Relationship between Built Form, Travel Behavior and Energy Use in Gated Communities in Bangalore

Building Sustainable, Energy Efficient and Connected Communities in India

October, 2014

EMBARQ India

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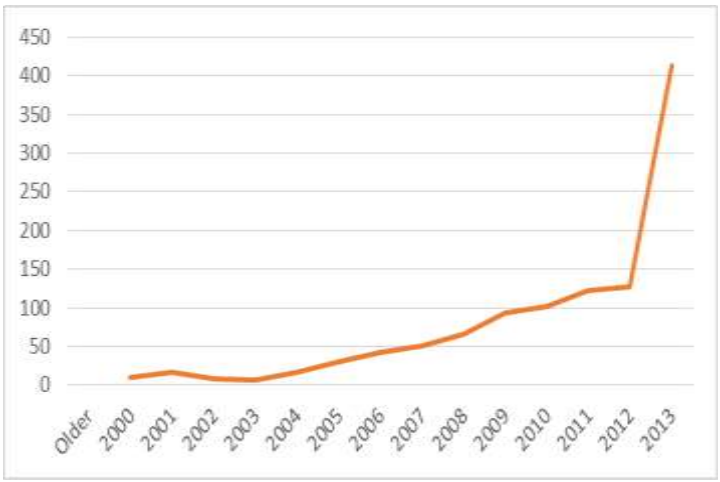
BACKGROUND

Rapid urbanization of mega cities in developing countries creates new challenges for meeting global sustainable energy and emission reduction goals, yet also provides unique opportunities for intervention in urban design and development. Urbanization in countries such as India is increasing incomes and vehicle ownership rates for a growing middle class. This increase in private vehicle ownership threatens sustainability goals by requiring reliance on fossil fuels and the production of additional greenhouse gases from the transportation sector. The energy and emissions associated with transportation can be tempered or aggravated by urban design of the transportation system and neighborhood layouts in which travel takes place.

In addition, rapid motorization also leads to unprecedented growth in the use of fossil fuels. Registered motor vehicles in India are expected to rise from roughly 5 million in 2005 to 600 million in 2050 – about equal to the entire planet's motor vehicle population in 2008 (Wilson 2008) . Transport is therefore the fastest growing sector of energy use and greenhouse gas emissions in India. These trends are especially present in Bangalore, mainly due to population growth and absence of good public transit systems. From 2008 to 2013, there has been an eight to nine percent increase per year in vehicle ownership in Bangalore (Transport Department 2013). In 2011, Bangalore had the equivalent of 85 cars per 1,000 people and with this trend, it is estimated that by 2025 the number of cars in major cities such as Bangalore will increase to an equivalent of 300 cars per 1,000 people (Akshima T Ghate 2014). This means a huge increase in daily trips and vehicle kilometers travelled (VKT), not to mention severe air pollution and traffic safety issues (Harish 2012). Currently, Bangalore has adopted an unsustainable strategy, which is to address electricity shortages and traffic congestion by increasing the supply of fossil fuel-based power plants, roads, highways, and automobile-oriented land uses that catalyze a cycle of motorization.

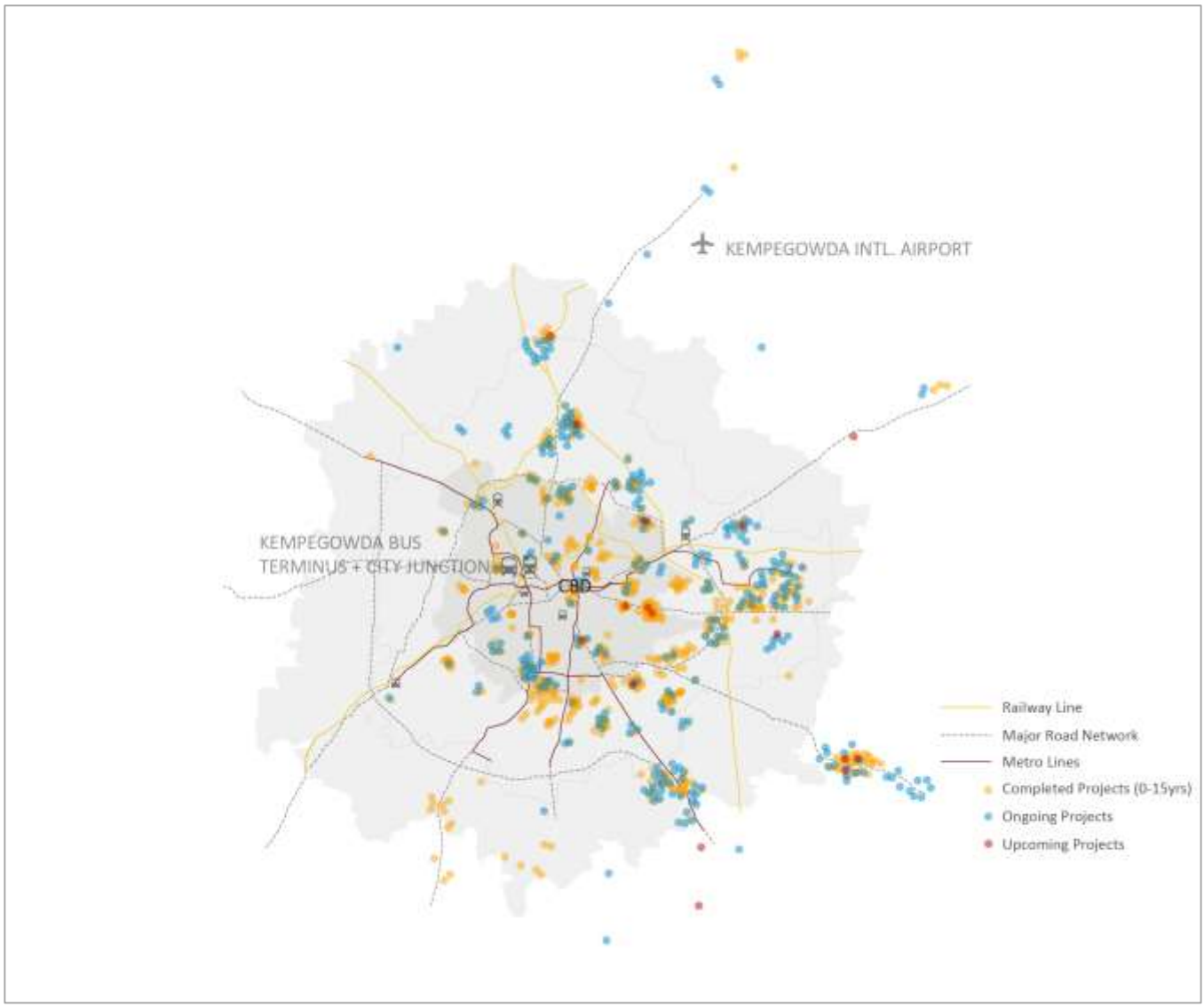
A report by McKinsey and Company in 2009 has estimated that "*India needs to build 700 to 900 million square meters of residential and commercial space each year-equivalent to adding more than two Mumbai's or one Chicago annually*." (E. Glaeser 2011). Spurred by its burgeoning technology sector, due in part to the 'reverse brain drain' (Chacko 2007), Bangalore city more than doubled its population in the past decade, reaching 9.6 million in 2011 and income levels have risen significantly. Bangalore's $83 billion economy (2009) boomed to claim the fourth position among India's top cities, just behind Mumbai, Delhi, and Kolkata. The increase in population and income in turn has resulted in a rapid increase in vehicle ownership rates and demand for housing especially in the upper-middle and middle classes. This demand has been filled by

Figure 1: Gated Communities Completed by Year in Bangalore



Source: www.commonfloor.com

*Figure 2: Spatial Distribution of Gated Communities in Bangalore showing Status of Completion in 2014**



** Ongoing Projects – Refers to projects that are currently under construction; Upcoming Projects – Refers to projects that are currently in master planning stages*

Source: www.commonfloor.com

independent, large-scale residential enclaves, commonly referred to as '*gated communities*' *(GCs)* that are often built through private investments. The sheer rise in number of such car-oriented communities in Bangalore over the last 15 years is represented in Figure 1 and Figure 2.

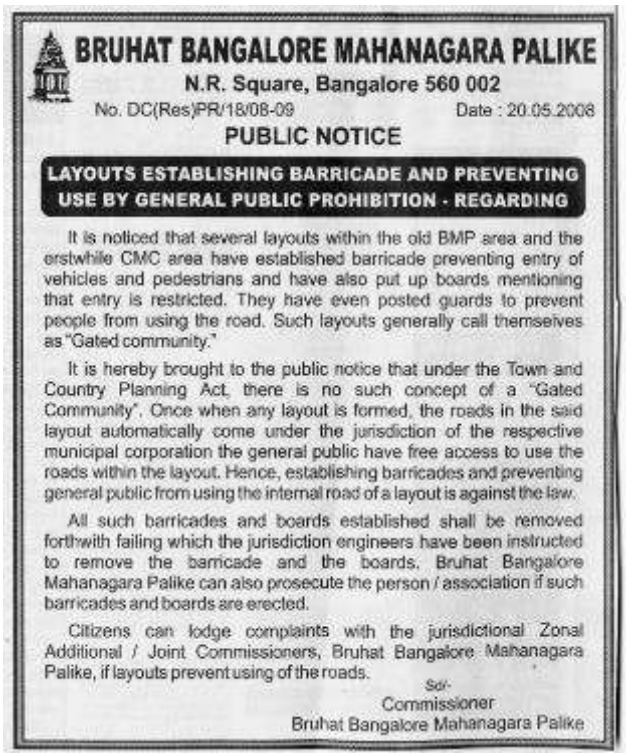
There are more than 1,500 completed gated communities, and almost 500 currently under construction. The data for figure 1 and figure 2 was retrieved from www.commonfloor.com, a website that advertises such residential projects for rent and sale, and indicates the number of GCs completed in each year.

With the smallest of these communities consisting of more than 100 residential units, and sometimes more than 10,000 units, their impact on the built environment is significant and at present without any oversight. They conform to no centralized growth plans or local planning authority regulations as the State of Karnataka and the Bangalore Development Authority lack policies for Gated Communities

(GC) (Ramachandra 2009). Typically state and city town planning policies guide the development of residential townships i.e. large developments comprising hundreds or thousands of dwelling units. However, the State of Karnataka and the Bangalore Development Authority (BDA) do not have a policy on townships and these government agencies discourage developers to form unauthorized residential layouts (BDA n.d.) These agencies do not recognize 'Gated Communities' under the Town and Country Planning Act (Times of India 2008) (Citizen Matters 2010).

Gated Communities are considered just like any other residential layouts and are required to provide space for parks, roads and other common areas. Bruhat Bangalore Mahanagara Palike (BBMP), the Municipal Corporation for the City of Bangalore prohibits walled or barricaded residential layouts (Figure 3). The lack of a comprehensive development policy, difficulties in urban growth regulation (Swilling M. 2013) and the demand for middle and upper class exclusive residences (Mohan 2008) are some of the reasons for the rapid increase in gated communities in the peripheral areas in Bangalore.

Figure 3: BBMP Public Notice Prohibiting Layouts with Restricted Entry, i.e. Gated Communities



BRUHAT BANGALORE MAHANAGARA PALIKE

N.R. Square, Bangalore 560 002

No. DC(Res)PR/18/08-09 Date : 20.05.2008

PUBLIC NOTICE

LAYOUTS ESTABLISHING BARRICADE AND PREVENTING USE BY GENERAL PUBLIC PROHIBITION - REGARDING

It is noticed that several layouts within the old BMP area and the erstwhile CMC area have established barricade preventing entry of vehicles and pedestrians and have also put up boards mentioning that entry is restricted. They have even posted guards to prevent people from using the road. Such layouts generally call themselves as "Gated community."

It is hereby brought to the public notice that under the Town and Country Planning Act, there is no such concept of a "Gated Community". Once when any layout is formed, the roads in the said layout automatically come under the jurisdiction of the respective municipal corporation the general public have free access to use the roads within the layout. Hence, establishing barricades and preventing general public from using the internal road of a layout is against the law.

All such barricades and boards established shall be removed forthwith failing which the jurisdiction engineers have been instructed to remove the barricade and the boards. Bruhat Bangalore Mahanagara Palike can also prosecute the person / association if such barricades and boards are erected.

Citizens can lodge complaints with the jurisdictional Zonal Additional / Joint Commissioners, Bruhat Bangalore Mahanagara Palike, if layouts prevent using of the roads.

Sd/-
Commissioner
Bruhat Bangalore Mahanagara Palike

Although Bangalore serves as a glittering example of how urban agglomeration can bring prosperity to a poor country, the growth has led to unprecedented demand for electricity and mobility, far outstripping how much the city's infrastructure could reliably supply. For example, the state of Karnataka, where Bangalore is the capital city, has a peak electricity-grid deficit of 13.64 percent, as of early 2011 (BMRDA n.d.) Given current growth trends, the electrical energy requirement in Indian megacities like Bangalore is expected to increase by 7% annually, suggesting a doubling of the electricity requirement in 10 years (Projectmonitor 2013).

Businesses and residents cannot rely on the city's dilapidated electricity grid. The 2012 massive power outage in Northern India affected more than 369 million people without electricity for hours (Chaturvedi 2012).In spite of several power purchase agreements, Karnataka faced the maximum energy shortage of 9.5 percent in 2013-2014 (Central Electricity Authority 2014). Of the eight districts that come under the Bangalore Electricity Supply Company (BESCOM) distribution circles(s), Bangalore's electricity consumption is significantly higher due to its consumer distribution rate (The Hindu 2013). Given the growing demand and shortfall in supply, the city must consider increased adoption of clean energy alternatives in collaboration with the private sector.

As shown in Figure 2, over 5,000 acres of Bangalore are currently being developed as GCs, located mostly in the peripheral areas of the city and designed to be car dependent (T. a. Litman 2014). This locks residents into highly energy-intensive travel and lifestyle patterns. Residents have no option but to use motorized vehicles to travel to, from and within these townships, and businesses must use inefficient, highly polluting diesel back-up generators to meet peak electricity demand (E. Glaeser

2010). In fact, these townships are often popular because they offer the availability of backup electricity during power cuts, which is also primarily diesel–fueled.

Research by Ramachandra and Uttam (2009) shows that there has been a 466% increase in the built up area of Bangalore from 1973 to 2000 primarily along the main growth corridors of the city (Sankhe 2010).

As the interaction of transportation patterns and urban form can be cyclical (T. Litman 2005), the design of the new developments that promote private and motorized transport risks creating and perpetuating sprawled growth and unsustainable transport patterns and an increase in vehicle kilometers travelled (VKT). Transportation thus has a strong spatial structuring effect on cities.

There is great urgency to address these long-term trends and understand the interaction of urban form and travel behavior in rapidly developing countries to avoid letting these new developments lock into a pattern of urban sprawl and unsustainable transport patterns. The need for large-scale developments in India creates an opportune time for auditing plans and recommending interventions to shape these new communities such that they promote increased use of non-motorized transit (NMT) and public transit. Through a focus on design, therefore the energy consumption and emissions generated by private travel to and from newly added residential units in India could be significantly reduced.

Between November 2013 and April 2014, 445 households were surveyed in 6 existing gated communities in Bangalore.

Project Approach

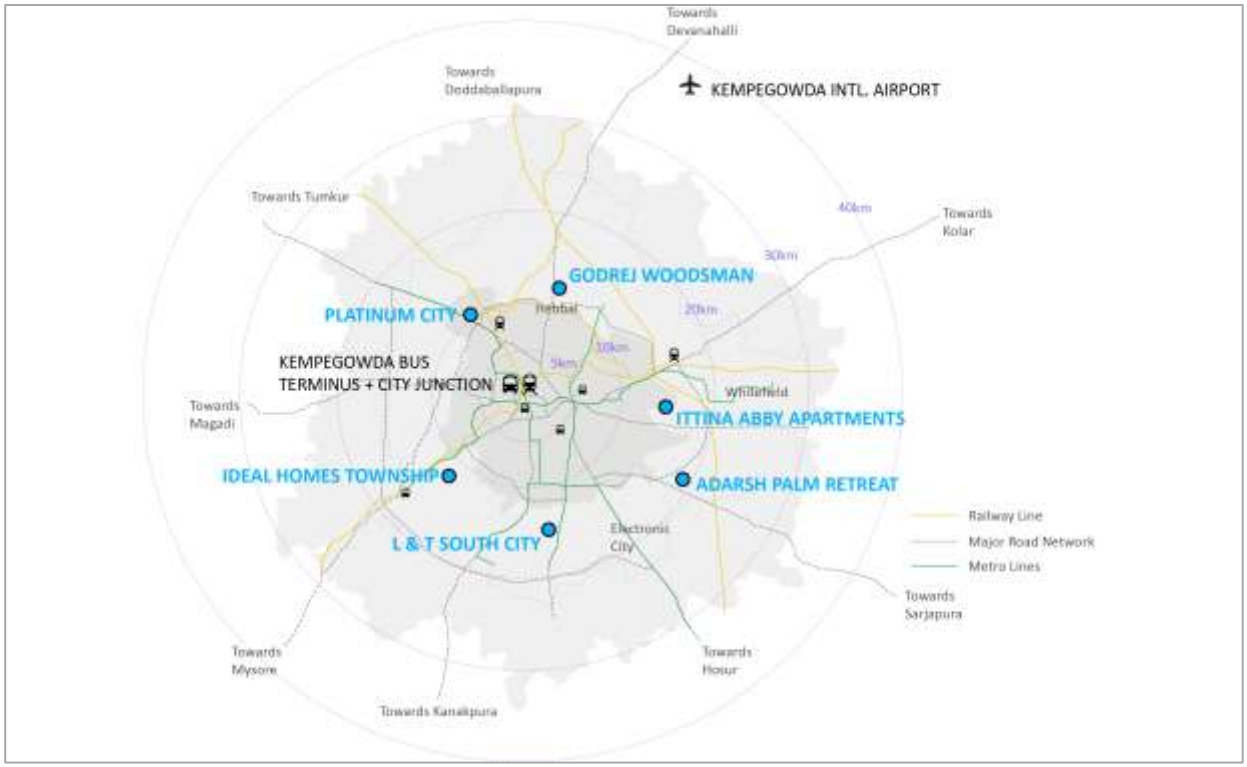
EMBARQ, the Cities and Transport program of the World resources Institute's (WRI), established partnerships with real estate developers planning and constructing large developments in the Bangalore metropolitan region. This effort is part of a grant received by WRI for a project titled "Building Sustainable, Energy Efficient and Connected Communities in India." These partnerships were intended to influence developers to identify opportunities to: (1) adopt sustainable urban mobility strategies and solutions that promote energy-efficient travel by foot, bicycle, and public transit, and (2) incorporate renewable energy to the extent possible and in the process, enable a scale-up in demand. As part of the project, EMBARQ India conducted energy and sustainability audits for three large developments in Bangalore that are in the planning stages.

In addition to the audits, EMBARQ India conducted visual assessments and household surveys at six existing gated communities. The survey focused on detailed travel patterns and residents' perceptions of the urban environment in which they live, attitudes about transport facilities and options, as well as preferences for different transport modes and commute patterns.

Our survey consisted of 445 respondents, at six Gated Communities (Figure 4). The largest community, Adarsh Palm Retreat has 13,000 households. IBC Platinum City will have 11,000 households when completed while L&T South City has almost 2,000 households. The smallest community, Ittina Abby has 220 households. Two other communities, Ideal Homes with 2,000 households and Godrej Woodsman with almost 1,000 households were also surveyed. The sample sizes in the survey for each of these communities were 110 for Adarsh Palm Retreat, 105 for IBC Platinum City, 113 for L&T South City, 89 for Ittina Abby and only 19 and 10 for Ideal Homes and

Godrej Woodsman respectively. The sample sizes are not proportionate to the number of households, given the challenges faced in accessing these communities. The survey responses were analyzed and the percentages were then applied to the percentages as a whole to be representative of Bangalore for both Ideal Homes and Godrej Woodsman. When these communities are completed, there will be approximately 30,000 households between just the six surveyed locations.

Figure 4: Locations of Gated Communities Identified for Household Surveys within the Bangalore Metropolitan Area



For each of the locations used in our calculations, we first attempted to access the households door to door using a random sample, after seeking appropriate permissions, but this was not possible in all locations. Wherever it was not, we set up a booth at a prominent location within the community, however very few responses were received by this method. The majority of responses were drawn from the door to door in person surveys. The survey consisted of 24 questions which took an average of 15 minutes to answer. The responses were then aggregated to understand the behavior and perceptions of residents in gated communities in Bangalore. .

The responses to perception-related questions were reported on a five point Likert scale as "Strongly Agree," "Somewhat Agree," "Neither Agree nor Disagree," "Somewhat Disagree," and "Strongly Disagree." For the purposes of comparative analysis, responses for "strongly agree" and "somewhat agree" were combined, as were responses for "strongly disagree" and "somewhat disagree." All results were then aggregated across the developments and calculated as percentages. We then compared the percentages for each of the individual developments versus the aggregate, and anywhere the difference was greater than 10% was taken to be significant.

This report presents a summary of observations from the visual assessments and results from the 445 household surveys conducted in these GCs from November 2013 to April 2014. This report also

attempts to correlate the visual observations with the survey responses to determine the linkage between built form and travel behaviour.

