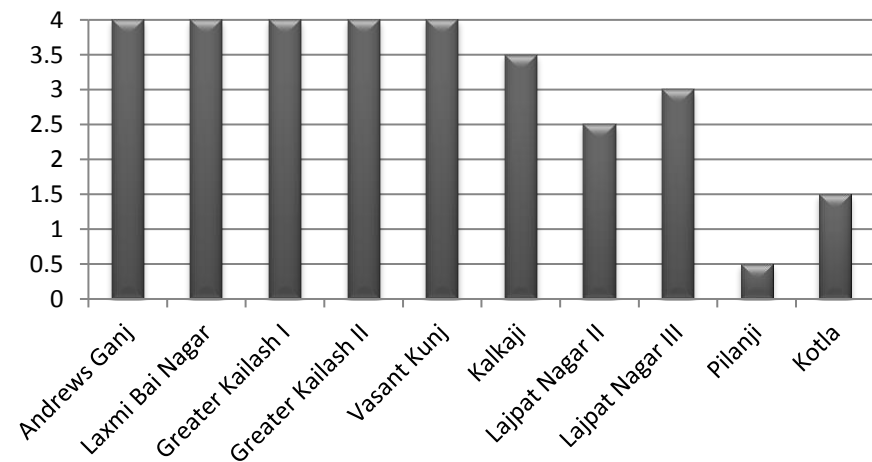
- The most efficient waste disposal system can be found in Andrews Ganj and Greater Kailash – 1.
- The least efficient waste disposal system can be found in Piliangji and Kotla.

EFFICIENT WASTE DISPOSAL



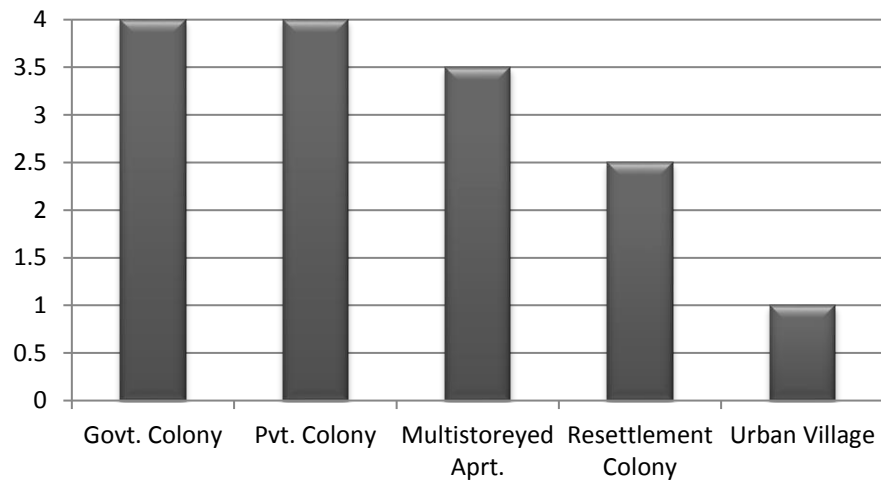
- On an average, the most efficient waste disposal system can be found in Private Colony.
- On an average, the least efficient waste disposal system can be found in Urban Villages.

EFFICIENT SEWAGE SYSYTEM



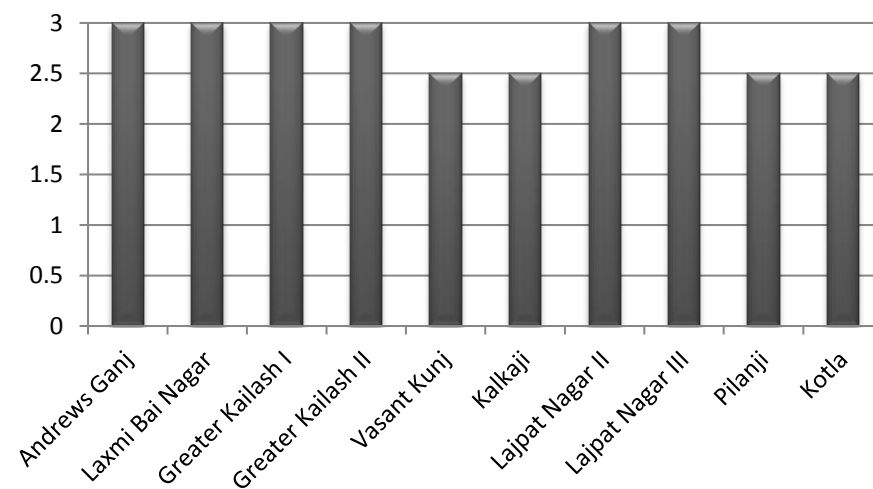
- The most efficient sewage system can be found in Andrews Ganj, Laxmi Bai Nagar, Greater Kailash – 1, Greater Kailash – 2 and Vasant Kunj.
- The least efficient sewage system can be found in Piliandji.

EFFICIENT SEWAGE SYSTEM

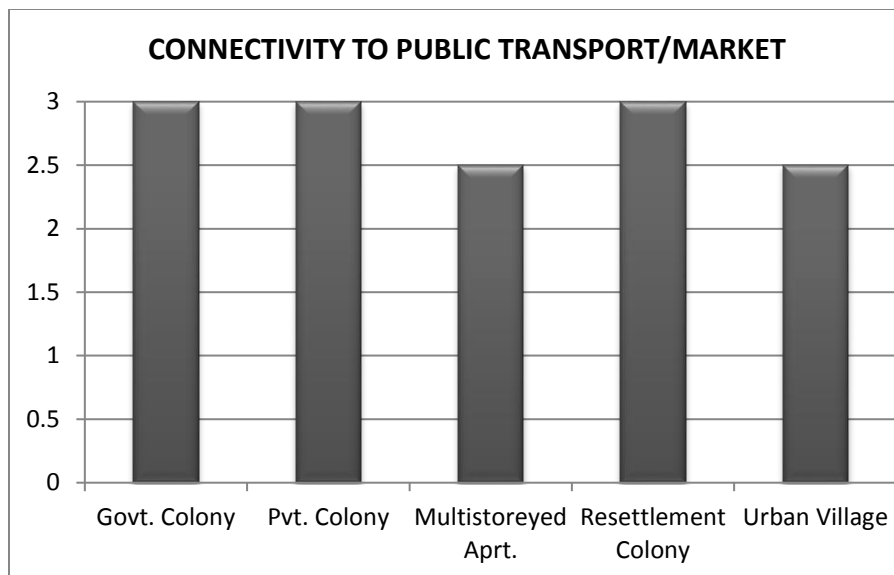


- On an average, the most efficient sewage system can be found in Government and Private Colonies
- On an average, the least efficient sewage system can be found in Urban Villages

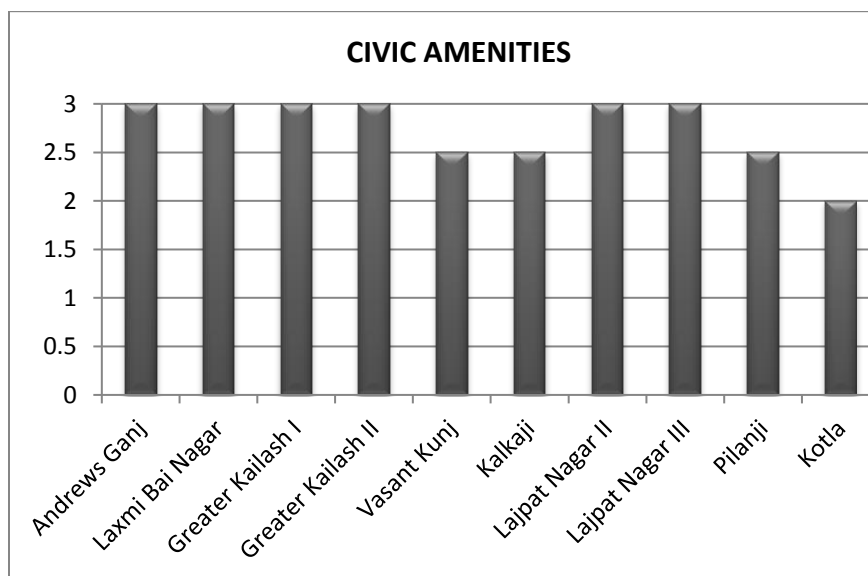
CONNECTIVITY TO PUBLIC TRANSPORT/MARKET



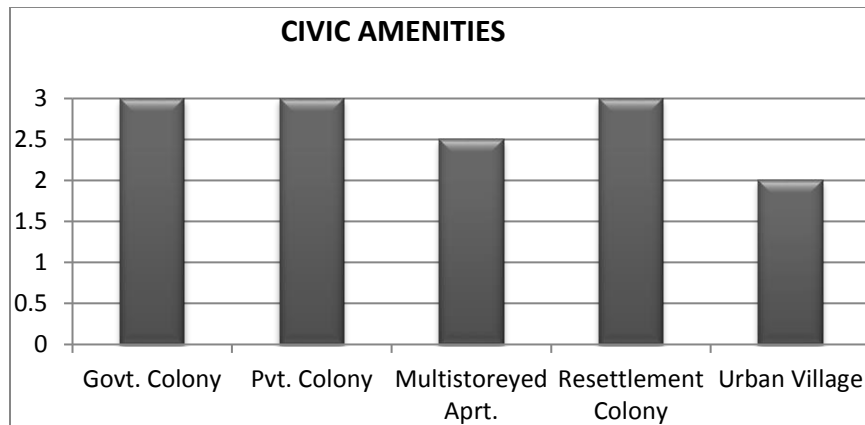
- The best connectivity to public transport and market can be found in Andrews Ganj, Laxmi Bai Nagar, Greater Kailash – 1, Greater Kailash – 2, Lajpat Nagar – 2 and Lajpat Nagar – 3
- The least good connectivity to public transport and market can be found in Vasant Kunj, Kalkaji, Pilihari and Kotla