The report is divided into the following sections:

- Household Profile: Includes a summary of respondent demographic data, housing data and ownership status and vehicle ownership profile.
- Travel Behaviour Characteristics: Highlights weekday travel patterns such as trip purpose, mode of travel, trip distance and travel duration, physical activity patterns and their reasons for mode choice.
- Resident Perceptions: Provides resident views of the community in which they live, and their levels of satisfaction regarding commute patterns, modes of transport available to them, household travel expenses, pedestrian and road network and safety levels within and outside the community in which they live.
- Key Benchmarks: Benchmarks derived for specific indicators of residents' travel patterns in gated communities.
- Built Form Correlations: Observations from visual assessments conducted to evaluate the urban form features in and around the chosen residential gated communities correlated with the survey responses.
- Impact Evaluation of EMBARQ's Design Audit Recommendations on Household Energy Consumption: Evaluate potential changes in energy consumption of residents living in these developments by quantifying various indicators, including energy saved through reduced motorized travel, number of developments adopting renewable energy, travel time saved, and lives saved from improved safety for pedestrians and bicyclists.
- Way Forward: Summarizes the findings and the impacts due to unchecked urbanization and provides some recommendations to pave the way for sustainable mobility and building practices.

HOUSEHOLD PROFILE

Demographic and social variables such as age, gender, education levels, annual income, and employment status have been found to influence built environment, vehicle ownership rates and travel behavior .

64% of the female respondents were homemakers, while 71% of males were working full-time.

Socio-Demographic Profile

Figure 5: Respondent Gender

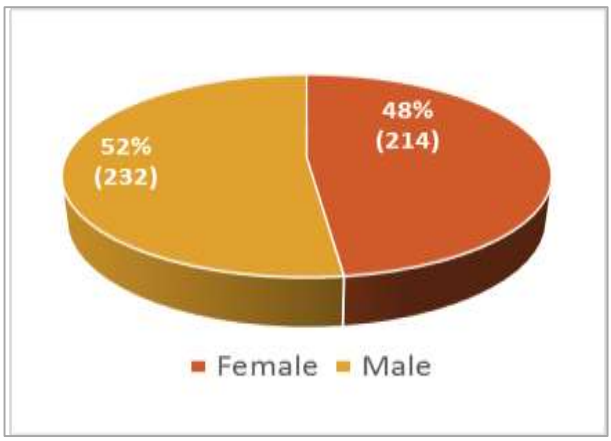
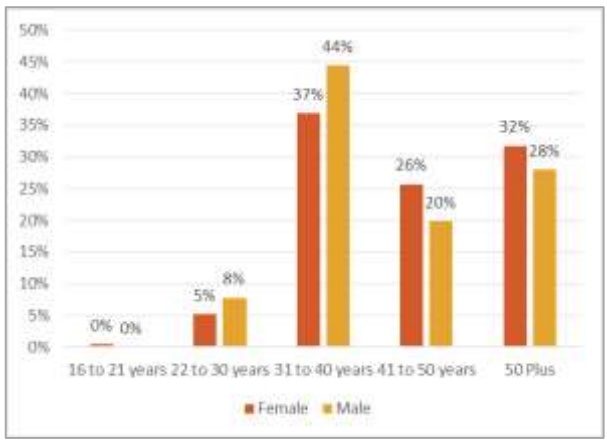


Figure 6: Respondent Age by Gender



As shown in Figure 5, 52% of the respondents were men and 48% were women, and 44% of the male respondents and 37% of the female respondents were between 31 to 40 years (Figure 6) – the age group with highest representation in the survey sample.

Education Levels

At least 93% of the 446 people interviewed have a bachelor's degree and around 38% are post-graduates (Figure 7).

Figure 7: Education Levels

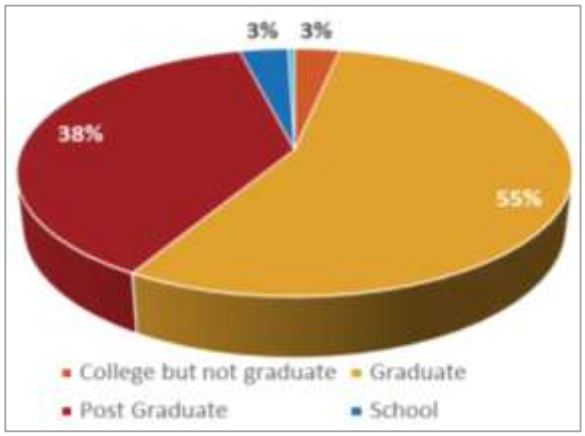
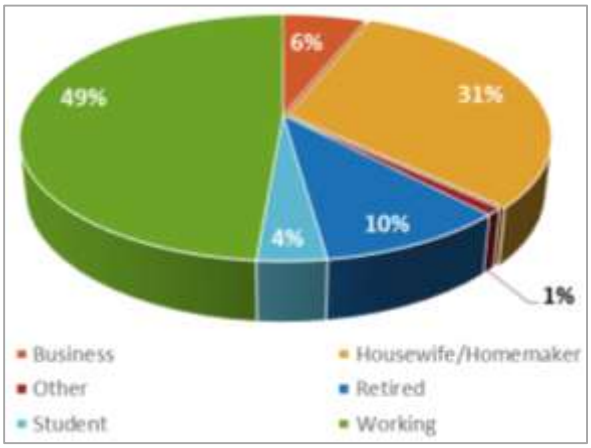


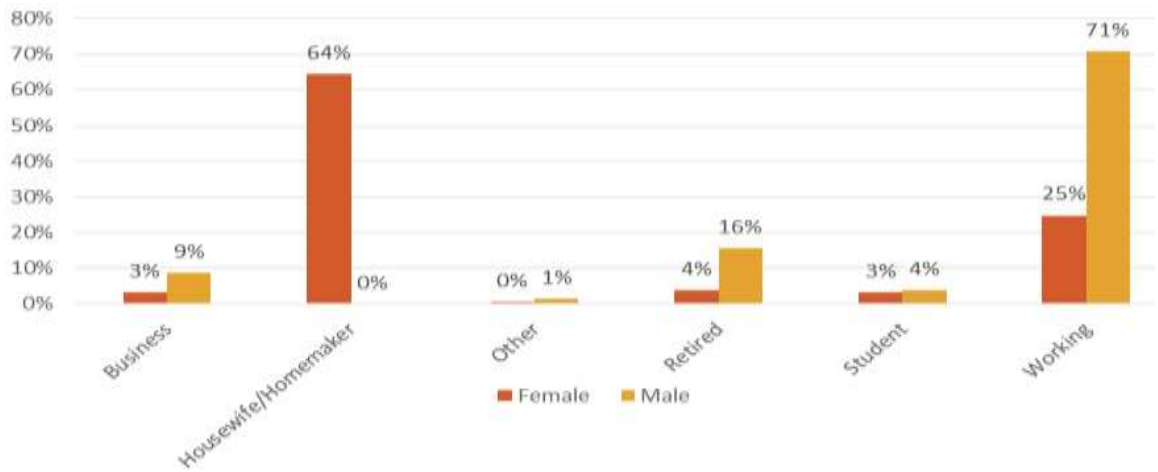
Figure 8: Employment Status



Employment Status

55% of the respondents were either employed full-time or had their own business. Around 31% (138) of the respondents were homemakers (Figure 8). Figure 9 illustrates the gender share of occupation. Around 28% of the female respondents interviewed were working full time or were business owners while 64% of the female respondents were homemakers.

Figure 9: Gender Share of Occupation

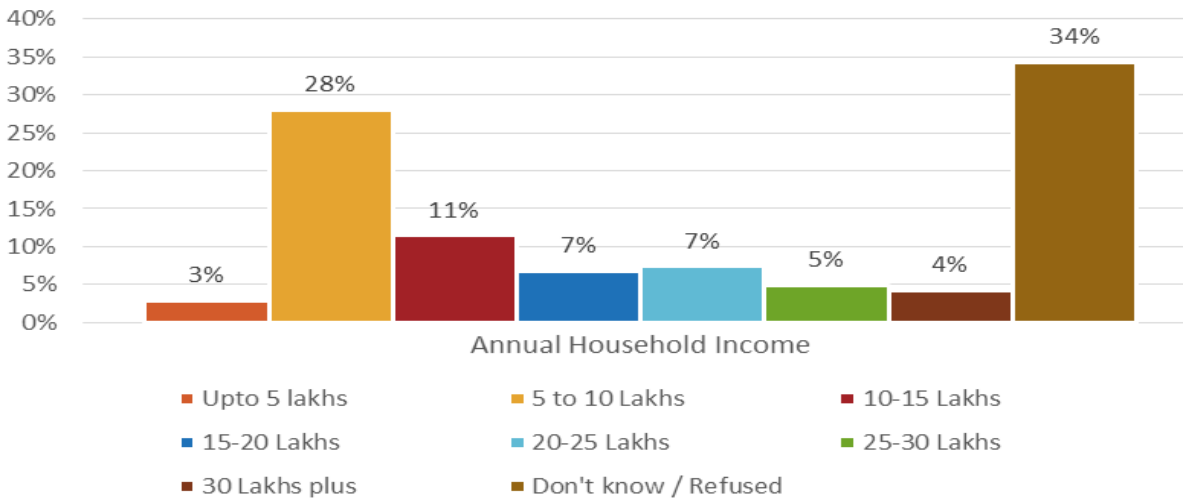


Annual Household Income

Of the 293 respondents who responded to the question on annual income, around 28% had an annual income of 5 to 10 lakh rupees (approximately USD 8,500-17,000) and 11% had an annual income of 10 to 15 lakhs (approximately USD 17,000-25,000) (Figure 10).

Of the 293 respondents who responded to the question on annual income, around 28% had an annual income of 5 to 10 lakh rupees (approximately USD 8,500-17,000) and 11% had an annual income of 10 to 15 lakhs (approximately USD 17,000-25,000) (Figure 10).

Figure 10: Annual Household Income



Housing Composition

Ownership Status

As shown in Figure 11, around 57% units were owner-occupied while 43% units were either rented, leased or provided by the company where the respondent was employed.

Dwelling Type, Size and Area

Of the 446 people interviewed, 85% (Figure 12) lived in apartments of which 51% were 3BHK (3 Bedrooms, Hall/Living Area and Kitchen) units. 39% of these houses were between the sizes of 1201 to 1500 sq.ft (Figure 13). Villas are typically detached and larger units, similar to single family homes in other countries, and across the survey sample, about 15% of respondents lived in such homes. Not all the developments included villas as an option though.

Energy Usage

Almost 86% i.e. 380 of the 446 households responded to having an electricity bill of Rs.1500 (approximately USD 25) per month or less (Figure 14). As shown in Figure 15, the average electricity bill paid by all respondents was

380 (85%)

Households pay an average of Rs 1500 or less for electricity consumption of which

173 (39%)

Households were between the sizes of 1201 to 1500 sq.ft.

around Rs. 1286 and the energy usage of IBC Platinum, L&T South City and Ittina Abby were found to be closer to the overall average. Respondents in Adarsh Palm Retreat had the highest energy usage, around Rs. 1411. This was probably due to larger home sizes than and also because Adarsh Palm Retreat is the only community that had the villa type of housing unit available.

Figure 11: Ownership Status

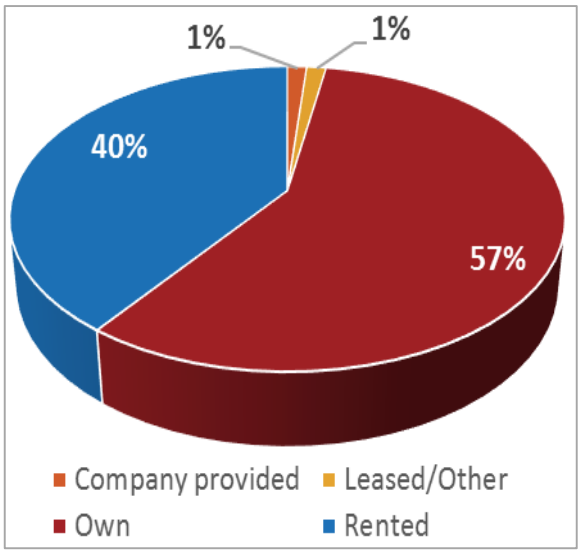


Figure 12: Dwelling Type

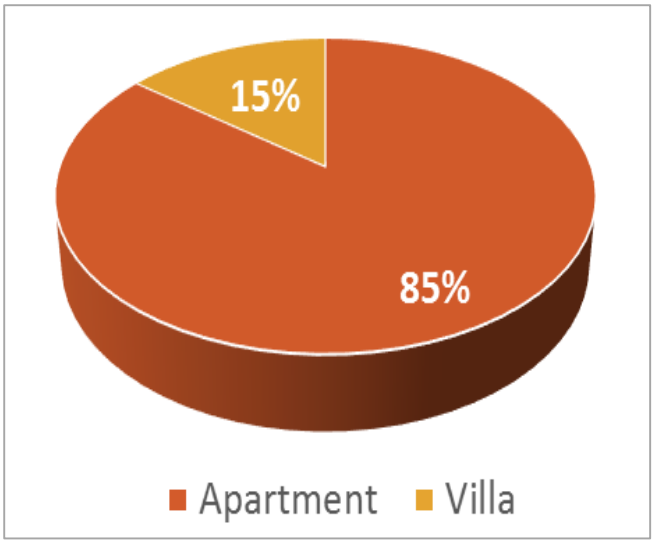


Figure 13: Dwelling Size and Area

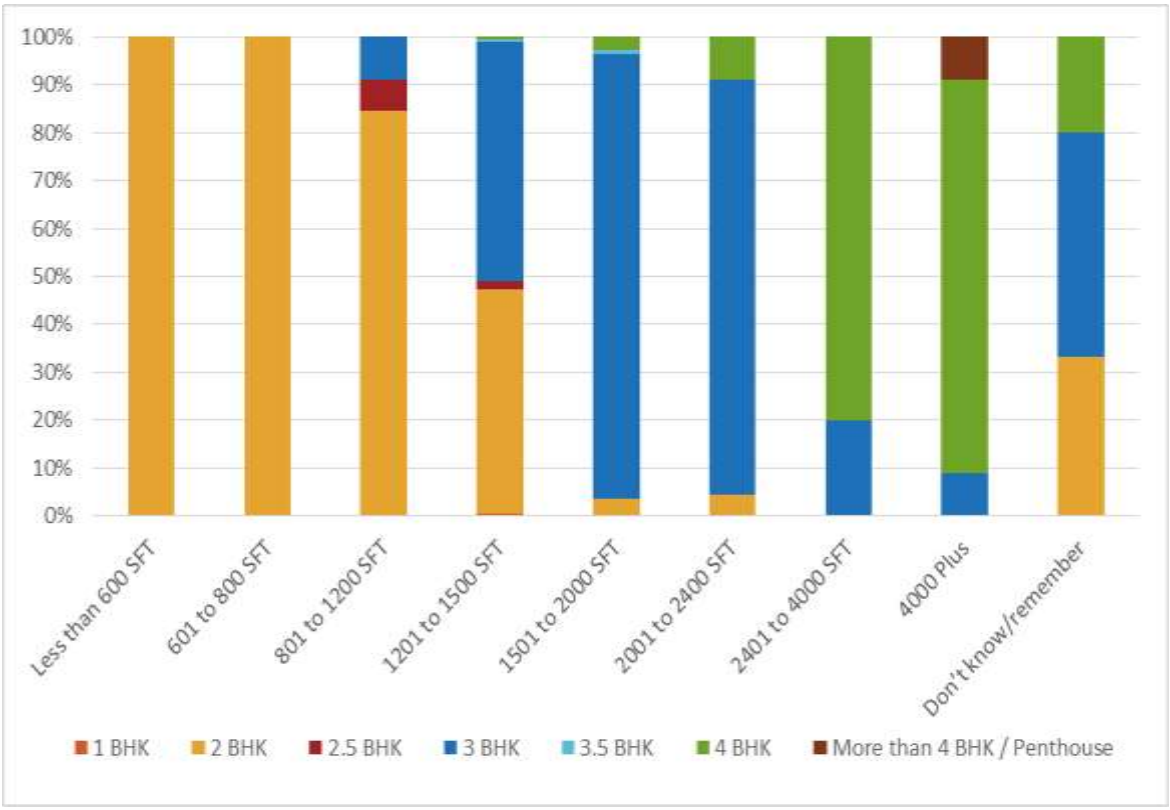


Figure 14: Energy Usage

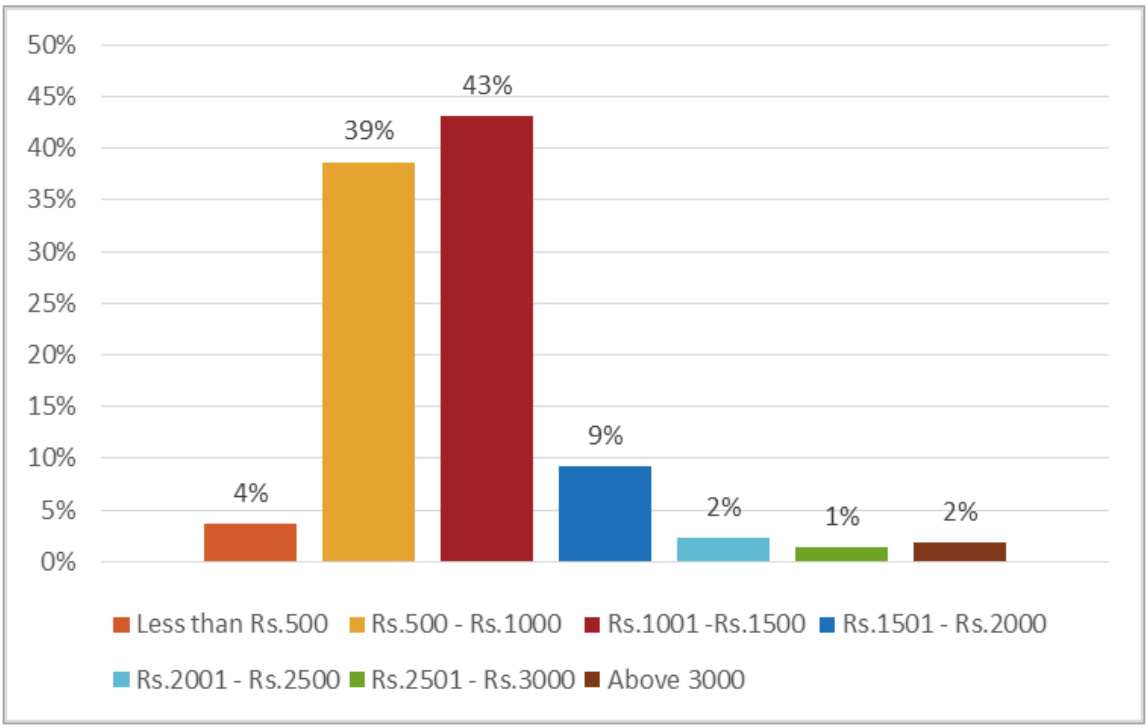
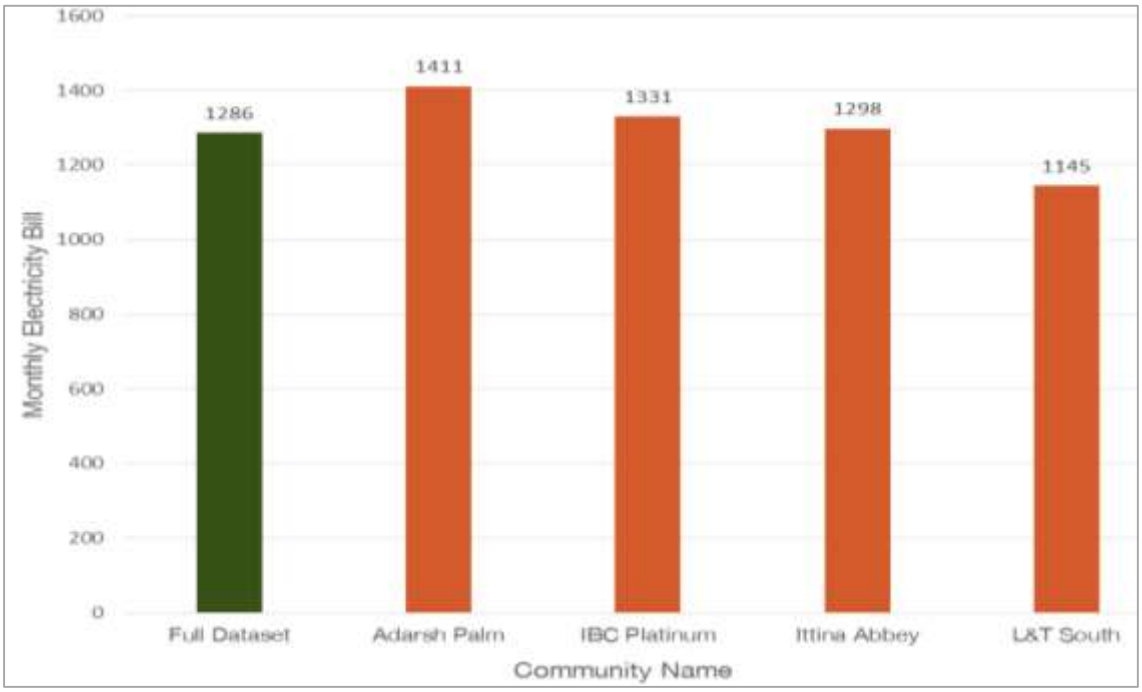


Figure 151: Energy Usage in Surveyed Developments

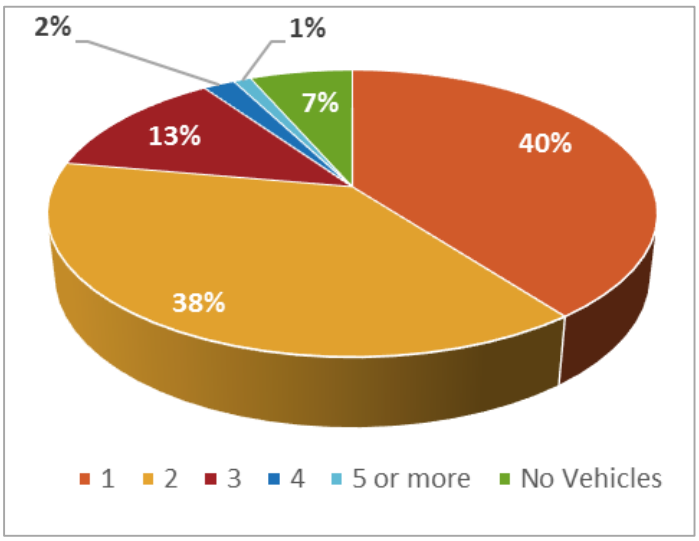


Vehicle Ownership Profile

As shown in Figure 16, around 93%, i.e. around 418 respondents owned at least one vehicle, either a car or two-wheeler. Only 4% or 20 respondents owned a two-wheeler as their primary vehicle. Around 53% respondents had two or more than vehicles. Car-ownership rates were the highest at 88% i.e.