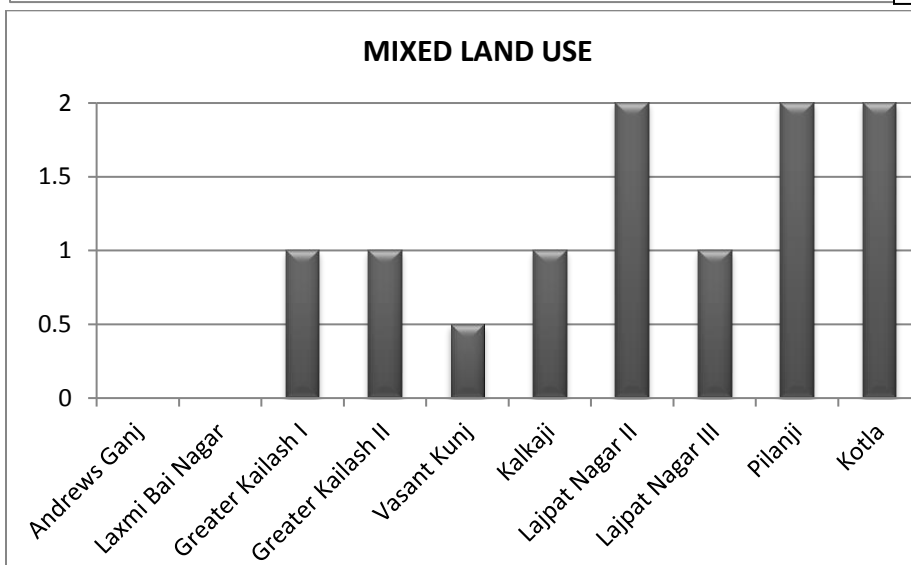
- On an average, the best connectivity to public transport and market can be found in Government, Private and Resettlement Colonies.
- On an average, the least good connectivity to public transport and market can be found in Multistoried Apartments and Urban Villages.



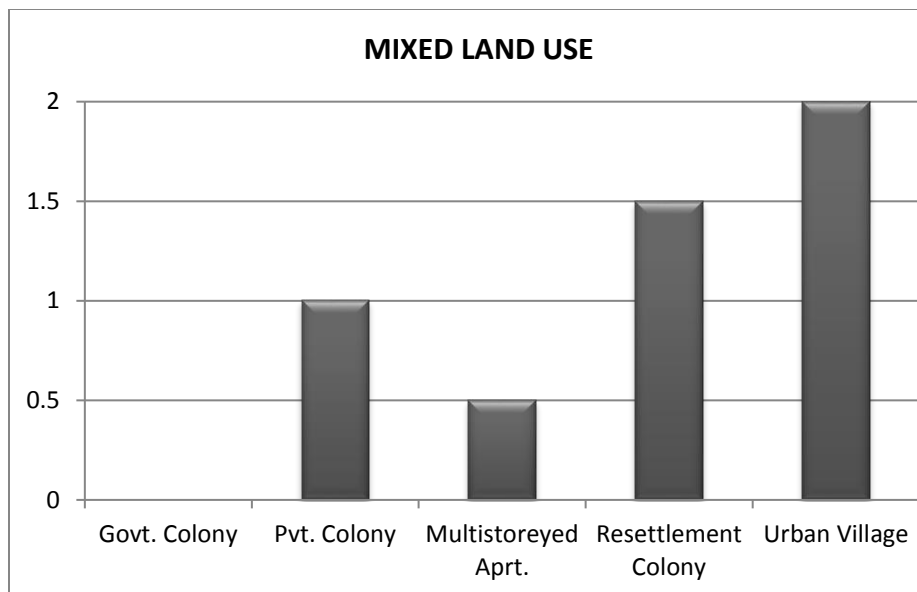
- The best civic amenities are available in Andrews Ganj, Laxmi Bai Nagar, Greater Kailash – 1, Greater Kailash – 2, Lajpat Nagar – 2 and Lajpat Nagar – 3.
- The least good civic amenities are available in Kotla.



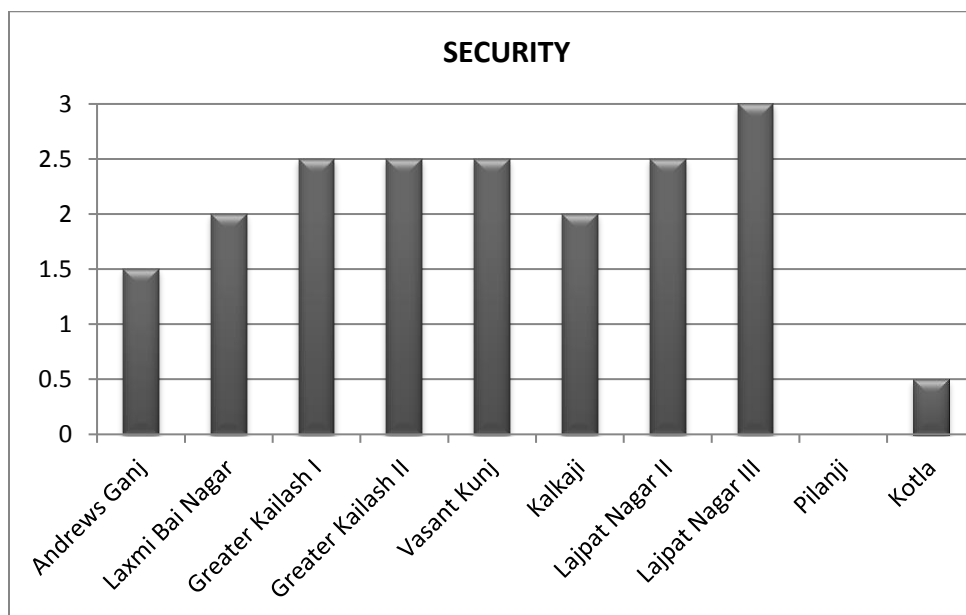
- On an average, the best civic amenities can be found in Government, Private and Resettlement Colonies.
- The least good civic amenities can be found in Urban Villages.