391 respondents and 39% i.e. 176 respondents had a two-wheeler as a second vehicle As seen in Figure 17, only 9% or 40 respondents owned a bicycle.

Figure 16: Vehicle Ownership Rates



418 (93%)

Respondents owned at least 1 vehicle

391 (88%)

Respondents owned a car

176 (39%)

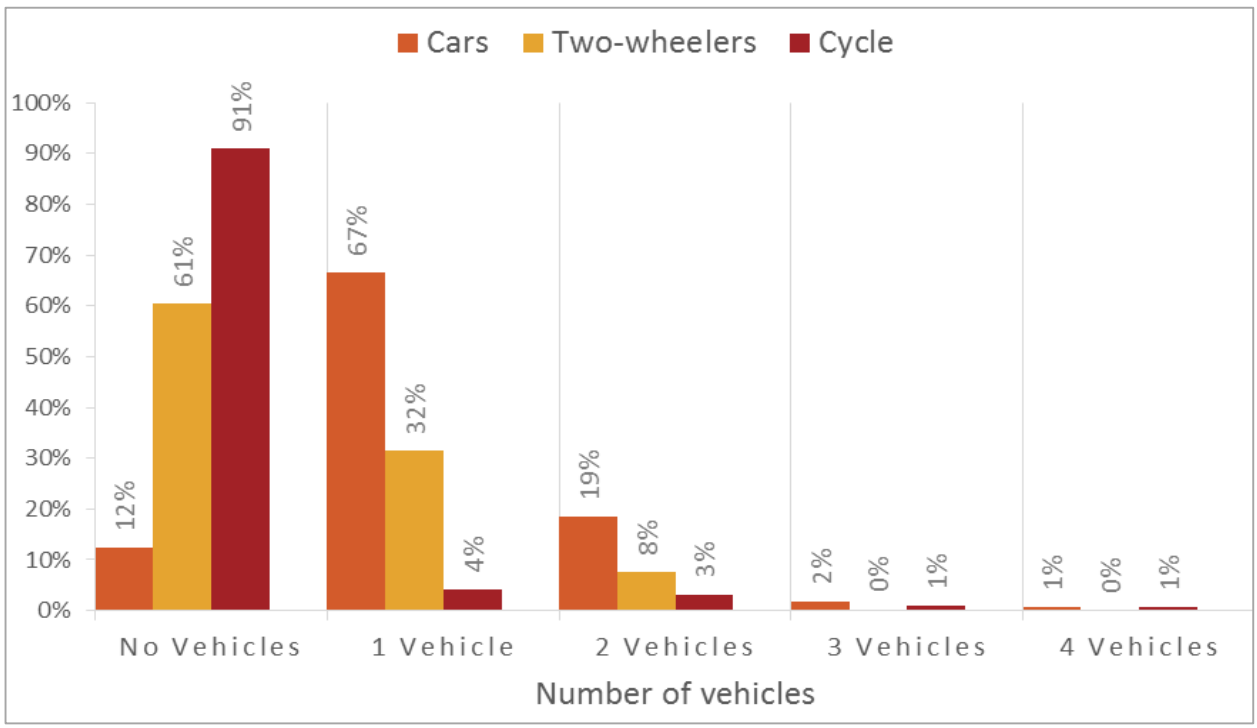
Respondents had a two-wheeler as a second vehicle

Only

40 (9%)

Respondents owned a bicycle

Figure 17: Vehicle Ownership Rates by Vehicle Type



Figures 18 and 19 illustrate the car and two-wheeler ownership rates in the surveyed communities. As shown in Figure 18, Adarsh Palm Retreat and L&T South City had the most number of cars and around 56% of respondents in Adarsh Palm Retreat owned two or more cars. Around 35% of respondents owned two-wheelers in Ittina Abby and only 14% of Adarsh Palm respondents owned two-wheelers. This is in direct contrast with the high car ownership rates at Adarsh Palms.

Figure 18: Car Ownership Rates

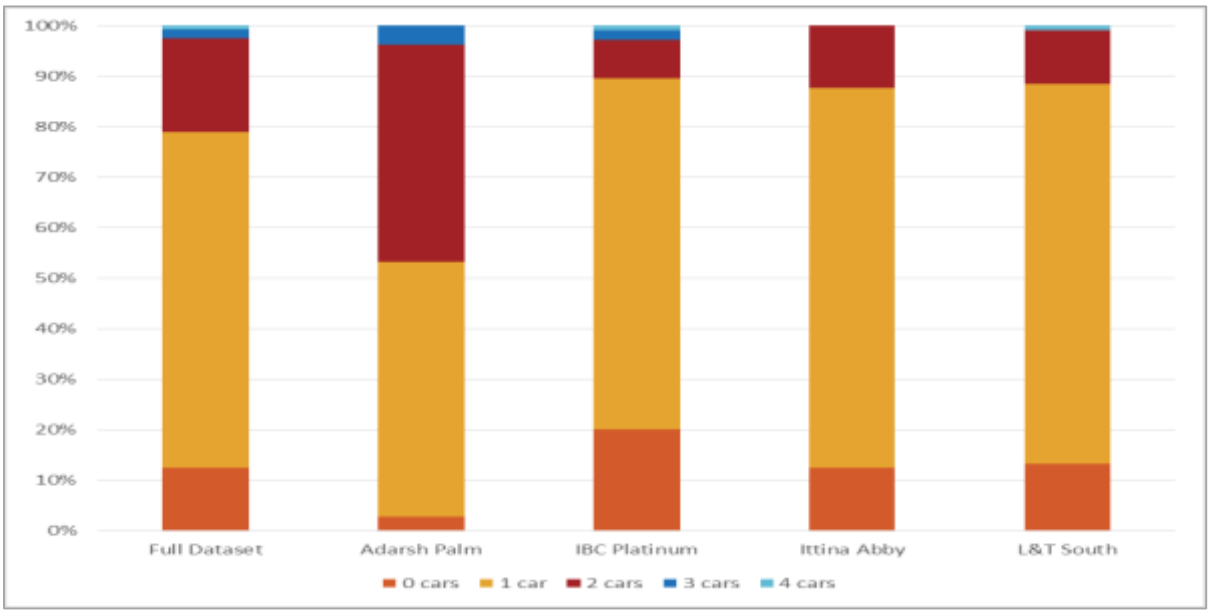
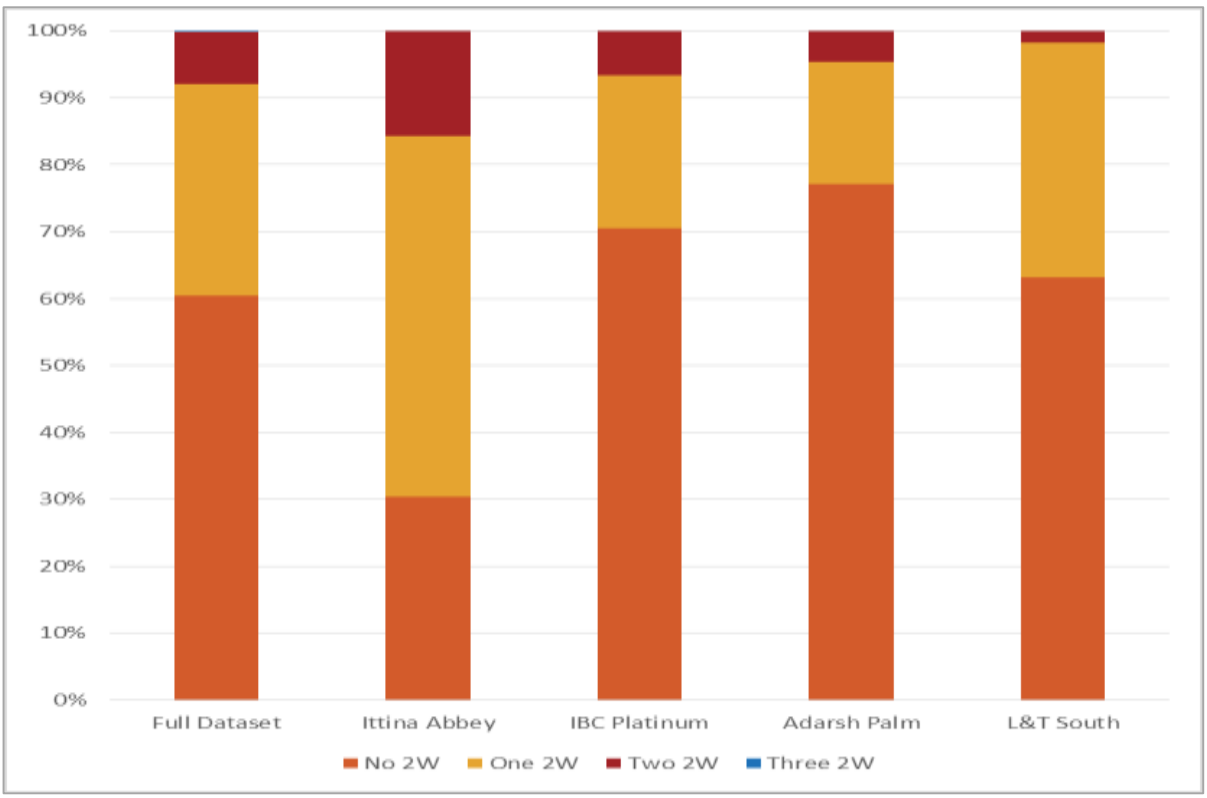


Figure 19: Two-Wheeler Ownership Rates



TRAVEL BEHAVIOR

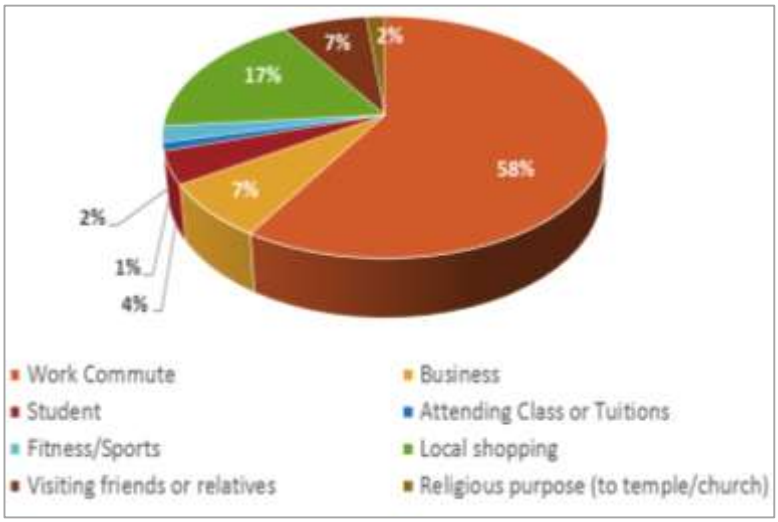
This section provides a summary of travel patterns of average weekday trips, work and additional trips and their reasons, and preferences towards different transport modes.

Weekly Travel Patterns[1]

58% of average weekday trips were work trips and 17% of total trips were local shopping or grocery trips (Figure 20).

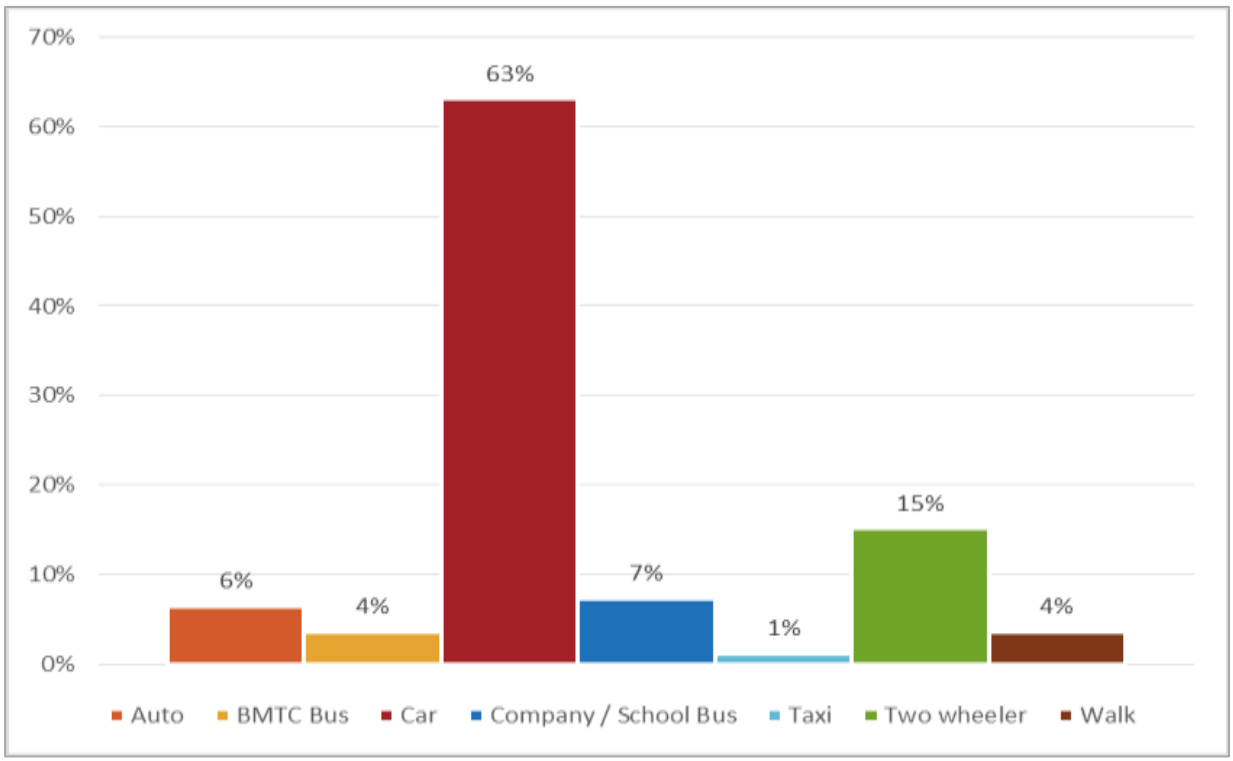
Of the 371 weekday trips made by the 446 respondents over the age of twenty-one, 63% were by car, 15% were by two-wheelers and around 18% involved public transit i.e. BMTC bus, taxis, auto rickshaws and/or company provided buses (Figure 21).

Figure 20: Trip Purpose – Weekday Travel



As shown in Figures 22 and 23, 40% of all respondents travelled more than 15 kilometers one-way every day and almost 55% of the respondents had daily travel times of more than 30 minutes.

Figure 21: Mode Share Proportion of Weekday Trips



[1] *Not applicable/blank responses were ignored*

Figure 22: Trip Times of Weekday Trips

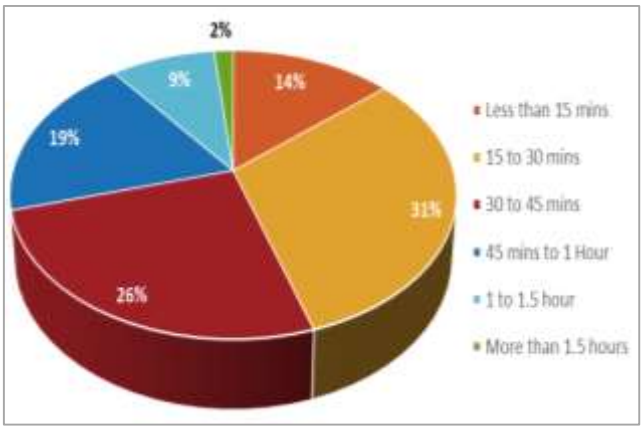
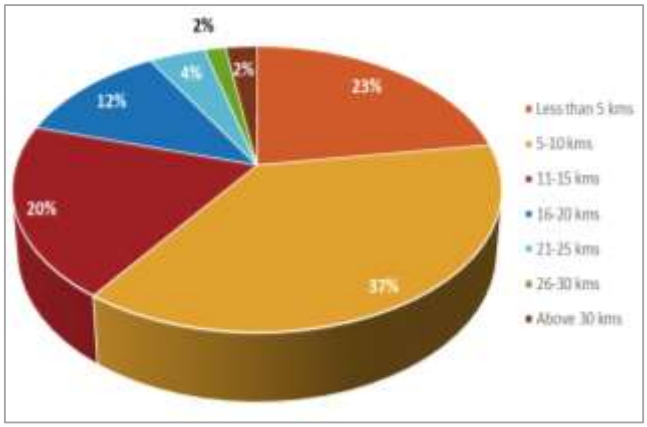


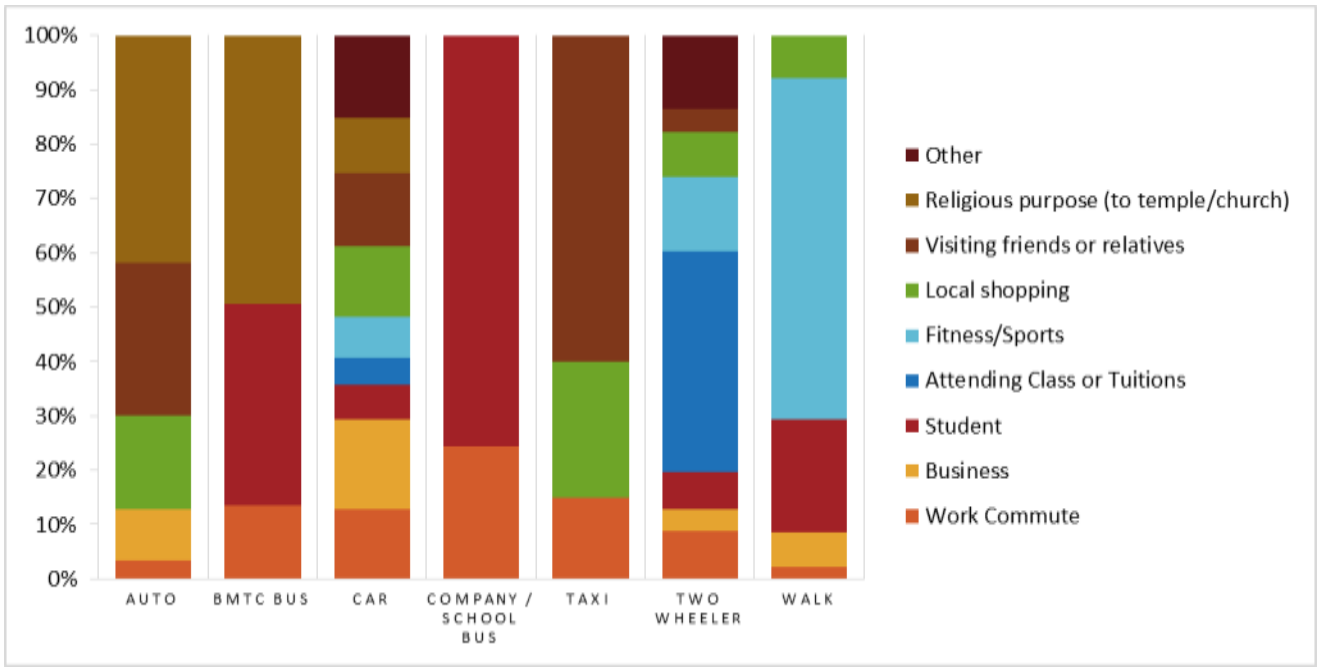
Figure 23: Distance Travelled during Weekday Trips



Mode Share and Trip Purpose

Private vehicles i.e. cars and/or two-wheelers were the dominant mode for all trip purposes, representing about 78% of all weekday trips. Two-wheelers were used mainly for education i.e.by students and/or parents to drop their children off to attend classes. Walking is the preferred mode of travel for fitness and or sports activities (Figure 24).