- The maximum mixed land use can be found in Lajpat Nagar – 2, Kotla and Piliangji.
- The minimum mixed land use can be found in Andrews Ganj and Laxmi Bai Nagar.

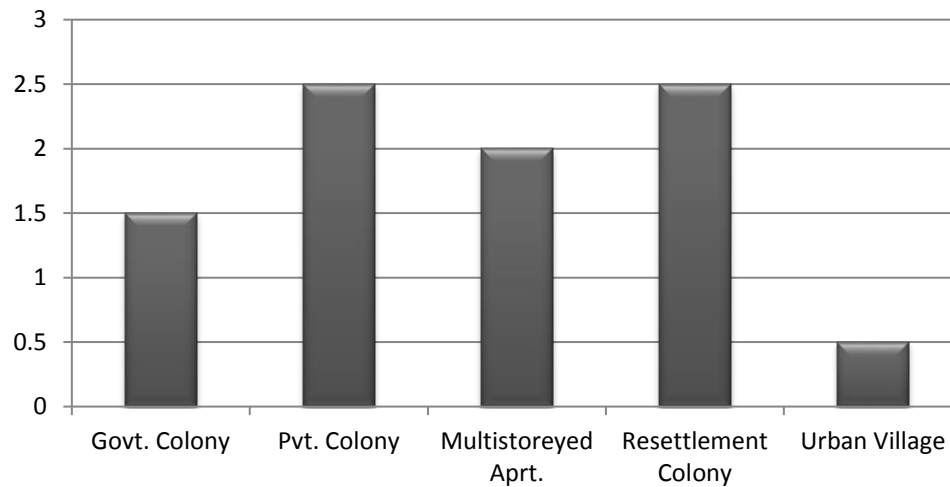


- On an average, the maximum mixed land use can be found in Urban Villages.
- On an average, the minimum mixed land use can be found in Government Colonies.



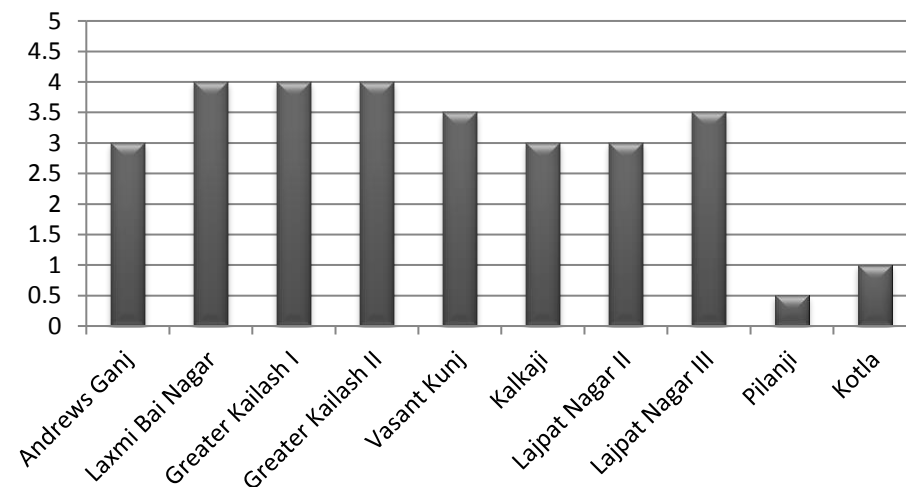
- The maximum provisions of security can be found in Lajpat Nagar -3.
- The minimum provisions for security can be found in Piliangji.

SECURITY



- On an average, the maximum provisions of security can be found in Private and Resettlement Colonies.
- On an average, the minimum provisions for security can be found in Urban Villages.