Figure 24: Mode Share and Trip Purpose of Weekday Trips

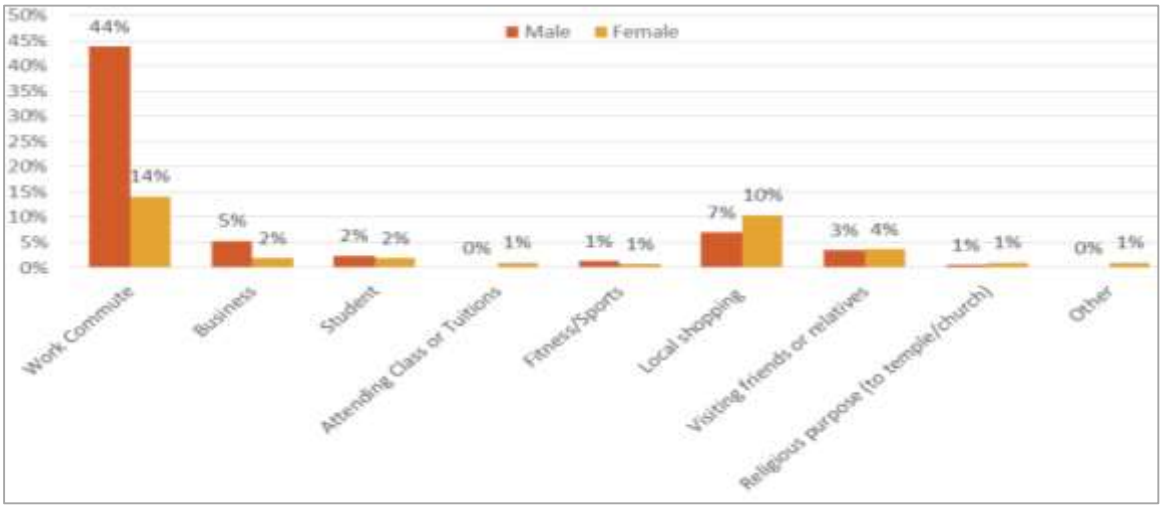


Gender Share of Weekday Trips

Males were more likely to commute for work while female travel patterns indicated that in addition to work trips, they also had a higher share of additional trips such as local shopping trips, attending classes or tuitions and visits to friends and relatives (Figure 25).

Work Commute Patterns

Figure 25: Gender Share of Weekday Trips



Primary Mode of Travel

As illustrated in Figure 26 and Figure 27, cars were the primary commute mode for work trips in all the communities, used for 64% of work trips. Cars were the primary mode of travel in Adarsh Palm Retreat and L&T South City. Around 53% of respondents in Ittina Abby used a two-wheeler to commute to work.

Figure 26: Primary Mode of Travel

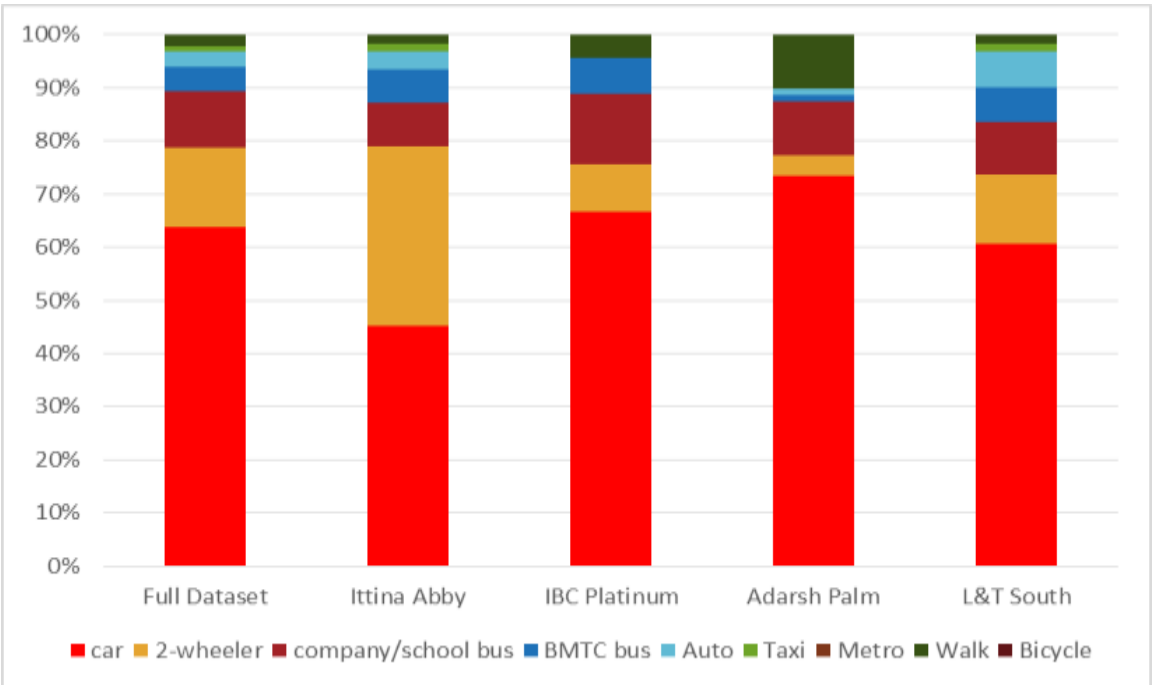
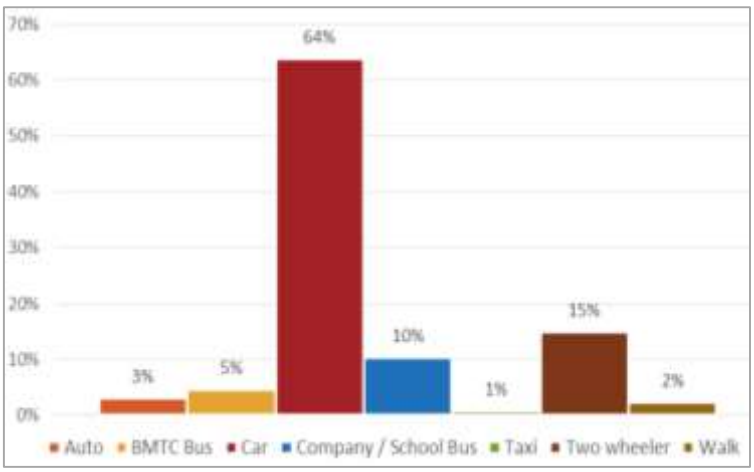


Figure 27: Mode Share of Work Trips



Mode Share of Work Trips by Gender and Age Group

As shown in Figures 28 and 29, males between the ages of 31 to 40 years were more likely to travel by car and/or two-wheelers. Females were most likely to undertake walk trips and/or informal transit such as by autos/ taxis. Walking, public transit and vehicle passenger trips were preferred modes by people over the ages of 40.

64%

work trips were by car

Males

were more likely to travel by car and/or two wheelers

Females

and respondents over **40**

years preferred walking, public transit and/or informal transit

Figure 28: Mode Share of Work Trips by Gender

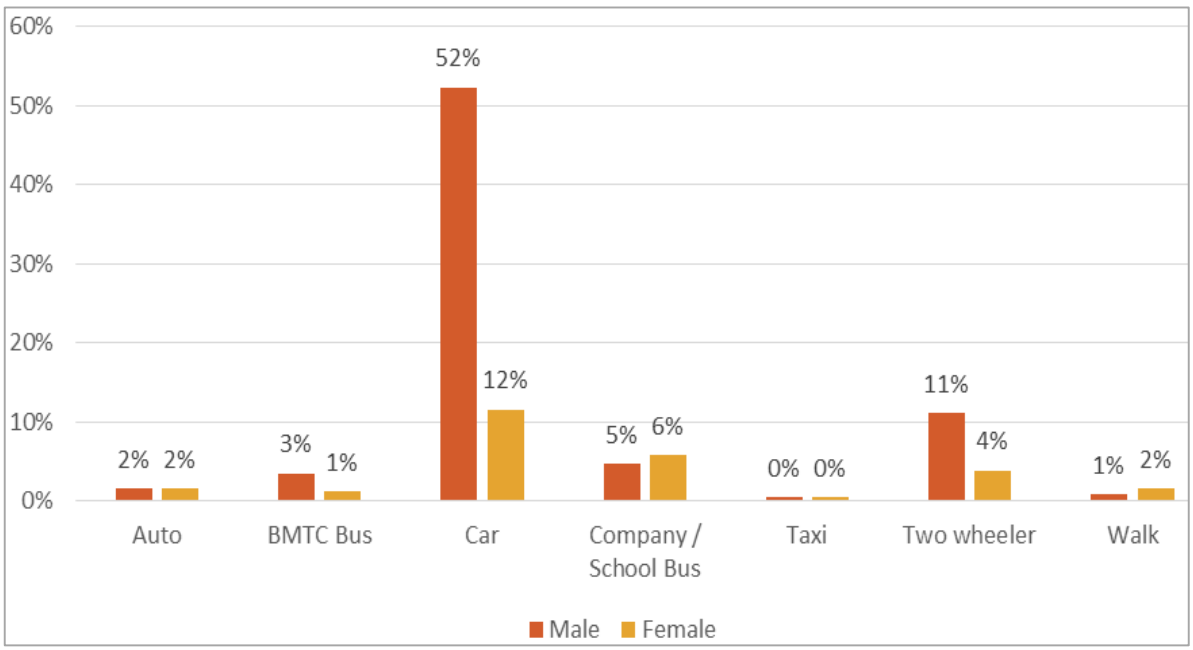
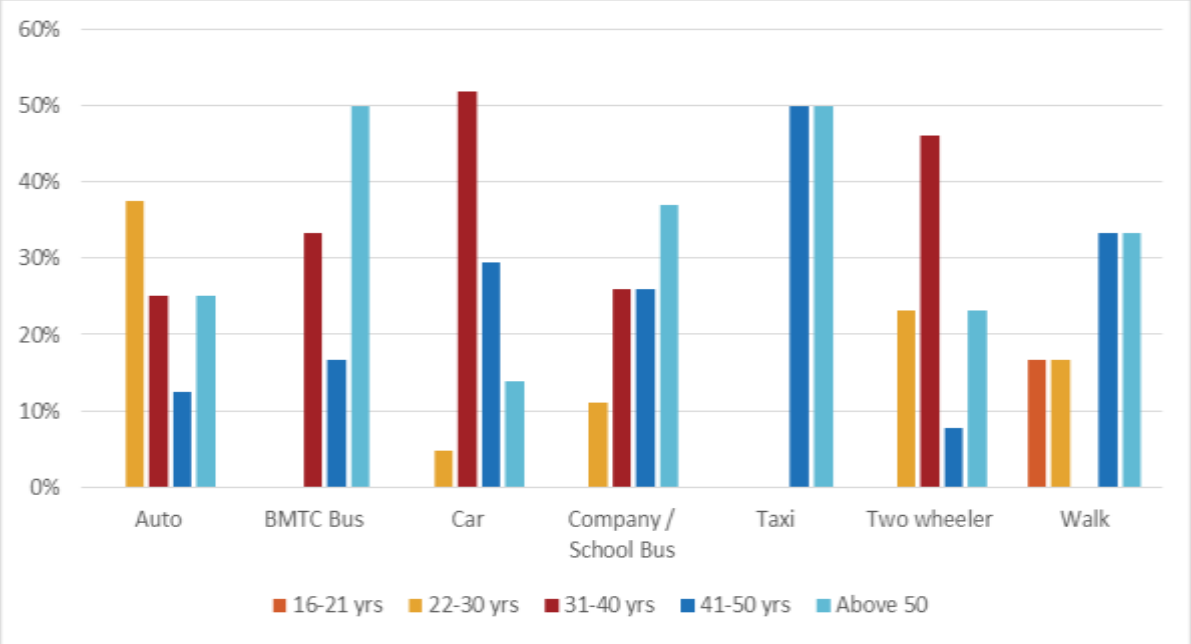


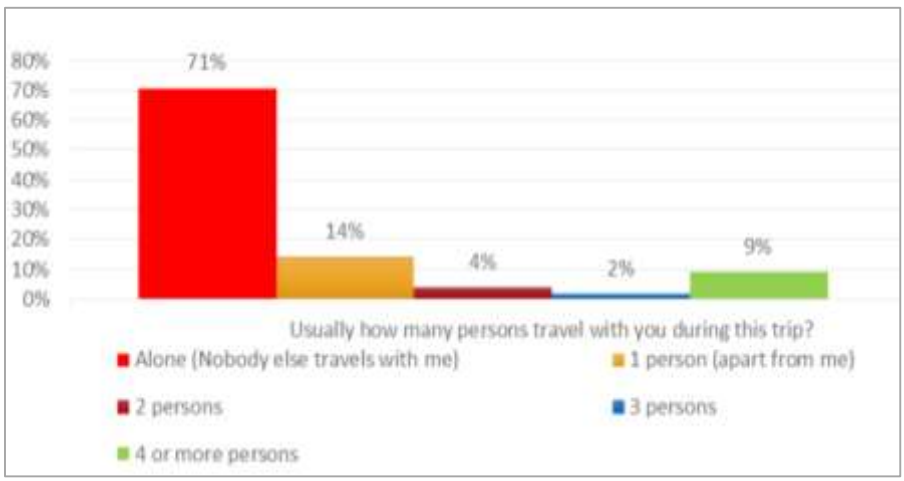
Figure 29: Mode Share of Work Trips by Age



Vehicle Occupancy Rates

Around 71% of the work trips were single occupancy trips (Figure 30) and majority of single occupancy trips were for time times less than 30 minutes (Figure 31). Figure 32 shows how all trips for a particular range of trip distance are disaggregated by occupancy. Trips with distances more than 15 kilometers and trip times ranging between 30 minutes to 1.5 hours typically had two to three occupants.

Figure 30: Vehicle Occupancy



Work Commute Cost

Around 47% of the respondents spent between Rs.100 to Rs.300 for their commute to work one way, translating to Rs, 200-600 (USD 3.5-10) for a daily commute (Figure 33). This cost includes cost of a one-way trip either by private vehicle or public transport and money spent on parking and fuel.

Figure 31: Vehicle Occupancy by Time

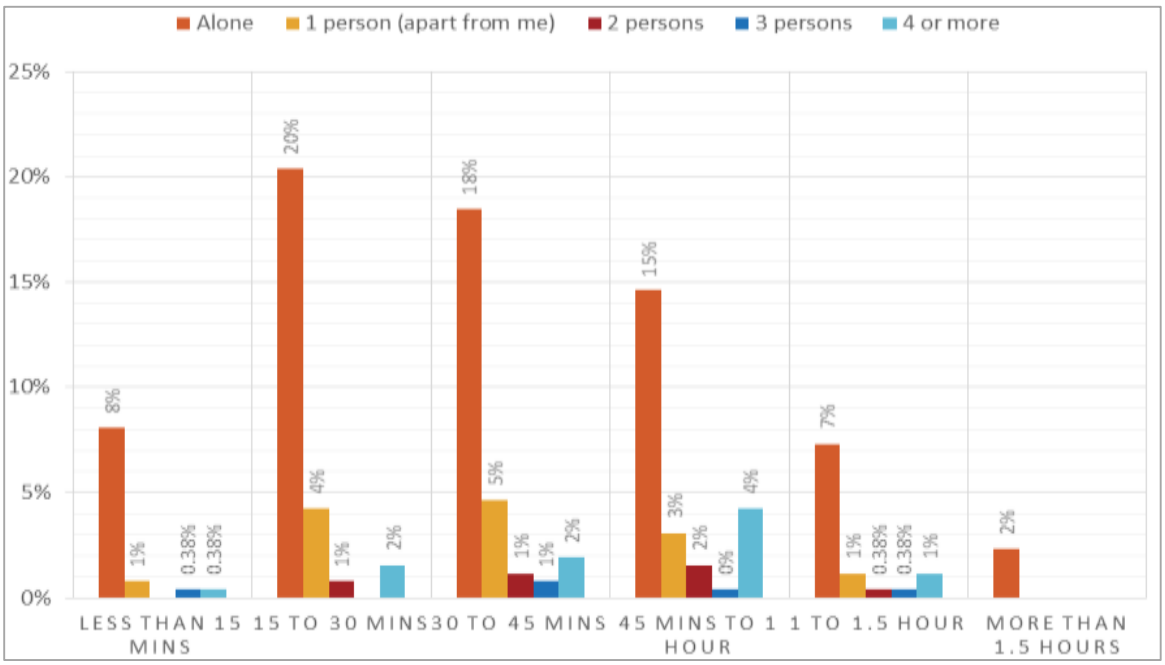


Figure 32: Vehicle Occupancy by Distance Travelled

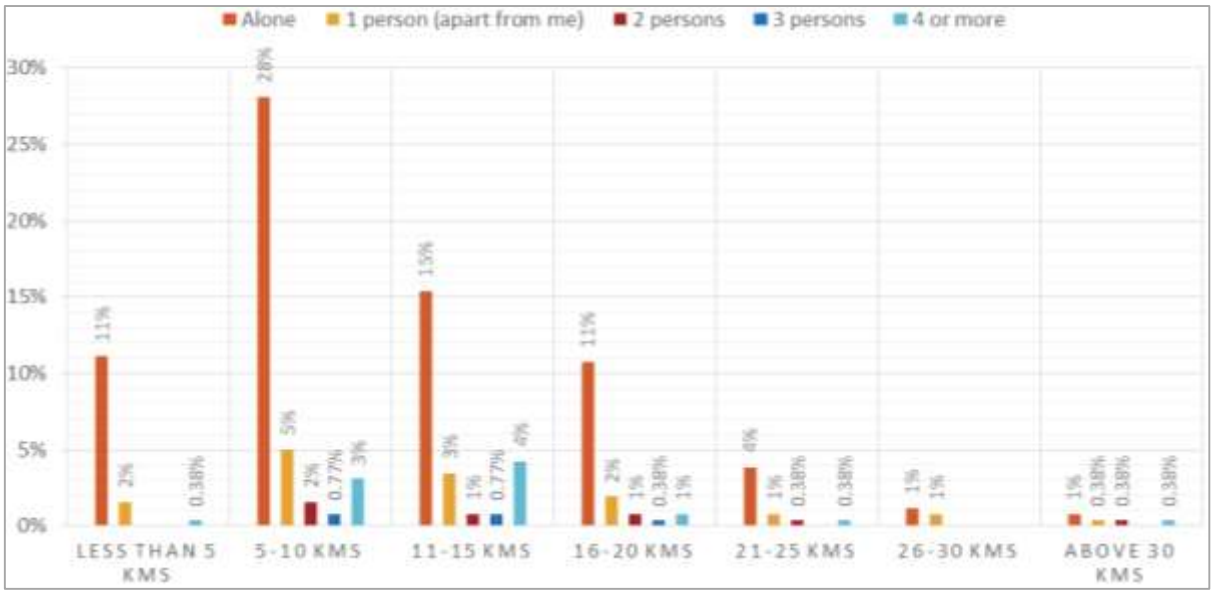
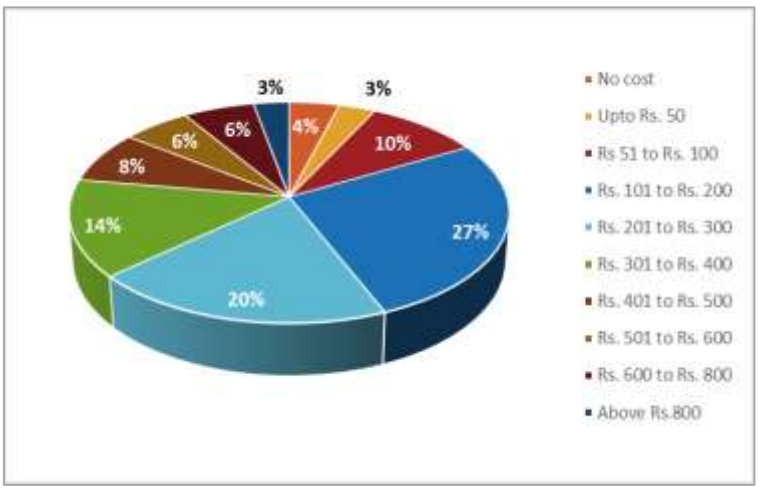


Figure 33: Cost of Work Commute



Additional Trips Patterns

112 people responded that their average weekday travel includes additional trips, i.e. trips not counted as work or school trips.

Local shopping trips accounted for almost 56% of additional trips (Figure 34) and almost 46% of the trips were less than 5 kilometers (Figure 35). Around 37% of the trips were done within 30 minutes one-way (Figure 36) and similar to work trips, cars (74%) were the primary mode (Figure 37).

Figure 34: Trip Purpose – Additional Trips

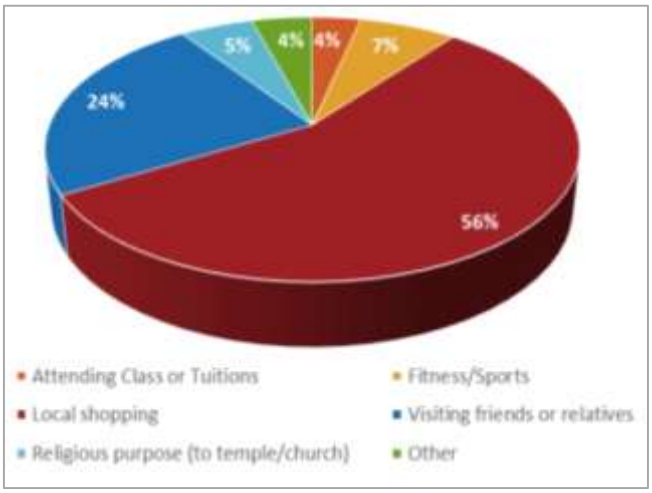


Figure 35: Distance Travelled for Additional Trips

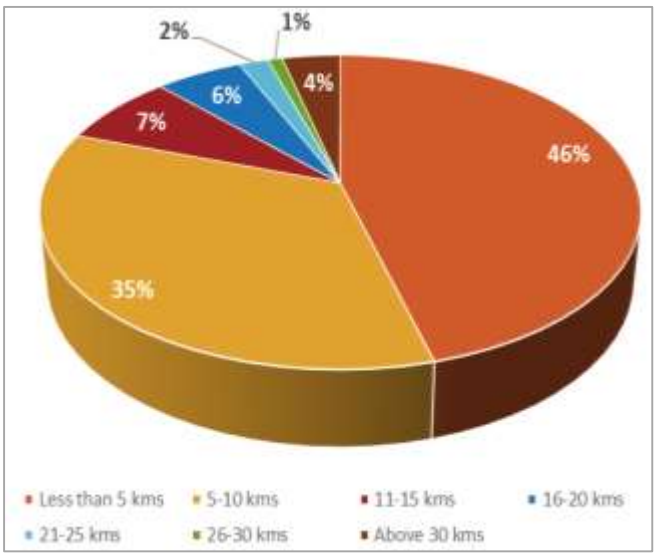


Figure 36: Trip Times for Additional Trips

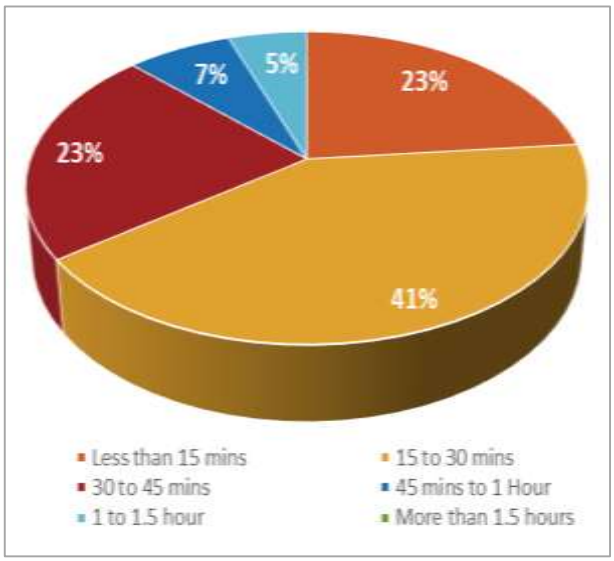
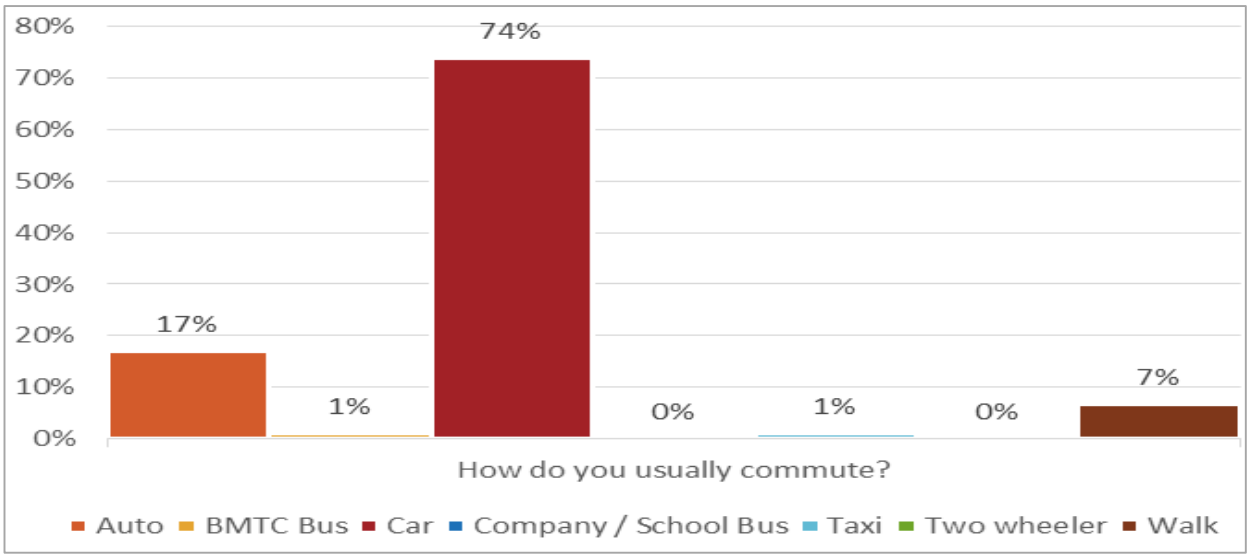


Figure 37: Mode Share of Additional Trips



Physical Activity

Around 60% of the respondents spent 30 minutes to an hour on physical activity (Figure 38). Of the people engaging in physical activity, 378 people, i.e. 85% of the respondents have a preference for walking over other physical activities (Figure 39). Typically, women and people over 40 years of age preferred to walk more.

Figure 38: Time Spent in Physical Activity

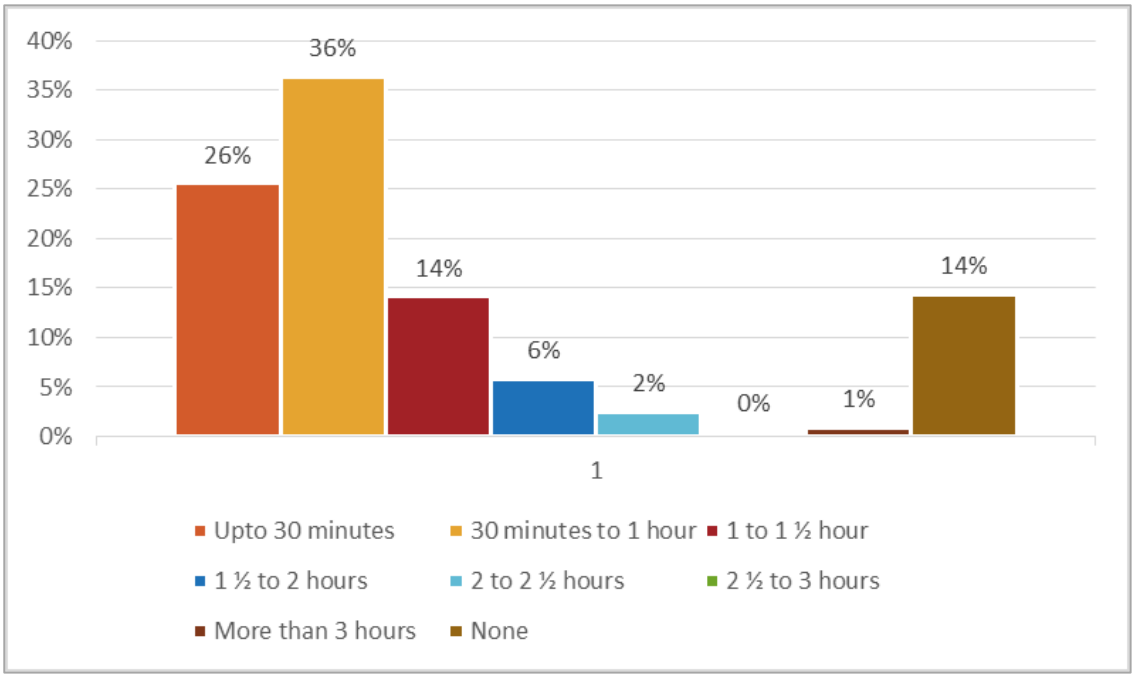
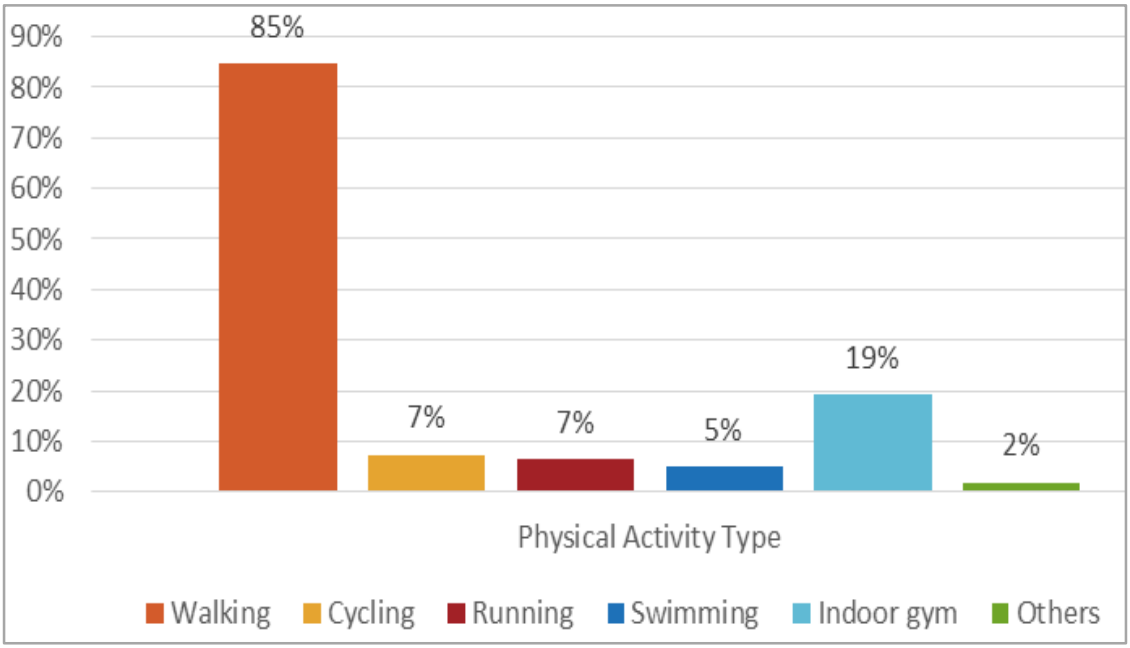


Figure 39: Physical Activity Type

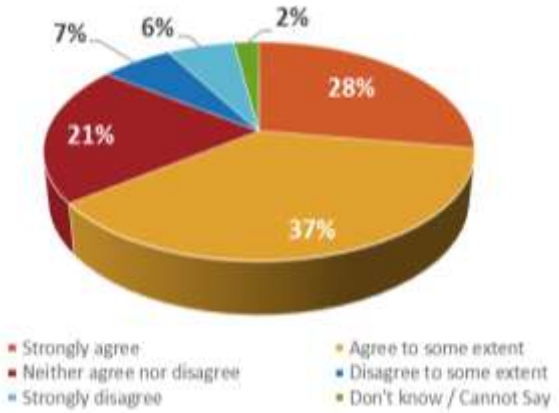


Respondents could give more than one response, therefore percentages add to more than 100%.

Shopping Preferences

65% of the respondents preferred (strongly agree or agree to some extent) to stay within the community for shopping (Figure 40). This indicates a clear preference for mixed use communities that include some retail provisions and access to daily needs.

Figure 40: Prefer to Stay Within the Community for Shopping



50%

responded that they preferred cars due to the convenience offered by them.

33%

felt that public transport options were not easily accessible.

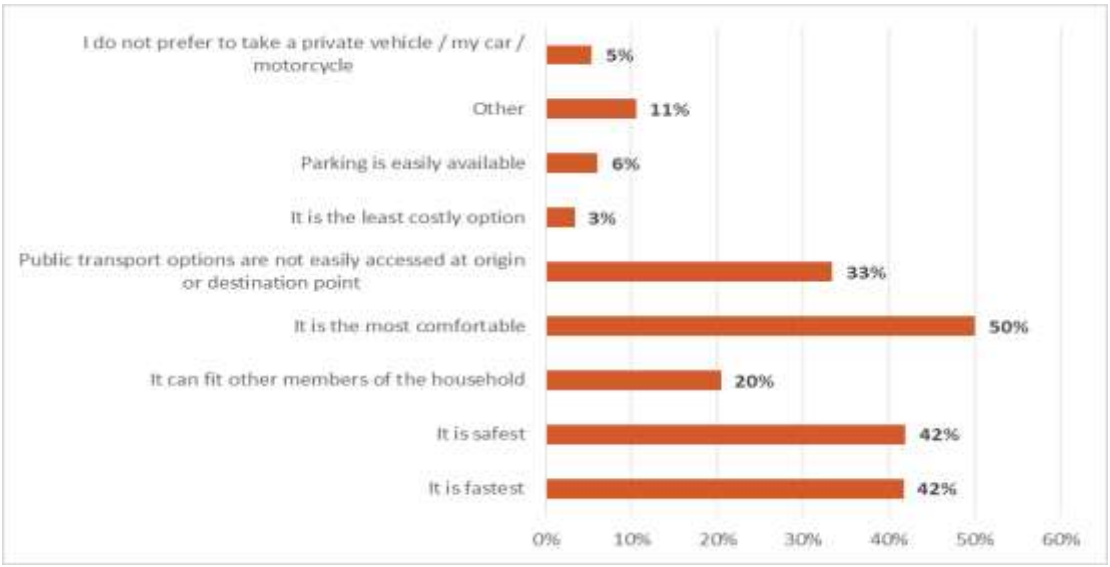
65%

preferred to stay within the community for shopping.

Reasons for Current Mode Choice

Figure 41 lists the top reasons for commuting by private transport, i.e. car or two-wheeler. Comfort (50%) and safety (42%) were cited by most respondents as their reason for choosing their current mode. There was also a perception (33%) that public transport options were not easily accessible both at origin and/or destination points.

Figure 41: Reasons for Current Mode Choice

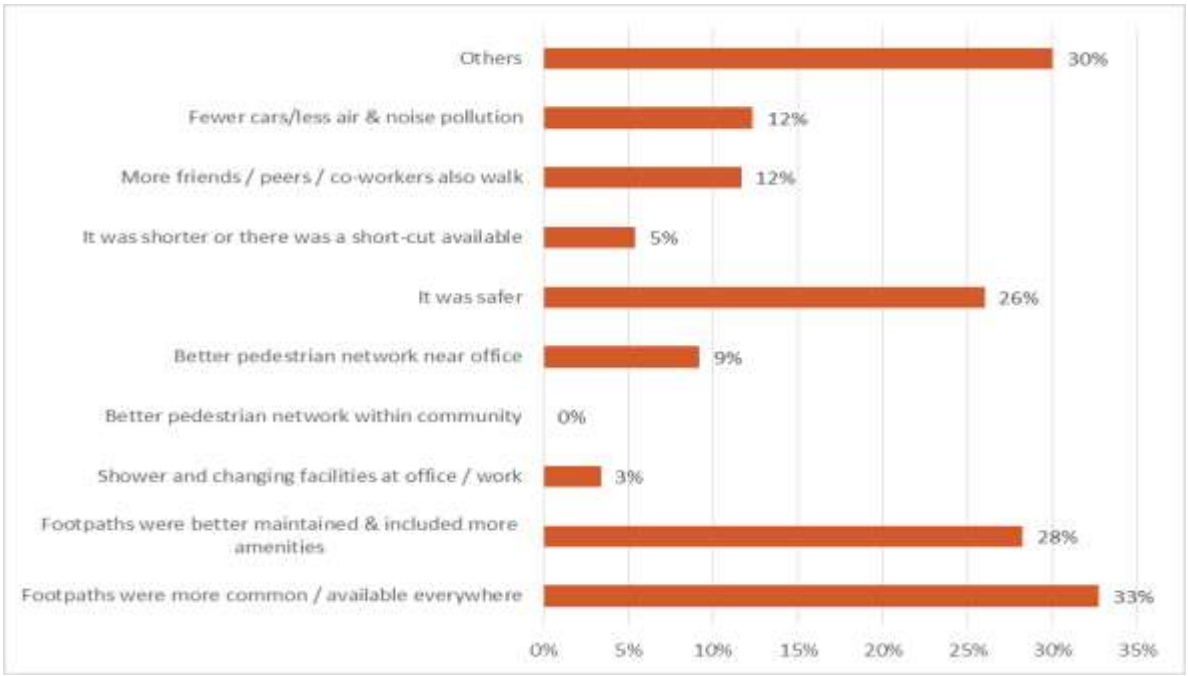


Respondents could give more than one response, therefore percentages add to more than 100%.

Reasons to Walk, Cycle and use Public Transit

Figure 42 lists the top reasons for considering walking. Availability of footpaths (33%), better maintenance of existing infrastructure and presence of additional amenities (28%) were among the key reasons mentioned by respondents. Safety (26%) also emerged to be one of the key concerns.

Figure 42: I would Walk More if

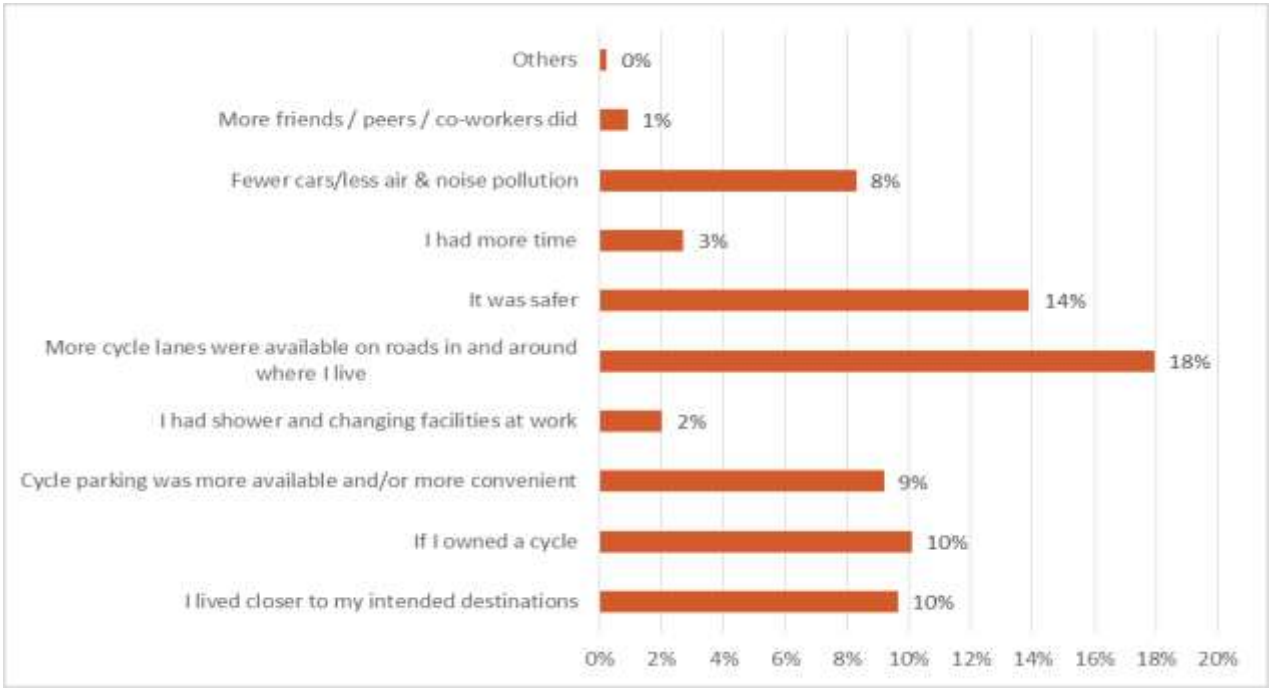


Respondents could give more than one response, therefore percentages add to more than 100%.

Figure 43 lists the top reasons for considering cycling. Lack of cycling infrastructure (27%) such as cycle lanes and cycle parking, distance to destinations (10%) and not owning a cycle currently (10%) were among the key reasons mentioned by respondents.

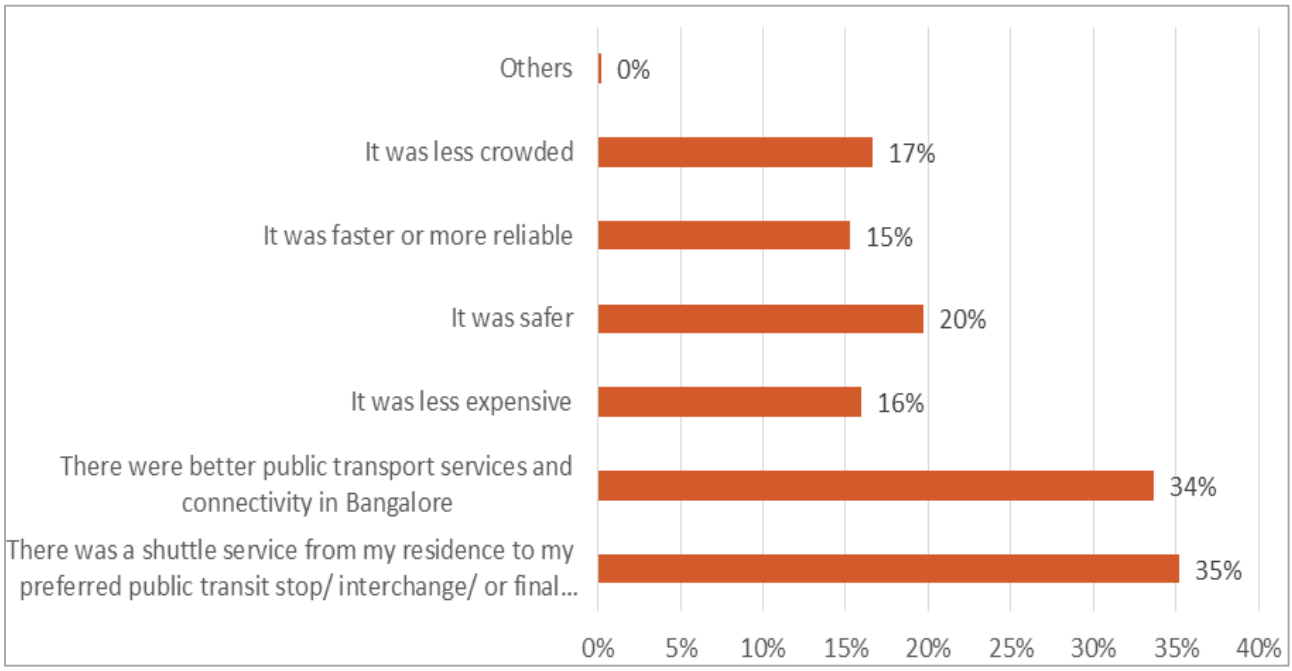
As mentioned earlier in Figure 41, lack of better public transit quality and connectivity (34%) and absence of shuttle services from the place of residence (35%) were hindering respondents from using public transit. Safety (20%) and affordability (16%) were other reasons mentioned by the respondents (Figure 44).