SUSTAINABILITY



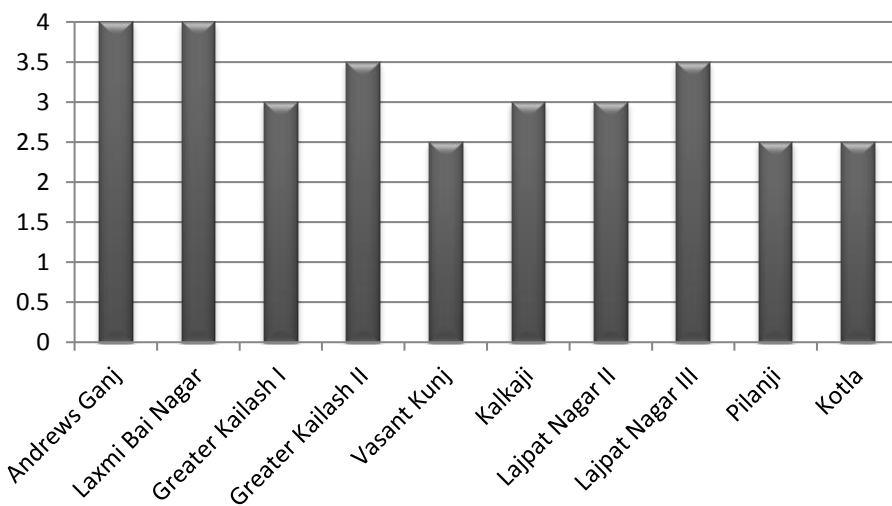
- The maximum environmental sustainability can be found in Laxmi Bai Nagar, Greater Kailash – 1 and Greater Kailash – 2.
- The minimum environmental sustainability can be found in Kotla.

SUSTAINABILITY



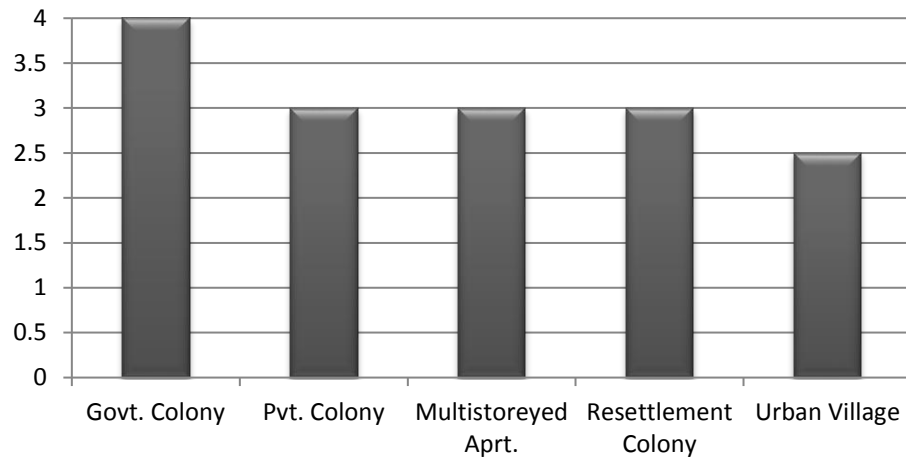
- On an average, the maximum environmental sustainability can be found in Private Colonies.
- On an average, the minimum environmental sustainability can be found in Urban Villages.

HAPPINESS



- The maximum happiness can be found in Andrews Ganj and Laxmi Bai Nagar.
- The minimum happiness can be found in Vasant Kunj, Piliangji and Kotla.

Happiness



- On an average, the maximum happiness can be found in Government Colonies.
- On an average, the minimum happiness can be found in Urban Villages.