Figure 43: I would Cycle more if



Respondents could give more than one response, therefore percentages add to more than 100%.

Figure 44: I would use Public Transit more if:



Respondents could give more than one response, therefore percentages add to more than 100%.

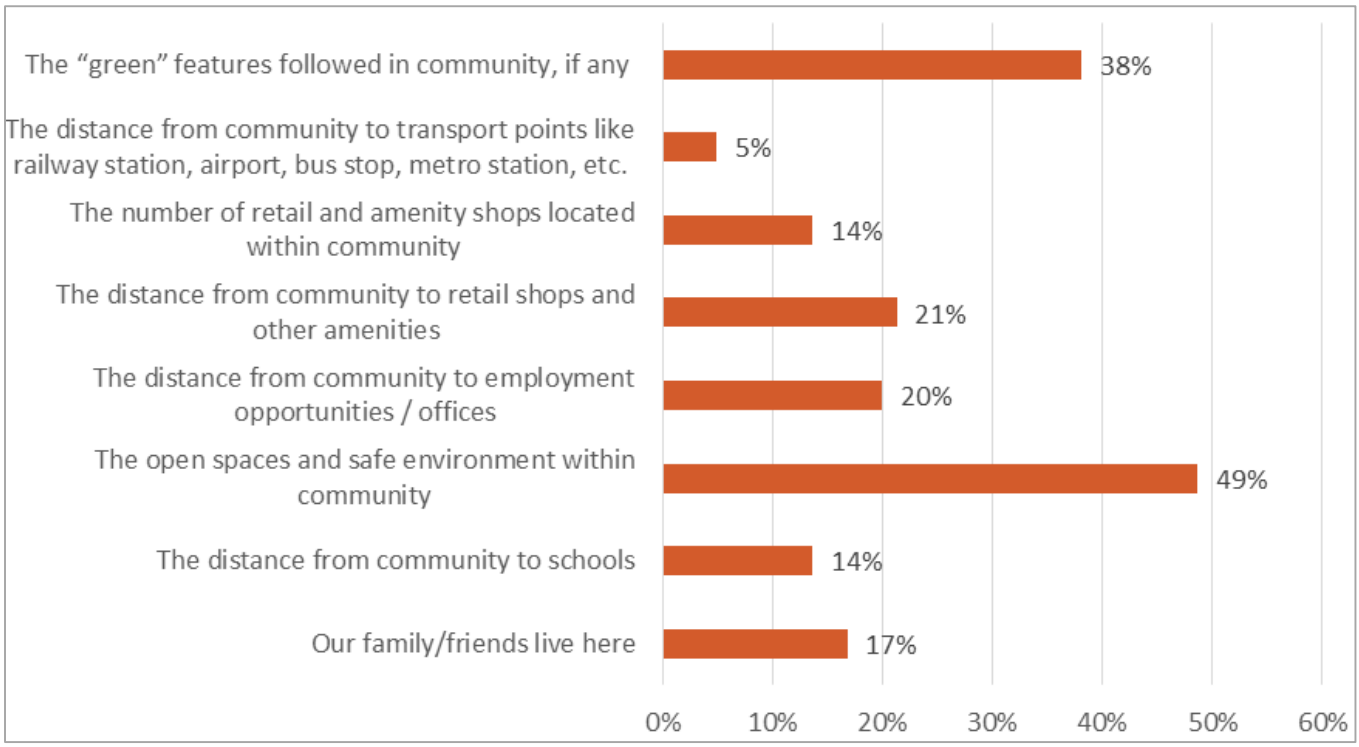
RESIDENT PERCEPTIONS

This section analyzes resident perceptions about their community including their views of the community in which they live, and their levels of satisfaction about current commute patterns, transport modes, travel expenses, safety within and outside the community in which they live.

Reasons for Choosing Current Community

Location, proximity to employment, schools and retail centers and availability of pedestrian-friendly infrastructure were some key factors in selecting the community. The majority of the respondents said that they chose the current community based on presence of open spaces and safe environment within the community (49%), green and sustainable practices followed (38%). Distance to retail and shopping (21%) and distance to employment (20%) were next in terms of importance for choosing the current residence location (Figure 45).

Figure 45: Reasons for Choosing Current Community



Respondents could give more than one response, therefore percentages add to more than 100%.

Level of Satisfaction

As elaborated in the following sections, safety was a key concern and impacted shopping and travel patterns. Respondents wanted to see a mix of uses such as retail and amenity shops within the community. While many of them felt that the pedestrian and road network within the community was satisfactory, the network outside the community was inadequate and they felt that impacts their mode choice. Similar opinions were expressed about levels of safety within and outside the community and this in turn impacted their current travel mode. Respondents were also aware of green practices and ensured that they were being followed in their community.

Community Facilities

While 41% of the respondents felt that facilities such as retail shops within the community were satisfactory (Figure 46), and 39% expressed some dissatisfaction over the availability of such facilities and wanted to see a variety of accessible retail and amenity shops within the community. The majority of residents expressed satisfaction with the parking spaces (82%) available within the community (Figure 47). A majority of respondents also expressed satisfaction with the green practices followed (Figure 48). “Green practices” referred to the environment friendly, sustainable development related practices, such as use of solar energy for water heating and lighting, waste water recycling, use of recycled building materials, rain water harvesting, waste segregation, electric car charging points and green roofs.

Figure 46: Satisfaction with Retail and Amenity Shops within the Community

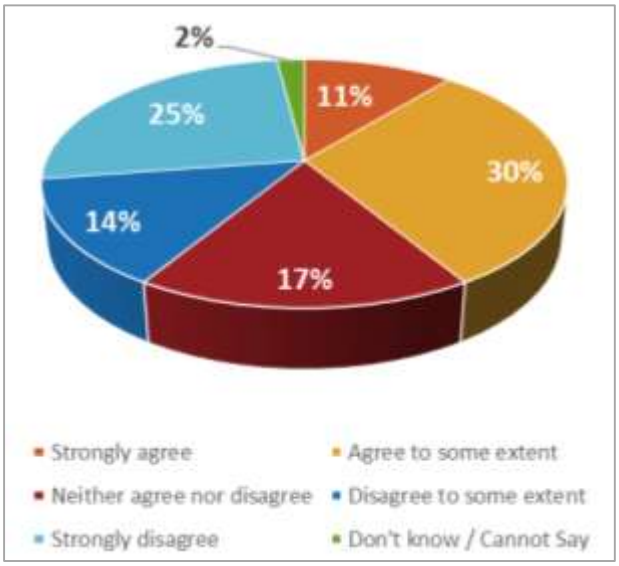


Figure 47: Satisfaction with Availability of Parking Spaces within the Community

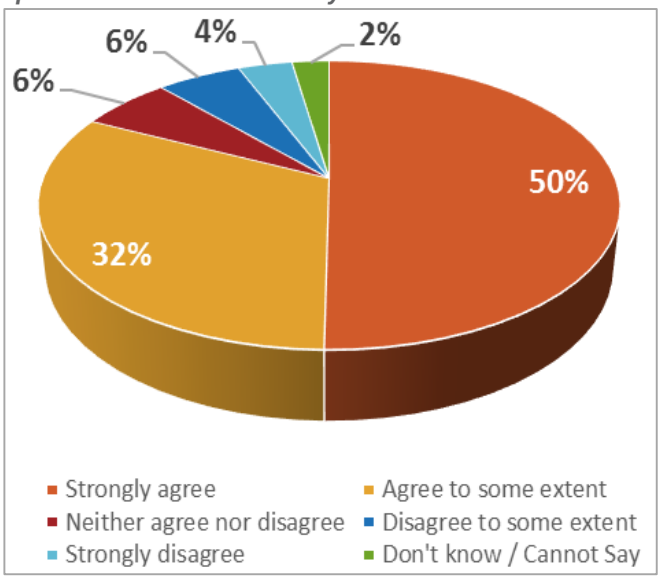
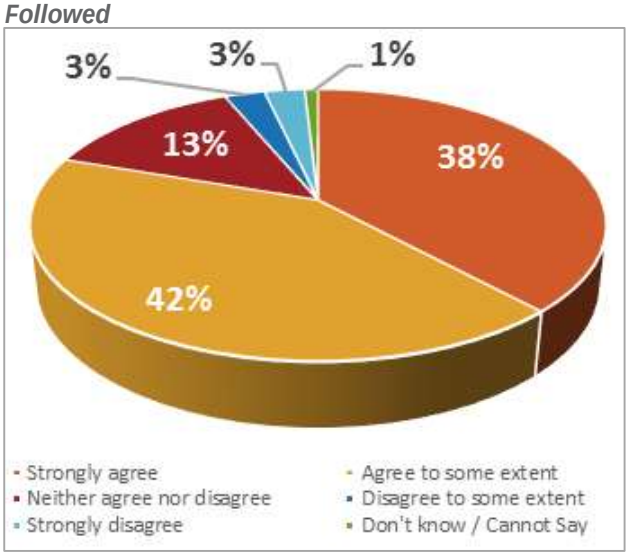


Figure 48: Satisfaction with Green Practices Followed



Commute Patterns

Almost 60% of respondents mentioned that they face heavy congestion during their commute to work (Figure 49) however 43% of respondents expressed satisfaction over their work commutes (Figure 50). Majority of people are broadly satisfied because they use cars for their trips. 52% felt that their community environment impacts their transportation choices (Figure 51) and as illustrated in Figure 52, around 37% of respondents were satisfied with their children's commute to school.

Figure 49: Heavy Congestion during Work Commute

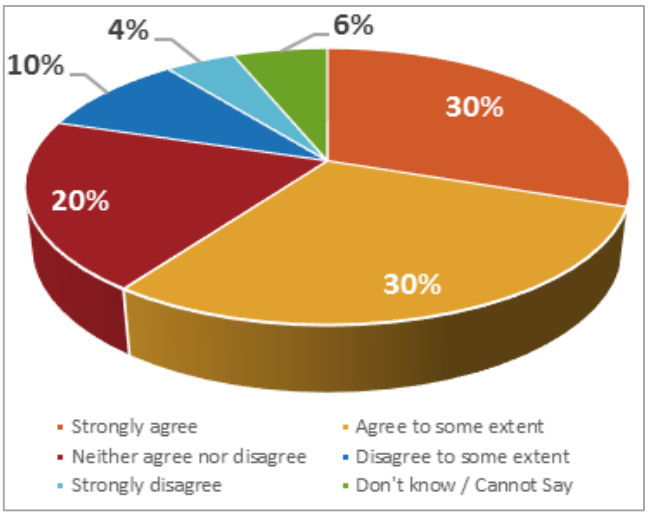


Figure 50: Satisfaction with Work Commute

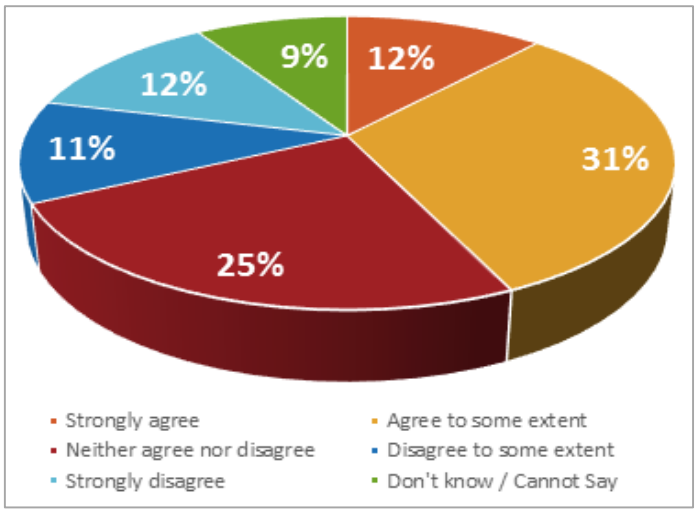


Figure 51: Impact of Community Environment over Transportation Choices

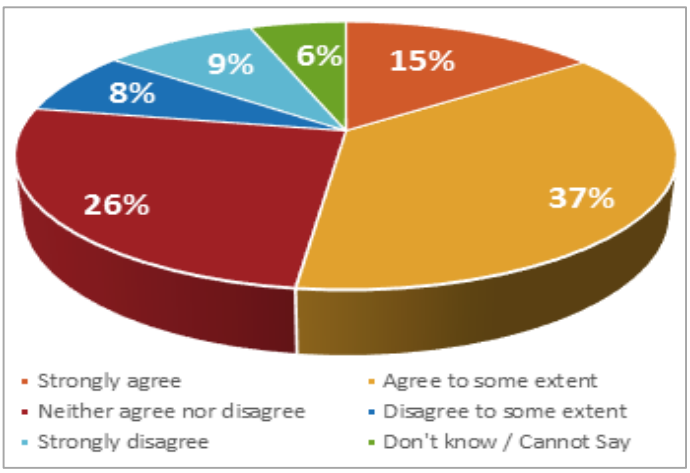
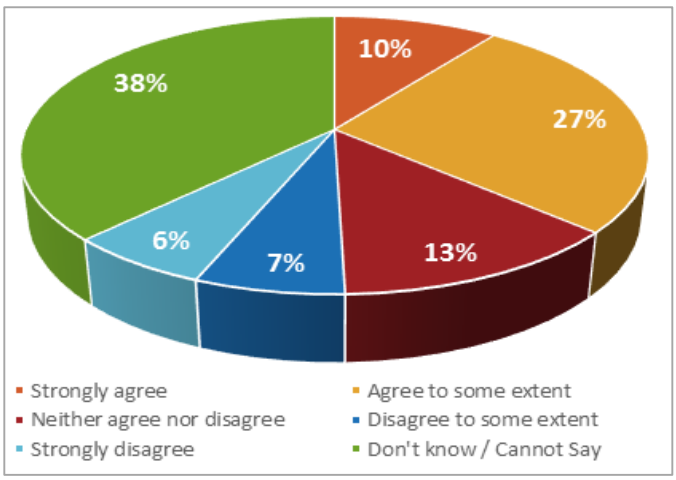


Figure 52: Children's Commute to School



Available Transportation Options

Figures 53 and 54 illustrated that a large proportion of the respondents were satisfied with the transportation options available to their household (61%) and to access retail and other amenities (50%). Around 63% expressed concern over their household travel expenses (Figure 55) and 43% of the respondents felt that they do not have good access to public transit stops from their community (Figure 56).

Figure 53: Available Transportation Options to our Household

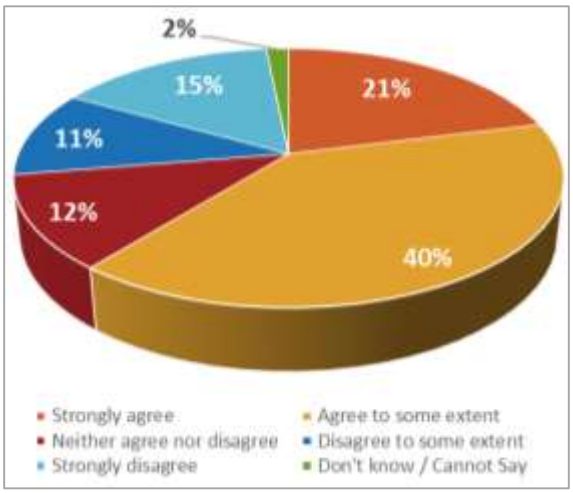


Figure 54: Travel Options to Access Retail/Amenities

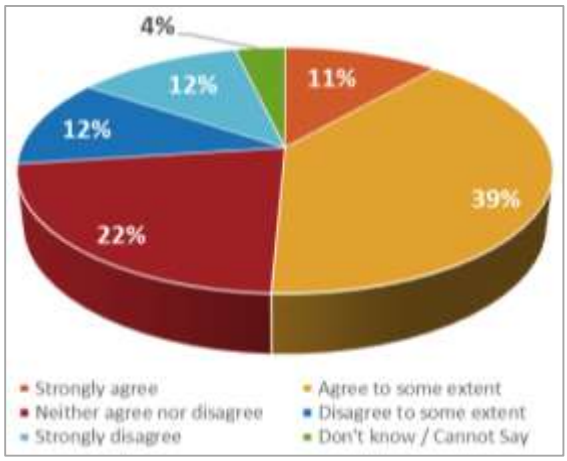


Figure 55: Household Travel Expenses

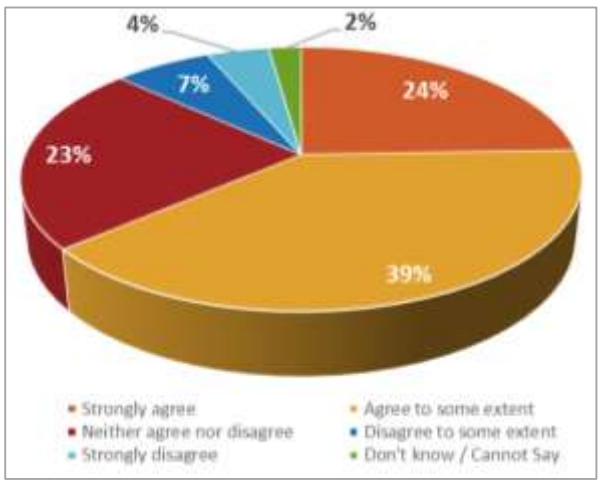
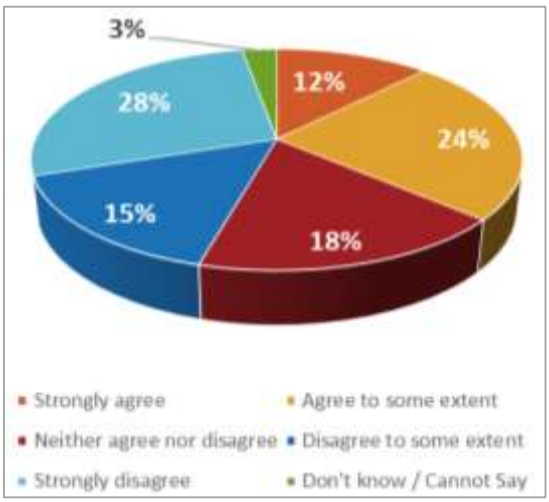


Figure 56: Access to Public Transit Stops from the Community



Road and Pedestrian Network

Around 57% of respondents expressed concern over the road and pedestrian network and associated infrastructure (Figure 57).

Safety Levels

Around 69% respondents expressed concern over safety of household members during travel to and from the community (Figure 58) but a majority of the respondents (90%) expressed satisfaction with the quality and safety of open spaces within the community (Figure 59).

Figure 57: Concern about Road and Pedestrian Network outside the Community

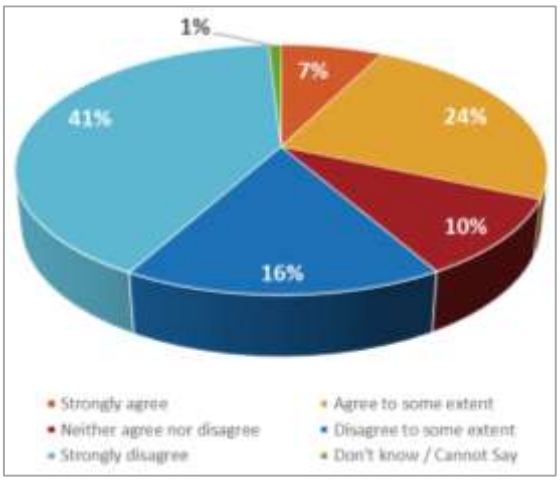


Figure 58: Concern about Safety of Household Members during Travel to/from Community

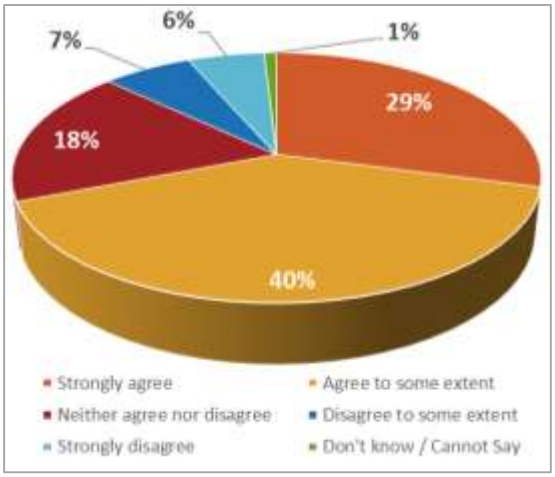
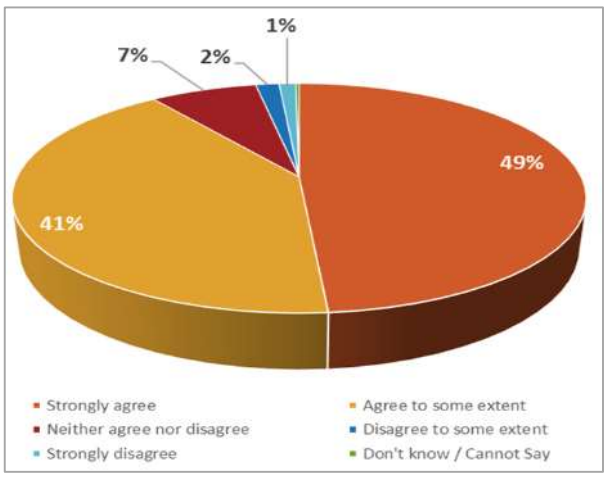


Figure 59: Satisfied with Quality and Safety of Open Spaces within the Community



KEY BENCHMARKS

Based on the survey analysis, benchmarks for average expenditure on energy, travel, resident's travel behavior and physical activity preferences were developed for a set of key indicators.