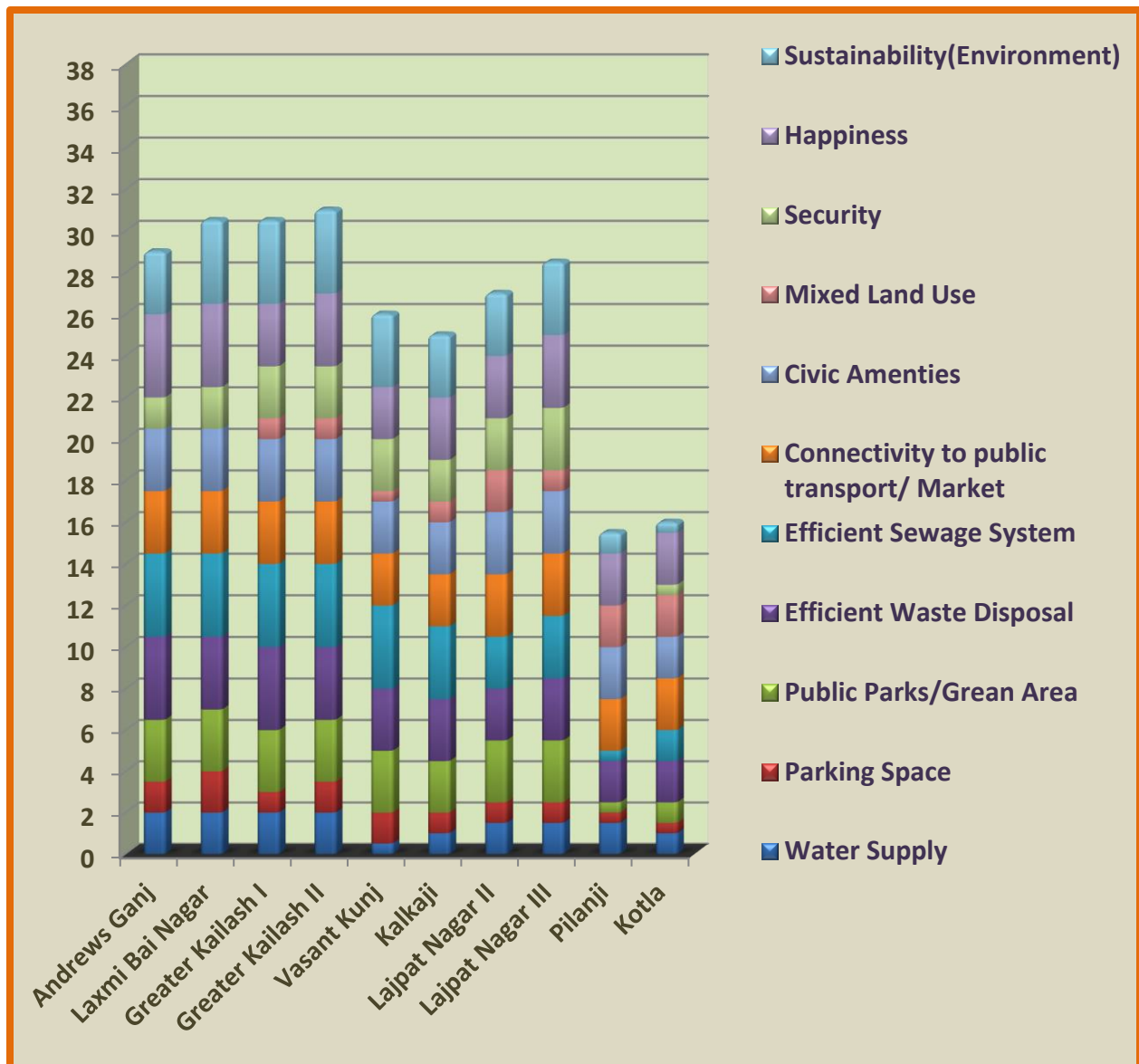


Figure 2. Comparative green rating of individual colonies. Greater Kailash-II has been found to be the highest performing colony while Piliandji has been found to be the lowest performing colony.

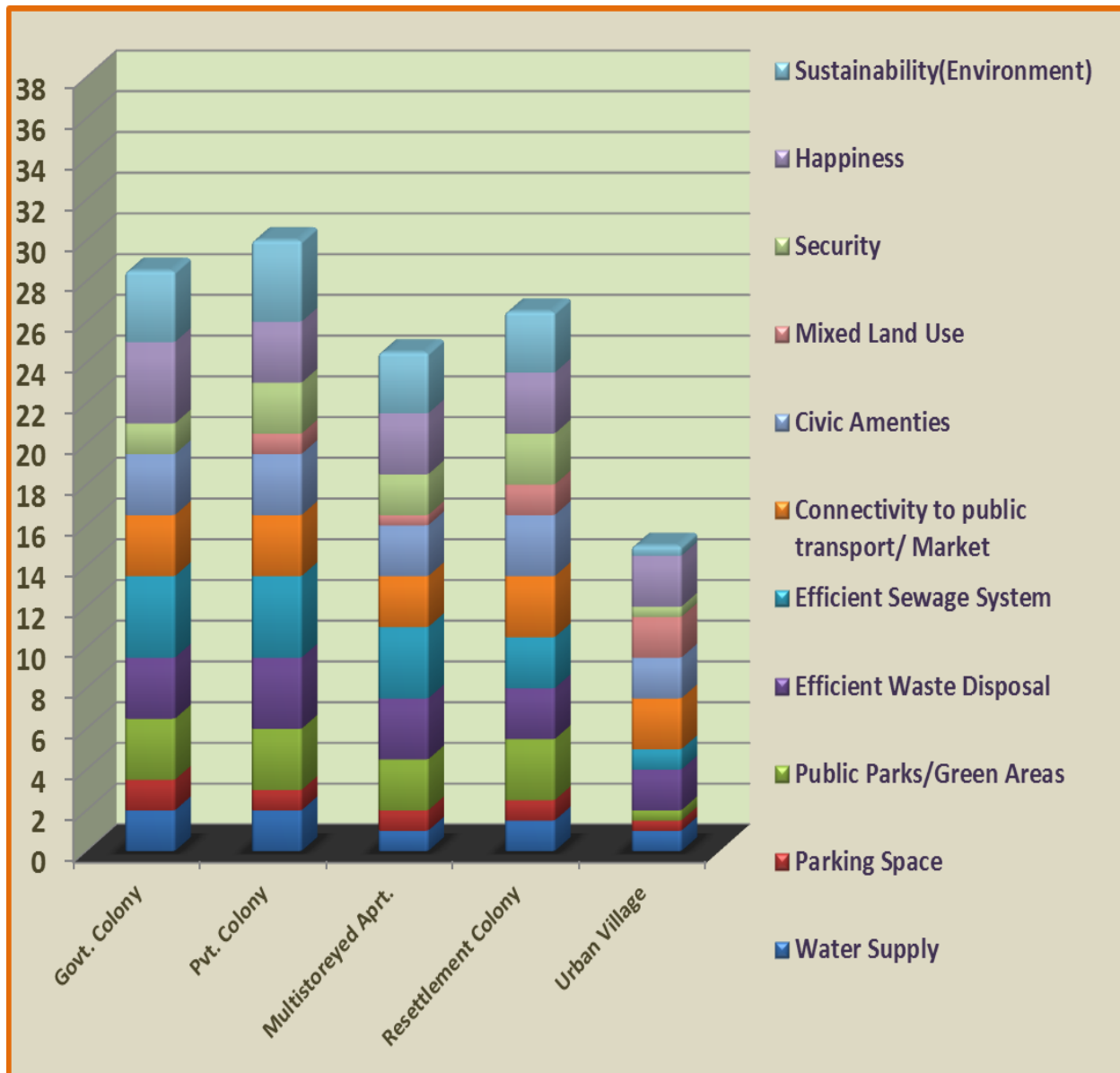


Figure 3. Comparative green rating of urban environments. Private colonies have been found to be the highest performing type of urban environments while the Urban Villages have been found to be the lowest performing type of urban environments.

6. DISCUSSION

The results of various parameters of our study can be reasoned as following:

There is maximum water supply in Government and Private Colonies. It is because there is fair supply of water in Government Colonies while in the Private Colonies people have facilities in place which allow abundant access to water including private motors. The minimum water supply is in Urban Villages and Multistoried Apartments. In Urban Villages as well as Multistoried Apartments, the greater number of floors allows a greater number of people to encroach upon a space that is meant to sustain much lesser. This has created the phenomenon of water shortage in these types of colonies. It is also noteworthy that while Vasant Kunj (Multistoried Apartment) has provision to excellent water quality, this is ground water that the residents extract. This will eventually lead to a crisis by lowering down the ground water table.

There is maximum parking space available in Government Colonies. It is because they are spacious and well planned, allowing almost all the residents a fair share of parking space. There is minimum parking space area available in Urban Villages. It is because the areas of Urban Villages are densely populated, and the migration of rural population to these villages ensures that the lanes are highly congested are that barely any space remains to allow one to park their vehicles. In Urban Villages there is no restriction to the amount of floors that can be built, so anybody is free to move in and build another floor. However, the area of Urban Villages is fixed and so the parking space is unable to accommodate these new residents. In the Private and Resettlement Colonies, it has been found that the inadequacy of parking space is in relation with the fact that the residents have more than a single vehicle with some families having around 6 cars; naturally the space for a single car cannot accommodate the other extras.

There are maximum green areas in Government, Private and Resettlement Colonies. The Government Colonies are well planned and so they house sufficient green areas; while people also have private lawns within the premises of their flats. The Private Colonies have a likeable amount of verdure with a lot of residents having private lawns of their own. The common green areas of these colonies are huge, green and well maintained. The Resettlement colonies have abundant parks too, with a few houses accommodating private lawns. We also observed a unique blend of flora and fauna in the Royal Plum Park situated in Lajpat Nagar – 2, Block – A which accommodated ducks, rabbits and a variety of birds. The minimum amount of green spaces has been observed in the Urban Villages, where the residents barely have any space to accommodate a park. Whatever parks we observed were devoid of grass, and there seemed no greenery in and around the place.

The most efficient waste disposal system is in Private Colonies, where private contractors come and collect the waste every day. Moreover, the maids of the house are also responsible for the

garbage disposal. This two tier model results in great efficiency of waste disposal. The least efficient waste disposal system is in Urban Villages where no private contractors have been hired; the residents dump their garbage into the MCD Vans whenever they come and in their absence they dump them at the corners of the street. The people living on rent do not care much about garbage disposal and the stray animals feed on the garbage, making the roads more dirty and unkempt.

The most efficient sewage system is in Government and Private Colonies. The Government colonies, as mentioned earlier are well planned and built to deal with the sewage effectively. Also, any complaint about blockage is immediately looked into by the authorities. The Private Colonies have a well-developed sewage system and any issues regarding it get rectified easily. The least efficient sewage system is in the urban villages. The open drainage system of most of the Urban Villages is in a primeval state and not developed enough to deal with the sewage and the monsoon downpour. Congested lanes and dirty roads have worsened the condition further.

The best connectivity to public transport system and markets can be found in Government, Private and Resettlement Colonies. The Government Colonies have general provision stores owned by the government situated within the colony and the residents have access to public transport. The Private and Resettlement Colonies have markets situated nearby and some shops are situated within the colonies; and they have good connectivity to public transport. The least good connectivity to public transport system and markets can be found in Urban Villages and Multistoried Apartments. These are considerably far off from the metro stations as compared to the other colonies.

The highest quality civic amenities can be found in Government, Private and Resettlement Colonies. The Government Colonies have government dispensaries, broad and clean roads with tree lined buffers, government schools and fire stations nearby along with rare power cuts. The Private and Resettlement Colonies have broad and clean roads, excellent health care provisions with hospitals, dispensaries and private clinics in the vicinity, private schools and fire stations nearby along with rare power cuts. The lowest quality civic amenities can be found in Urban Villages. Health care facility units are situated at a greater distance as compared to the other colonies; the roads are dirty and congested and fire station at a greater distance as compared to the other colonies. We came across an NDMC School in Pillanji, of which the residents complained that there was no quality education being provided there and a school we came across in Kotla Mubarakpur was in a dilapidating state.