Table 1: Key Indicators and Benchmarks

Indicator	Bangalore City Benchmarks	Gated Communities Benchmarks	Ittina Abby	IBC Platinum	Adarsh Palms	L&T South City
Average Daily Trip Lengths (VKT) (KM)	8.8	9.4	11.4	8.6	8.5	8.5
Average Commute Trip Lengths By Mode - Work Trips (KMs)*						
* Data greater than two standard deviations was not taken into account.						
Car	10.2	11.7	13	9.7	10.5	13
Two-Wheeler	8.9	12.1	13.4	7.5	9	11.9
Company/School Bus	7.3	13.9	14.5	11.2	16.1	11.2
BMTC Bus	10	14.7	16.8	14.3	6	15
Auto	13	10	11.5	-	4	11.8
Taxi	16.75	13.5	20	-	-	7
Metro	2	0	-	-	-	-
Walking	1.8	1	1	1	1.5	0
Bicycle	3.8	0	-	-	-	0
Average One-Way Work Trip Lengths for Bangalore from the Bangalore Transport Model, 2012						
- Car: 7						
- Two-Wheeler: 7.79						
Average One-Way Work Trip Lengths for Bangalore from Comprehensive Traffic and Transportation Plan, Bangalore 2011						
- Auto: 8.6						
- Walking: 1						
Both the Bangalore city survey and the Gated Communities survey had good response rates for primary trips but low response rates for secondary trips.						
Trip Times for Work Trips (in Minutes)						
<15 mins	1675 (32%)	25 (10%)	2 (3%)	7 (16%)	11 (15%)	4 (7%)
15-30 mins	1954 (37%)	70 (27%)	15 (24%)	9 (20%)	26 (36%)	13 (21%)
30-45 mins	903 (17%)	70 (27%)	11 (18%)	17 (38%)	20 (27%)	20 (33%)
45-60 mins	410 (8%)	62 (24%)	21 (34%)	6 (13%)	10 (14%)	19 (31%)
60-90 mins	317 (6%)	27 (10%)	9 (15%)	5 (11%)	6 (8%)	4 (7%)
>90 mins	-	6 (2%)	4 (6%)	1 (2%)	0	1 (2%)
Trip Times for Non-Work Trips (in Minutes)						
<15 mins	1151 (34%)	27 (24%)	-	-	-	-
15-30 mins	1148 (34%)	41 (37%)	-	-	-	-
30-45 mins	514 (15%)	28 (25%)	-	-	-	-
45-60 mins	272 (8%)	8 (7%)	-	-	-	-
60-90 mins	321 (9%)	7 (6%)	-	-	-	-
>90 mins	0	0	-	-	-	-

Indicator	Bangalore City Benchmarks	Gated Communities Benchmarks	Ittina Abby	IBC Platinum	Adarsh Palms	L&T South City
Car Ownership Rates by Household						
no car/vehicle	2290 (90.98%)	55 (12%)	11 (12%)	21 (20%)	3 (3%)	15 (13%)
one car/vehicle	218 (8.66%)	67% (296)	67 (75%)	73 (70%)	55 (50%)	85 (75%)
two cars/vehicles	7 (0.28%)	19% (83)	11 (12%)	8 (8%)	47 (43%)	12 (11%)
three cars/vehicles	2 (0.08%)	2% (8)	-	2 (2%)	4 (4%)	-
four cars/vehicles	0 (0%)	1% (3)	-	1 (1%)	-	1 (1%
five cars/vehicles	0 (0%)	0	-	-	-	-
six cars/vehicles	0 (0%)	0	-	-	-	-
Vehicle Ownership Rates by Household						
No Vehicle	820 (33%)	29 (7%)	4 (4%)	11 (10%)	2 (2%)	0
One Vehicle	1320 (52%)	176 (40%)	23 (26%)	60 (57%)	36 (33%)	49 (51%)
Two Vehicles	297 (12%)	170 (38%)	40 (45%)	25 (24%)	52 (48%)	40 (41%)
Three Vehicles	59 (2%)	56 (13%)	22 (25%)	9 (9%)	9 (8%)	6 (6%)
Four Vehicles	20 (1%)	9 (2%)	0	0	6 (6%)	2 (2%)
Five Vehicles	3 (0.12%)	2 (1%)	0	0	4 (4%)	0
Six Vehicles or more	3 (0.12%)	0	0	0	0	0

Mode Share for All Trips	**Work trips**	**Non-Work Trips**	**Total Mode Share**	**Work trips**	**Non-Work Trips**	**Total Mode Share**	**Total Mode Share**	**Total Mode Share**	**Total Mode Share**	**Total Mode Share**
Auto	65 (3%)	88 (3%)	153 (3%)	8 (3%)	16 (14%)	24 (6%)	2 (3%)	0	1 (1%)	4 (7%)
BMTC Bus	616 (27%)	894 (27%)	1510 (27%)	12 (5%)	1 (1%)	13 (4%)	4 (6%)	3 (7%)	1 (1%)	4 (7%)
Car	81 (4%)	72 (2%)	153 (3%)	166 (64%)	68 (61%)	234 (63%)	28 (45%)	30 (67%)	58 (73%)	37 (61%)
Company / School Bus	199 (9%)	167 (5%)	366 (7%)	27 (10%)	0	27 (7%)	5 (8%)	6 (13%)	8 (10%)	6 (10%)
Taxi	4 (0.18%)	4 (0.12%)	8 (0.14%)	2 (1%)	2 (2%)	4 (1%)	1 (2%)	0	0	1 (2%)
Two wheeler	744 (33%)	806 (24%)	1550 (28%)	39 (15%)	18 (16%)	57 (15%)	21 (34%)	4 (9%)	3 (4%)	8 (13%)
Walk	546 (24%)	1289 (38%)	1835 (33%)	6 (2%)	6 (5%)	12 (3%)	1 (2%)	2 (4%)	8 (10%)	1 (2%)

Indicator	Bangalore City Benchmarks			Gated Communities Benchmarks			Ittina Abby	IBC Platinum	Adarsh Palms	L&T South City
Metro	1 (0.04%)	0	1 (0.02%)	0	0	0	0	0	0	0
Bicycle	20 (1%)	34 (1%)	54 (1%)	0	0	0	0	0	0	0
Other	-	-	-	0	0	0	0	0	0	0
Mode Shares from Transport Model Car - 10% Two-Wheeler - 31.30% BMTC Bus - 50.40% Auto - 7.40% Other - 0.90%										
Per capita trip rate from Bangalore HH Surveys*	0.62			0.37			0.4	0.31	0.35	0.54
** The per capita trip rate based on the 2013 household survey conducted in Bangalore is 0.62. T This low value is due to the fact that the survey had good response rates for primary trips but low response rates for secondary trips.*										
Per capita trip rate from 2012 Bangalore Transport Model	1.78									

Mode Share by Gender	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Car	107 (3%)	21 (2%)	136 (70%)	30 (45%)	27 (53%)	1 (9%)	20 (67%)	10 (67%)	43 (90%)	15 (60%)	34 (69%)	3 (25%)
2-wheeler	1319 (35%)	137 (10%)	29 (15%)	10 (15%)	17 (33%)	4 (36%)	2 (7%)	2 (13%)	1 (2%)	2 (8%)	7 (14%)	1 (8%)
Company/School Bus	232 (6%)	135 (10%)	12 (6%)	15 (22%)	3 (6%)	2 (18%)	4 (13%)	2 (13%)	3 (6%)	5 (20%)	2 (4%)	4 (33%)
BMTC Bus	1061 (28%)	402 (29%)	9 (5%)	3 (4%)	2 (4%)	2 (18%)	3 (10%)	0	1 (2%)	0	3 (6%)	1 (8%)
Auto	104 (3%)	45 (3%)	4 (2%)	4 (6%)	1 (2%)	1 (9%)	0	0	0	1 (4%)	2 (4%)	2 (17%)
Taxi	143 (4%)	27 (2%)	1 (1%)	1 (1%)	0	1 (9%)	0	0	0	0	1 (2%)	0
Metro	0 (0%)	1 (0.07%)	0	0	0	0	0	0	0	0	0	0
Walking	796 (21%)	607 (44%)	2 (1%)	4 (6%)	1 (2%)	0	1 (3%)	1 (7%)	0	2 (8%)	0	1 (8%)
Bicycle	48 (1%)	6 (0.43%)	0	0	0	0	0	0	0	0	0	0

Proportion of population that walks	30%	2.30%	1.60%	4.40%	2.70%	1.60%
Expenditure of Fuel/Week (Rs.)	140	1198	1047	1300	1623	803
Daily Transport Costs (Rs.)* **Includes only fare spent on public transit and does not include fuel costs.*	Not enough data	57	134	28	15	55
Mode Share among Domestic Help						
Car	No data	0%	0%	0%	0%	0%

Indicator	Bangalore City Benchmarks	Gated Communities Benchmarks	Ittina Abby	IBC Platinum	Adarsh Palms	L&T South City
2-wheeler	No data	11%	67%	80%	29%	14%
Company/School Bus	No data	0%	0%	0%	0%	0%
BMTC Bus	No data	21%	17%	11%	29%	14%
Auto	No data	1%	0%	0%	7%	0%
Taxi	No data	0%	0%	0%	0%	0%
Metro	No data	0%	0%	0%	0%	0%
Walking	No data	63%	17%	6%	29%	71%
Bicycle	No data	4%	0%	3%	7%	0%
Average Trip Lengths for domestic help (KM)** ***=trips less than 1 km were calculated as 1 km*	No data	1.7	1.2	1.7	2.5	1.3
Electricity Consumption (Rs.)	No data	1286	1298	1331	1411	1145
Average Access time and Wait time for Public Transit	30-60 minutes	10-15 mins	Not enough data	Not enough data	Not enough data	Not enough data
Resident Reported Green Practices in the Development*** **** = Multiple responses were permitted per respondent*						
Rain Water Harvesting	No data	44%	19%	3%	5%	13%
Sorting of Waste	No data	68%	19%	9%	17%	20%
Waste Water Recapture	No data	48%	17%	12%	7%	8%
Car Charging Locations	No data	17%	7%	1%	2%	5%

SURVEY SUMMARY

Based on the benchmarks, the following conclusions can be drawn:

- Vehicle ownership rates: A huge majority of the households (93%) owned at least one vehicle, of which the largest proportion was cars (88%).
- Travel mode: There is a greater reliance and dependency on cars for work trips and additional trips, i.e. trips not counted as work trips and includes trips to grocery store, classes and others. Cars were the primary mode for 63% of the weekday trips.
- Gender preferences for mode: Men were more likely to travel by car and/or two-wheelers, while women and respondents over 40 years of age preferred walking, public transit or intermediate public transit, like auto rickshaws.
- Distance and time to work: Trips with distances more than 15 kilometers and trip times ranging between 30 minutes to 1.5 hours typically had two to three occupants.
- Mode choice preference: Cars and/or two-wheelers were preferred due to convenience and safety.
- Work Travel Dissatisfaction: Even though 60% respondents mentioned facing heavy congestion during their commute to work, around 43% of the respondents expressed satisfaction over their work commutes. This might due to the perceived comfort from using cars for these trips.
- Pedestrian network: Lack of continuous and safe pedestrian network was the main reason (61%) behind lack of walking.
- Travel to and from community: Travel to and from the community was generally perceived to be unsafe by 69% of the respondents.
- Shopping preferences: Around 65% of the respondents wanted to see a variety of accessible retail and amenity shops within the community. This indicates a demand for mixed-use.
- Community amenities: A majority of the existing communities surveyed followed green practices and had safe and adequate open spaces within the community. Presence of open spaces was, one of the key reasons, 49% of respondent residents chose to live there.

BUILT FORM CORRELATIONS

Urban Built Form Indicator

Table 2 lists the urban form indicators that take into account the localized nature of urban form features and associated impacts on transportation. The chosen indicators reflect design and planning features in and around residential gated communities in Bangalore that can decrease the tendency to use private vehicles.

Table 2: Built Form Indicators

Category	Sub-Category	Indicator	Data Collected through Visual Observation
Design	Neighbourhood	Neighbourhood descriptor	Predominant neighbourhood type – residential, commercial, industrial, mix of uses etc.

Category	Sub-Category	Indicator	Data Collected through Visual Observation
	Presence of on-street parking	Parking supply	On-street parking/parking supply
	Street Network	Presence of street network around development	Number of lanes, road types, if any interconnectivity, including presence of arterial roads, street network directness
Design/Distance to Transit	Presence of pedestrian network around the development	Sidewalk quantity and quality	Presence of sidewalk, sidewalk cleanliness, slope, number of pedestrian benches, pedestrian oriented signage, sidewalk lighting
	Distance to nearest bus stop – last mile connectivity and accessibility to public transit by foot	Sidewalk connectivity to public transit	Presence of sidewalk to nearest public transit stop and accessibility to public transit by foot
Destination Accessibility	Trip proximity and trip type	Types and number of destinations within walking distance from residence Presence of complimentary amenities within walking distance	Proximity to amenities - schools, markets, hospitals, access to key roads, highways, transport hubs like airports, or proximity to key employment center

Summary of Visual Assessment of Built Form Indicators

Visual assessments were conducted by the EMBARQ India team to better understand and evaluate the urban built form features around the chosen gated communities. The following section summarizes the built form observations at Ittina Abby, IBC Platinum, L&T South City and Adarsh Palm Retreat.

Ittina Abby

Located 2 kms off Airport Road, Ittina Abby is a 3.5 acre apartment community located in a predominantly residential, middle-class neighbourhood. Completed in 2004, the development accommodates 220 apartments with a residential population of 900 people in 2-3 bedroom units for the middle-class income group.

Key observations on built form around Ittina Abby are as follows:

Indicator	Description
Predominant neighbourhood type	Residential with neighbourhood commercial
Street network	Two-way neighbourhood street (around 6.0m) with on-street parking on either side. The roads are unpaved and the narrow streets make navigation difficult for vehicles and pedestrian movement. There is no segregation of space between motorized & non-motorized traffic.
On-street parking/parking supply	Allowed on both sides
Presence of pedestrian network around the development	Sidewalk is not present in most places. Where they are present, the storm water drain cover acts as a sidewalk. The sidewalk near Ittina Abby is used for two-wheeler parking. Street lighting is present in some areas.
Sidewalk connectivity to public transit	The nearest transit stop is the LB Shastri Nagar bus stop which is around 0.45 km. Poor connectivity due to absence of sidewalks, narrow streets and lack of segregation.
Types and number of destinations within walking distance from residence	• Ittina Abby is only 2kms from Old Airport Road, which is a major arterial road. However poor quality of roads, narrow roads, mixed travel modes and lack of segregation increases the travel time. • Ittina Abby is within a 5 minute walking distance to Uthkarsh Park, which serves as a green lung space for residents of this neighbourhood.
Presence of complimentary amenities within walking distance	Neighbourhood commercial such as a small grocery store, vegetable store, a salon and internet café are within a 10 minute walking distance from Ittina Abby. However poor accessibility and lack of pedestrian infrastructure forces residents to drive to the nearby stores.

The entry/exit point to and from the community facilitated easy movement for cars and two-wheelers. Except at the front entry/exit gate, pedestrian movement was separated from vehicular movement with pedestrian walkways around the building boundary and internal courtyards. The entry gate leads directly to a basement parking area for cars. There is no separate provision for two-wheelers and cycles parking. Residents typically use the left over space or free space to park their two-wheelers and cycles. Facility management staff, such as security, maintenance staff etc. have their own parking spaces. The apartment also provides

Entrance/Exit Gate at Ittina Abby, Leading Directly to Basement Parking Area

Built Form around Ittina Abby

Road leading to Ittina Abby. Sidewalk on the right is used for two-wheeler parking

Unpaved roads with on-street parking on either side

Absence of sidewalks, uncovered storm water drains and narrow streets

Neighbourhood commercial within a 10 minute walking distance from Ittina Abby

amenities such as an informal garden area, children's play area, tennis court, gymnasium, multipurpose hall, pedestrian walkway/jogging track.

Parking at Ittina Abby




Pedestrian Movement at Ittina Abby: Internal Courtyard, Pedestrian Walkway



Internal Courtyard

Pedestrian walkway around Ittina Abby

Amenities at Ittina Abby

Children's Play Area and Tennis Court

Multipurpose Hall

Informal lawn

Gymnasium

IBC Platinum

IBC Platinum City is located in Yeshwanthapur, off Tumkur Road (AH 47), enroute to Peenya. It is a residential township located near institutions such as the National Institute of Design, Indian Plywood Industries Research and Training Institute and United Nations Industrial Development Organization (UNIDO). Currently under construction, the development is spread over 34 acres and accommodates more than 2500 units in around 14 high rise towers. The estimated residential population is around 11000 people in 2, 3 and some 4 bedroom apartments and belong mostly to a middle to upper-middle class population.

Entry to IBC Platinum

Indicator	Description
Predominant neighbourhood type	Institutional area with some roadside shops for office users.
Street network	HMT Main Road is a two-way (around 13m), unpaved and roads with no medians oriented towards the motorist.
On-street parking/parking supply	Temporary parking allowed
Presence of pedestrian network around the	Broken sidewalks or no sidewalks force pedestrians to

Indicator	Description
development	share the road with vehicles.
Sidewalk connectivity to public transit	Distance to the Peenya Metro Station is 0.4 km and to the nearest bus stop is 0.6 km. Poor connectivity due to broken and/or absence of sidewalks and lack of segregation.
Types and number of destinations within walking distance from residence	IBC Platinum is only 0.4 kms from the Tumkur Road, which is also a National Highway.
Presence of complimentary amenities within walking distance	Neighbourhood commercial such as a general grocery store, produce store, a pharmacy and clinic are within the development. In addition, there is also a preschool within the development. ATM and auto rickshaw stands outside the main gate.

Built Form around IBC Platinum

HMT Main Road

Access to the Peenya Metro Station

Broken Sidewalks and Unpaved HMT Road with Two-Way Traffic

Even though there is a separate gate for pedestrians, access to IBC Platinum is primarily oriented towards the motorist. Buildings are raised on a podium with parking on ground level with open access. This hinders pedestrian circulation within IBC Platinum as cars are allowed even in areas that were originally meant for pedestrians. Two-wheelers have distinct marked parking but facility management staff including security and maintenance staff do not have separate parking areas. Since IBC Platinum is still under construction, there is regular ingress/egress of vehicles transporting

construction materials. These vehicles are parked as close to the building as possible making pedestrian circulation unsafe. The apartments also provide amenities such as a landscaped garden with a gathering area, children's play area, tennis court, gymnasium, multipurpose hall and swimming pool. The apartments also have retail within the community such as a general grocery store, produce store, a pharmacy and clinic.

Parking and Circulation in IBC Platinum

Parking at IBC Platinum

Scooter Parking

Parking allowed in areas meant for Pedestrians

Amenities in IBC Platinum: Multipurpose hall, Swimming pool. Children's' Play Area, Garden with Seating,

L&T South City

Located in Arekere Mico Layout, Bannerghatta Road, L&T South City is a 34 acre residential township with 18 high rise towers, with 2000 2, 3 and 4 BHK apartments. Still under construction, L&T South City accommodates a residential population of approximately 8500 people in 2 and 3 bedroom units in the middle to upper middle-class income group.

Key observations on built form around L&T South City are as follows:

Indicator	Description
Predominant neighbourhood type	Developing – around institutions and new employment centers.
Street network	Two-way internal road network feeds into the City road network. Lack of segregation of space between motorized & non-motorized traffic. Distance between farthest blocks to their nearest gates is between 350 – 550m or 10 -15 min walking. Most School drop off points are accessed by vehicle in the mornings clogging up movement along main access road.
On-street parking/parking supply	Resident parking allowed in the internal road network.
Presence of pedestrian network around the development	Pedestrian Infrastructure not designed for seamless movement – insufficient facilities, obstructed walking paths.
Sidewalk connectivity to public transit	Distance to the Arekere Mico Layout Bus Stand is 0.5 km and Mico Arekere BPL bus stop is 0.8 km. However pedestrian infrastructure is poor with obstructed walking paths.
Types and number of destinations within walking distance from residence	Some neighbourhood commercial and L&T South City park.
Presence of complimentary amenities within walking distance	Some neighbourhood commercial retail is located within 0.4 kms from L&T South City.

Like most communities in Bangalore, L&T South City is also oriented towards the motorist. Pedestrians do not have a separate entry and have to use the same entry as the vehicles and this causes confusion and congestion especially during morning hours, due to school and office pick-ups.

Neighbourhood around L&T South City

Buildings are raised on a podium with two levels of basement parking. Vehicular traffic is not segregated within the community and even from playing fields for children. There are limited pedestrian connections within the development and the common movement path is the parking access ramp for both vehicles and pedestrians. Accessibility to ground level from podiums is suitable for vehicles but increases walking distances for residents to amenities. Distance between farthest blocks to their nearest gates is between 350 – 550m and 10 -15 min by walking. Most school-drop off points are accessed by vehicle in the mornings clogging up movement along main access road. The apartments also provide amenities such as tennis courts, club houses, swimming pools, gymnasium, multipurpose halls, children's play area, badminton courts etc.

Street Network at L&T South City

Lack of segregation of space between motorized & non-motorized traffic

Neighbourhood Retail near L&T South City

Entry and Exit Gates – L&T South City

Pedestrian movement within L&T South City

Vehicular traffic is not segregated within the community and even from playing fields for children

Parking access ramp for both vehicles and pedestrians

Traffic congestion along main access road at school-drop off points

Adarsh Palm Retreat

Located on Outer Ring Road, Adarsh Palms Retreat is a mixed-use development that extends over 250 acres of land, located on the outskirts of Bangalore city, about 18 km from the main city. The development accommodates 3 Special Economic Zones (SEZ), a five-star hotel, a municipal lake, around 750 high-end villas and 2,040 luxury apartments. Still under construction, Adarsh Palm Retreat accommodates a residential population of approximately 13,000 people in 3 and 4 bedroom units in the upper middle-class and upper class income group.

Key observations on built form around Adarsh Palm Retreat are as follows:

Indicator	Description

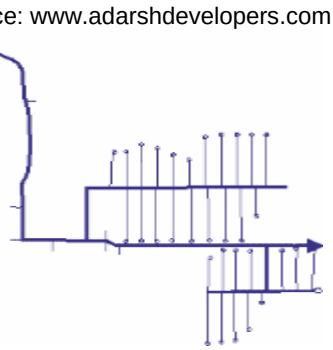
Predominant neighbourhood type	Along Outer Ring Road – main connectivity to major IT companies and business parks.
Street network	Hierarchical internal road network with wide carriageways feeds into the City road network. Oriented towards the motorist.
On-street parking/parking supply	No
Presence of pedestrian network around the development	The sidewalks on the main street was too narrow but residential streets had continuous sidewalks.
Sidewalk connectivity to public transit	Distance to the nearest bus stop is around 2 km and narrow sidewalks with no trees makes walking difficult.
Types and number of destinations within walking distance from residence	Grocery store, ATM, stationary shop and dry cleaners common to both the villas and apartments
Presence of complimentary amenities within walking distance	None

The road system followed a hierarchical pattern oriented towards car trips. Three clear entry points with restricted movement lines were defined, for issues of safety and control. These would then

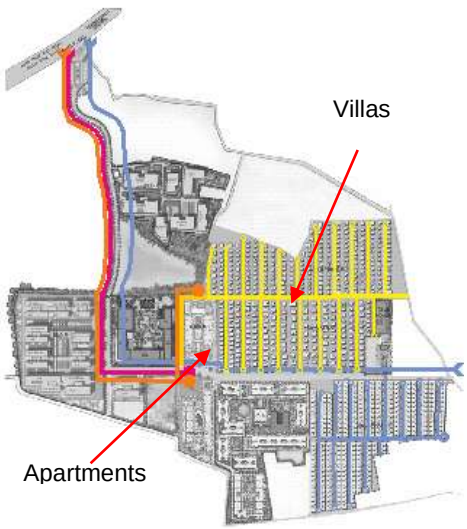
Wide Carriageways with Minimal Preference for the Pedestrian

Street Network at Adarsh Palm Retreat

View of Adarsh Palm Retreat
Source: www.adarshdevelopers.com



Hierarchical Road Network within the Community



Restricted Movement Pattern

segregate users by function creating congestion during peak hours and lengthening travel distances and times. Internal accessibility for pedestrians or bicyclists was not planned for, creating a hostile urban environment that was primarily car friendly. Residual spaces, interfaces with the water's edge, open recreational spaces, or common waiting areas were not designed for within the master plan - inhibiting the growth of a socially vibrant community. Due to traffic congestions at certain intersections and regressive master planning strategies for pedestrians and bicyclists, personal cars are the preferred mode of travel.

The apartments also provide amenities such as tennis courts, club houses, swimming pools, gymnasium, multipurpose halls, children's play area, badminton courts etc.

Pedestrian Network on the Main Spine of Adarsh Palm Retreat

a. No Street Frontage

b. Narrow Sidewalks

c. Transit Waiting Area

Residential Street Network

Narrow Streets

Cul-De-Sacs – Physical Barriers Hindering Seamless Circulation

Narrow but Continuous Sidewalks

Summary of Built Form Correlations based on Survey Responses

This section summarizes the relationship between built form and travel behavior based on survey responses. The survey responses sought to assess the respondent preferences for choosing that particular community and their perceptions about their community.

Based on our analysis, the following three key relationships were identified as being statistically significant:

1. Access to public transit stops from the community
2. Distance from the development to transit points
3. Transportation options available to the household

The *distance from the development to schools* was not perceived differently across the developments.

The *open spaces and safe environment internal to the development* was also not perceived differently across the developments.

The *distance from the development to employment opportunities/offices* was mixed. Ittina Abby and L&T South City had more residents disagreeing with this survey question IBC Platinum and Adarsh Palms both had more residents who agreed with this statement. IBC Platinum is located near metro stops, bus stops, and a train terminal. Adarsh Palms has reported twice the number of commuters who walk to work as the other developments, most likely because of the presence of three Special Economic Zones with some concentration of jobs within the development itself

The *distance from the development to retail shops and other amenities* was significant for both L&T South City, where residents reported agreeing with the statement more frequently, and Adarsh Palms, where less residents agreed with the statement than at the other developments.

Residents at IBC Platinum were satisfied with *the number of retail and amenity shops located in the development*, while those living in Adarsh Palms and Ittina Abby were unhappy with the availability of internal retail.

This distance from the development to transit points was our second strongest relationship, where IBC Platinum responded a high level of contentment with the transit connectivity. L&T South City and Ittina Abby both disagreed with this statement, suggesting there is room for transit connectivity improvement.

When asked *if the family/friends of residents also lived internal to the developments*, IBC Platinum and Ittina Abby responded that they did, while L&T South City and Adarsh Palms indicated that their friends lived elsewhere.

When asked to *evaluate the green building practices internal to their development*, Ittina Abby reported agreement, while Adarsh Palms indicated disagreement. This is also noteworthy because Ittina Abby is the smallest and lowest income of the developments, while Adarsh Palms is the largest and highest-income community of all the developments.

Regarding the *transportation options available to the household*, Ittina Abby largely disagreed (the third strongest relationship in our dataset), perhaps because of the lack of a complete road network, missing sidewalk and narrow roads with on-street parking which force pedestrians to walk in the

middle of the unpaved roads. IBC Platinum agreed with this statement, perhaps because of connectivity to mass transit, and while the metro stop nearby hadn't opened when the survey took place, it was under construction at the time of the survey and has opened since then.

When asked if the residents of developments are *concerned with the high cost of household travel expenses*, Ittina Abby residents agreed with this sentiment, while Adarsh Palms residents disagreed. This may be a reflection of income differences.

When asked to *rate the pedestrian infrastructure outside of the development*, IBC Platinum (which has a wide, unpaved road) scored highly, while Ittina Abby (previously addressed) scored poorly-indeed, 91% of residents were not satisfied with the condition of the external pedestrian network.

There was little *concern for safety when getting to or from any of the apartment complexes*, and the results were almost the same for each of the developments.

When considering *the congestion during the morning commute*, Ittina Abby and Adarsh Palms were both more concerned than average, while IBC Platinum and L&T South City were both less concerned with their morning commute times.

Regarding *the commute to work*, responses were not significantly different from the calculated benchmarks.

The *children's commute to school* was a positive for L&T South City, but a negative for Ittina Abby and IBC Platinum. This may be dependent on the age of the school attending children, presence of designated pick-up/drop-off points and several schools within 2-3 kms of L&T South City as IBC Platinum has an internal pre-kindergarten, but no facilities for older students.

Regarding *travel to retail*, IBC Platinum residents were again more agreeable than the others in regards to their travel options, while Ittina Abby residents were again more likely to indicate disagreeing with accessibility.

Regarding *satisfaction with available parking within the community,* only L&T South City had a significant response for parking, and they were more content with the on-site parking than the benchmarks.

When asked about *their level of content with public transit options*, the strongest relationship in the survey comes out, with 92% of residents at Ittina Abby being unsatisfied, while only 13% (the benchmark was 36%) of the residents at IBC Platinum city were unsatisfied.

Regarding *preference to stay within the development if internal retail/shops were available*, the residents all agreed that they would rather do their shopping internal to their developments.

When asked *if the internal environment of their development impacts household transportation decisions*, only L&T South City differed from the calculated benchmarks, with more people disagreeing than the benchmark (56% of total residents believed the internal environment impacted their transport decisions).

For the *satisfaction regarding the number of internal retail and amenity shops located within the development*, L&T South City and IBC Platinum were both content, while Adarsh Palms was dominated by 73% of residents reporting that they disagreed with this statement.

IMPACT EVALUATIONS BASED ON CHANGES IN TRAVEL BEHAVIOUR

When evaluating the Gated Community Survey, we analyzed the number of trips that could be transferred from individual motorized transportation to non-motorized transit (NMT) and public transit, to prevent negative impacts on air quality, public health, spending on vehicle infrastructure, and safety.

As mentioned earlier in the report, as part of this project, the EMBARQ team partnered with real estate developers building upcoming new developments in Bangalore, conducted design audits of their designs and plans, and shared recommendations. The impact evaluation part of the project aims to answer the question – *what if the design recommendations provided by the EMBARQ were adopted in these existing developments? What would the impact of this be on the extent of private motorized travel and energy consumption by residents in these gated communities?* In our findings, 64% of Gated Communities residents commute by car, while only 3% do so Bangalore wide (The Bangalore Household Survey does include Gated Communities). In contrast, 28% of Bangalore used a two-wheeler for their commute while only 15% do so in Gated Communities. However when two-wheelers are included, we find that 78% of trips made by residents of gated communities are private, motorized transportation. The primary mode share in Bangalore is walking (30%) while in the gated communities it makes up a paltry 2%. Bangalore's local bus system has a citywide ridership of 28%, while in the surveyed communities it is 5%.

The relatively few people who live in GCs are often driving long distances from beyond the ring road to the CBD for work, and are congesting the streets for the rest of the residents of the city. This increases travel times across the board, but more importantly, it reduces the safety of pedestrians. In Bangalore, the sidewalks that do exist are frequently used as parking areas for two-wheelers, cars, spillover from ongoing construction, etc. These challenges force pedestrians to walk on the road and indicate a lack of awareness regarding the importance of NMT dedicated infrastructure in the city.

In order to calculate the fuel savings resulting from these changes to the built form, shown in Table 3 we surveyed the residents of the GCs as to what factors would encourage more walking, cycling, and usage of public transit. There is obvious demand for better walking conditions, with 61% of the residents stating that they would walk more if there were safe, usable footpaths. We used previously estimated figures for acceptable walking (T. Litman 2014) and cycling (Favez 2008) distances. While applying this large percentage to our dataset results in a relatively small saving in terms of fuel consumption, there are many public health benefits which were not considered for this study. Using these numbers, we calculated the number of trips that were less than 1.5 km, and from that a median walking distance (0.5 km). All calculations are done for one way, and not round trip, so would in most cases be doubled in the real world.

Trips that were already NMT or public transit were excluded, which gave us 23 trips in our survey sample that were less than 1.5 km. We scaled this number up to the GCs surveyed, simply using the ratio of households in our survey sample versus the total number of households in the GCs we surveyed. This gave us a total of 1,551 walkable trips made daily from the six communities. We then used 61% of this number, giving us 946 final trips which would be shifted from cars, two-wheelers, and auto-rickshaws if the appropriate infrastructure was available. We then applied average fuel consumption data, fleet composition, for diesels and petrol cars, shares of petrol and LPG auto-rickshaws, as well as motorcycles and scooters. All considered, these 946 trips, which were switched to NMT or public transit, had an estimated savings of 43 liters of fuel per day.

While fewer individuals reported that they were willing to cycle, their fuel savings is larger, due to the longer distances. 23% of residents reported that they would cycle more if safe cycle lanes were present. All trips less than or equal to 1.5 km or greater than 5 km were excluded from analysis here, as well as those already on NMT or public transit. The average cycle trip was estimated at 3.75 km, with 1,178 trips moved from auto-rickshaw, car, or two-wheeler. These trips would result in an estimated fuel savings of 381 liters of fuel per day.

The net effect for walkable trips and cycleable trips are understated in two ways, first, short trips often have distances which are underreported (The World Bank 2010), and secondly do not account for cold start conditions, which result in higher emissions. The motor vehicle emission simulator (MOVES) model from the EPA estimates that cold starts contribute 60% to 80% of trip CO emissions and over 90% of trip HC emissions (EPA 2014). This is especially important for our dataset, where 80% of the trips of 1 km or less are made by car.

The number of individuals who reported being willing to take public transit if there were an internal shuttle was 35%, and all trips greater than 5 km, not already on public transit, were included here for analysis. The average distance of these trips was 14.9 km. When applied to the total dataset, there were 4,884 trips which would be switched to public transit. This would result in an estimated daily savings of 6,450 liters of fuel.

Taken together, safe sidewalks, bike lanes, and an internal shuttle, would save an estimated 6,873 liters of fuel every day, or about 2.5 million liters every year. Given the current fuel prices, the savings would be about $3 million USD every year—just for the residents of our six GCs.

Table 3 provides the information on fuel saved based on changes in travel behavior.

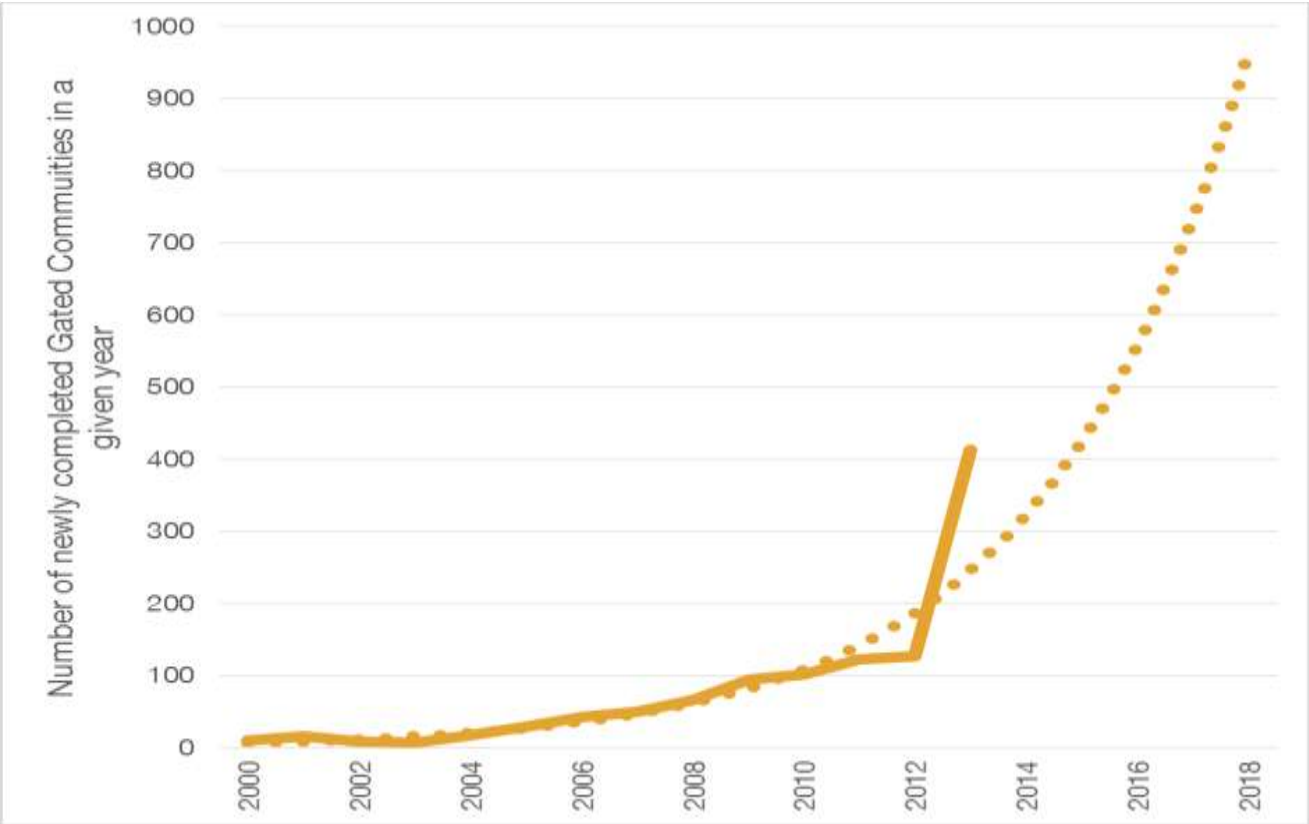
Table 3: Fuel Changes based on Travel Behaviour

	Walkable Trips (≥1.5 km)	Cycleable Trips (1km<x≥5km)	Public Transit Trips (> 5KM)
Trips within Distance(Survey)	1551	5124	13955
Potentially Mode-Shifted Trips	946	1178	4884
Average Distance (km)	0.5	3.75	15
Daily Fuel Savings (L)	43	381	6450
Daily CO2 Emissions Prevented (kg)	64	608	9653
Annual Fuel Savings for 41,000 Households (6 gated communities)			
Total= 2.5 million Liters	15,695	139,065	2,354,250
Annual Emissions Prevented (CO2) for 41,000 Households (6 gated communities)			
Total= 3.8 million kg	23,360	221,920	3,523,345

WAY FORWARD

Well-planned and compact development – with mixed uses and high-quality walk, bike, and transit access – can improve energy efficiency and livability, while reducing the cost of delivering basic services by 30 to 40 percent (The World Bank 2010). Energy savings can accrue from many forms: shorter trips, a greater share of trips by foot, bicycle, and transit, smaller indoor spaces that require less heating and cooling, smaller outdoor spaces that require less water to maintain, and more compact infrastructure that requires less energy for transportation. Even conservative estimates reveal that the impact in terms of reduced fuel consumption and CO_2 emissions from our built form recommendations will be substantial. We estimated an annual fuel savings of 2.5 million liters and an annual prevention of CO_2 emissions of around 3.8 million kg in just the 30,000 households from the 6 GCs as compared with the Business-As-Usual scenario.

Figure 60: Newly Completed Gated Communities by Year through 2013- Projected to 2018



With approximately 1,500 completed GCs in Bangalore (Bangalore Property n.d.), and around 500 projects currently under construction, the need for transportation planning is evident. GCs vary in size significantly, however, using our smallest development as an example will yield us a conservatively small estimate. Given that the average household size from our GCs was 2.3 people, we can estimate that these effects will hold true for 1,500 communities * 220 households per development * 2.3 individuals, which is approximately 250,000 people. As the majority of these developments are located on the periphery (60% are outside of the ring road), and the fact that 78% of the commuting is done by personal vehicle, these GCs are creating enormous challenges for already over-crowded and unsafe road networks. When scaled up to the estimated current number of developments, and accounting for a return trip, our estimates are that by adopting these changes in planning and design the built form, Bangalore's gated communities could reduce their annual fuel consumption by 55 million liters of fuel, save approximately $64 million USD, and reduce CO2 emissions by 82 million kg each year. However, the actual negative effects of this built form are truly staggering when projected even only five years forward, as shown in Figure 57. By 2018, there will be an estimated 1,000 new gated communities finished every year, again using our conservative numbers for households in each

gated community, and the size of those households, we can calculate that Bangalore will have 4,500 communities * 220 units per community, * 2.3 individuals = approximately 2.3 million people, spread across about 1 million households. We must then assume that these trips will return home, doubling the fuel savings of a trip moved from private, motorized transit to NMT or public transit. The annual fuel savings- only from short sidewalks, bike lanes, and internal shuttles connecting to city transit, would be an annual savings of a staggering 167 million liters of fuel, and more than 250 million kg of CO2. This potential decrease in fuel consumption could save the residents of these gated communities almost $200 million USD, given current fuel prices, and only accounting for the fuel consumed by their vehicles. These estimates do not include the high costs that residents face due to increased commute times caused by additional traffic congestion on the road if the adoption of a car-oriented lifestyle continues unabated in India.

While residential developers have shown reticence towards adopting many of the green building techniques, the commercial sector has been making strides towards a more sustainable built environment. There are many green building rating systems in India, most notably GRIHA (Green Buildings Rating System India) and IGBC (India Green Building Council). These systems have developed a variety of incentives towards adoption, most frequently additional floor-area-ratio benefits. Some additional encouragement programs, like lower-interest loans, and a fast-track through the permitting process have also increased participation. These benefits should be better publicized and increased, which will result in increased participation in the programs.

Commercial developers, such as Infosys, have embraced the technological improvements that are possible, and have made huge changes (such as installing a radiant cooling system), while calculating the payoff periods to ensure that their investments are sound. However, there is greater resistance in the residential sector, perhaps due to the fact that developers often sell off the properties before their returns on investment can be achieved. This is damaging to all parties involved, as it creates a cycle where residential developments require ever increasing amounts of energy, water, and resources. However, with so much of the built form still to be constructed in India, now is the time to educate both developers and residents so that supply and demand shift towards less energy intensive development patterns.

In order to achieve more sustainable buildings, the awareness of payback periods for different green techniques must be developed. Education of both developers and tenants could be in the form of a public database, publication, or training. A best practices guidebook tied to a few specific case studies could also shed light onto the possible adaptations, as well as their anticipated returns on investment. Additionally, designers need to push the boundaries of what is acceptable, looking at long-term paybacks to following sustainable practices rather than only focusing on the initial building cost. In addition, coupling urban design practices with energy efficiency and adoption of renewable energy sources is necessary to achieve the highest levels of energy sustainability – since any use of non-renewable fossil fuels is unsustainable in the long-term.

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PHOTO CREDITS

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