There is maximum mixed land use in the Urban Villages where the residential area almost coincides with the area for commercial activities. There is minimum mixed land use in the Government Colonies. Almost all of the commercial activities within a Government Colony are Government enterprises.

There are maximum security provisions in Private and Resettlement Colonies where they have common security guards, private security guards, colony gates, CCTV Cameras installed in the premises of the colony and an Intercom system installed in most of the houses. There are minimum security provisions in Urban Villages with no security guards and no colony gates.

Happiness as a parameter is inclusive of harmony among colony residents, interaction between the colony residents, sense of security in the colony, rarity of crime and thefts, sense of satisfaction of job, living and access to basic amenities. There is maximum happiness in Government Colonies as there is sufficient interaction amongst the neighbors, sense of security and infrequent incidences of crime and thefts and high sense of satisfaction of job and living along with access to basic amenities. There is minimum happiness in Urban Villages due to a strikingly low sense of security, frequent crimes and thefts, less satisfaction with job and living along with less access to basic amenities.

There is highest environmental sustainability in Private Colonies due to greenery and well planned and built infrastructure. This minimizes the harm done to the environment. There is lowest environmental sustainability in Urban Villages due to the alarming shortage of greenery and green spaces along with congested and roughly built infrastructure.

Urban Environments	Points (EPQI)	Property Rates (2 BHK)	Value of each point
Urban Village	15	Around 40 lakhs	₹2,66,000
Resettlement Colony	26.5	Around 3 crores	₹11,32,000
Multistoried Apartment	24.5	Around 2 crores	₹8,16,000
Private Colony	30	Around 7 crores	₹23,30,000
Govt. Colony	28.5	No sale or purchase	-

The highest performing type of colony on the basis of the EPQI is the Private Colony with the highest property rates. The lowest performing type of colony is Urban Village with the lowest property rates. This shows a direct correlation between the property rates and the standard of living that the colony offers to the residents.

7. CONCLUSION AND RECOMMENDATIONS

We can conclude that Private Colonies are the highest performing colonies with respect to the EPQI. They have sufficient water supply, which is the maximum among all the five types of colonies. As it has been discussed earlier, the inadequacy in parking space can be attributed to the fact most of the families have more than one vehicle while the available space can only accommodate one for each family. They have good parks and green areas. These parks are exceptionally well maintained. Not only this, but most residents have private lawns too. Private Colonies have the most efficient waste disposal system where the residents have private contractors hired to collect the waste daily. Private Colonies have the most efficient sewage system equipped to deal with the monsoon downpour. There is excellent connectivity to markets and public transport in Private Colonies. They also have the advantage of provision of best civic amenities. Mixed land use is a notably common feature. Private Colonies also have the best security system in place with multifarious provisions including gates, guards, CCTV Cameras and Intercom systems. The residents of Private Colonies are sufficiently happy with their living. The greenery of Private Colonies gives them a plus point in terms of environmental sustainability and theirs is a model that the others should emulate.

Urban Villages on the other hand are the least performing colonies. They receive the least water supply among the five types of colonies. They also have the least amount of parking space. There are minimal green spaces and parks in Urban Villages. Urban Villages have the least efficient waste disposal system. The Urban Villages also have the least efficient sewage system along with dirty and congested roads. Urban Villages have lesser connectivity to market and public transport among the five types of colonies. Urban Village residents have least access to civic amenities among the five types of colonies. There is maximum mixed land use in Urban Villages where there is no clear demarcation between residential area and commercial area. The Urban Villages have the least provision for security. The residents of Urban Villages are the least happy among the other five types of colonies. The lack of greenery and green spaces in Urban Villages indicates least sustainability.

Despite the difference in living conditions and the population, it is suggested that the Urban Villages urban environment must be improved in order to ensure that the quality of life of the residents of this urban environment is improved. Also, EPQI is found to be a good indicator of comparison of colonies and urban environments in Delhi.

The following is a set of recommendations that we would like to propose:

1. The Environmental Performance & Quality Index (EPQI) can be used for comparing the environmental performance of similar types of urban environments
2. The EPQI can also serve as a helpful tool for the newly developing areas in and around the Delhi.

3. The EPQI can be incorporated in the real estate business (e.g. in real estate dot coms) for enabling users to make appropriate decisions
4. The residents of Urban Villages need to be made more aware of the importance of greenery and sustainability
5. The residents of Urban Villages should be advised to review their infrastructure and invest in restructuring their buildings so as to prepare for disaster management
6. The government should look into the health care facilities of the Urban Village people.
7. The government should look into the waste disposal system and sewage system of the Urban Villages.
8. The people of Private and Resettlement Colonies should be made more aware of the negative impact of the pollution emitted by vehicles and should be discouraged to buy more vehicles.

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