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Planning Proposal for Public Bicycle Sharing (PBS) System: A Case of Navsari City

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Abstract - *Bicycling is the most efficient mode of eco friendly and sustainable transportation for shorter commutes. In cities where bicycling shares are low, efforts are being made to promote cycling as a viable mode of transport. The boom in bicycle sharing is receiving growing attention as societies become more aware of the importance of active non-motorized traffic modes. Public Bicycle Sharing (PBS) system is a flexible public transport service. Users can check out a bicycle from any station and return it to any other station in the system. The main objective of the dissertation is to reduce traffic congestion and encourage the use of public bicycles instead of private vehicles for short distance trips in Navsari city. According to the PBS guidance document, the entire PBS system planning proposal from feasibility assessment to completion will present through 5 major key steps: Assess, Enable, Plan + Design, Invest and Implement. The analysis supports the relevance of the role of urban planning for the best positioning of bicycle sharing stations. The results could be encouraging public bicycles for short trips and provide planning proposal of PBS system for Navsari city.*

Key Words: Public Bicycle Sharing (PBS) system, Sustainable transport, Non-motorized transport, Bicycling, Navsari city.

1. INTRODUCTION

Transportation is significant for giving flexibility to the individuals, and for development of commodities. Transportation encourages a wide scope of chances for a person for wanted exercises. In spite of the fact that transport isn't an end in itself, it is the way to numerous closures. Productive transportation brings about financial, social and political favourable circumstances.

India's vehicle area is huge and different; it obliges the requirements of 1.1 billion individuals. The actual availability in the metropolitan and country zones is basic for monetary development. Since the mid 1990s, India's developing economy has seen an expansion popular for transport foundation and administrations. Be that as it may, the area has not had the option to keep speed with rising interest and is ending up being a drag on the economy. Significant enhancements in the area are subsequently important to help the nation's proceeded with monetary development and to decrease neediness. Vulnerable air quality, gridlocks, and absence of stopping are a consequence of expanding portability needs. To take care of these issues without forcing serious limitations in close to home portability, options in contrast to vehicles, controlled by interior burning motors, are fundamental. One of these choices is Public Bicycle Sharing (PBS) framework. Ongoing examination in India's metropolitan transportation area gives enough proof to show that there is a solid connection amongst cycling and pays levels. As pay levels increment, cycling ridership and possession diminishes in metropolitan zones. With a declining market, India's cycling industry likewise keeps on confronting difficulties in supporting a reasonable plan of action to remain serious all around the world. As urban communities grow, increments in movement distances are likewise debilitating the utilization of non-mechanized modes (NMT).

Public Bicycle Sharing (PBS) is a high quality bicycle based public transport system in which bicycles, stored in an intimately spaced network of stations, are made available for short-term shared use. Bicycle sharing programs involve installing multiple bicycle stations at several different key locations. A user checks-out the bicycle from one location, rides to his or her destination, and drops the bicycle to another location.

1.1 Aim

- To encourage the use of public bicycles instead of private vehicles for short or inner city trips and give planning proposal of Public Bicycle Sharing(PBS) system for Navsari city.

2. PUBLIC BICYCLE SHARING (PBS) SYSTEM

Bicycle -sharing schemes have evolved severely since their introduction in the 1960s. The first-generation schemes that were introduced in Amsterdam (1965), La Rochelle (1976) and Cambridge (1993) provided free bicycle to use and return from any location. Then, a new "second generation" set of systems began in 1991, in Farsø and Grenå, Denmark (DeMaio, 2009). By 1995, the first large scale scheme was introduced in Copenhagen. These third-generation systems took the form of a "bicycle lending library" (Metrolinx, 2009) with a membership or annual fee. They used custom-built "heavy duty" bicycle with non-standard components to decrease stealing. Finally, introduction of smartcard technology in the late 1990s would usher in the third-generation schemes that have enabled bicycle-sharing to become what it is today. The evolution of bicycle -sharing and the different generations of bicycle-sharing programs are summarized in Figure below.

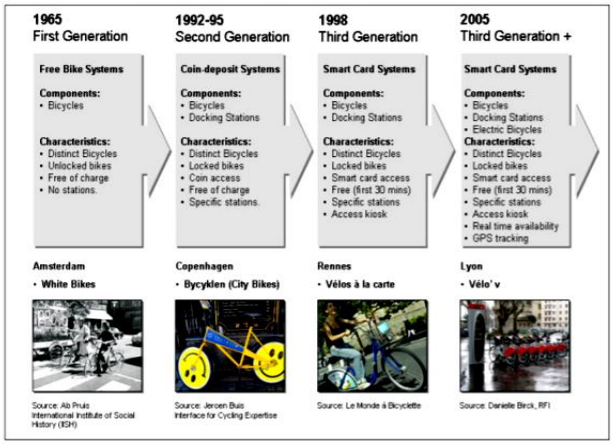

Fig -1: The evolution of bicycle-sharing
(Source: Dhingra, Chhavi and S. Kodukula, 2010)

In November 2013, the two-day conference on "Sustainable Cities Through Transport" at Coimbatore, with respective city engineers from Madurai, Trichy, Tirupur, Salem and Coimbatore, stressed for improving non–motorized transport in city corporations and town municipalities and also chalked out plans for creation of transit systems, pedestrian pathways, cycling tracks, parks, pedestrian zones, etc. In Indian cities, commuting mode choices are a direct function of income levels. As bicycle owners, however, such captive cyclists cannot be considered as potential users of a PBS system. It is therefore important to understand who would be the potential users of a PBS system.

2.1 Benefits of PBS system

PBS offers both tangible and intangible benefits at both individual and societal levels. In general, a high quality affordable bicycle share system combined with supportive NMT infrastructure can ensure access to sustainable travel options for all segments of the society.

The potential outcomes are illustrated below under the categories of mobility, environmental, social and financial benefits.

• MOBILITY BENEFITS

- Improve first & last mile connectivity and extend the reach of the city's transportation system: PBS fills that critical gap between the transit station or stop and the origin or destination. PBS enhances mobility and is a less expensive investment for the city compared to extending public transport service or providing feeder services.

- Reduce overcrowding on public transportation: PBS offers an alternative for short trips that people would have otherwise made by transit.

- Promote space efficiency: In assessment, bicycles are small and compact and take up less than 1/10th the space occupied by a single car, thus resolving parking woes faced in cities.

- Improve mode-share of bicycling: PBS offers an easy transition into bicycling for people who do not want to invest in owning a bicycle due to safety issues such as stealing, vandalism and lack of bicycle parking facilities.

- Change the nature of travel for short trips, by substituting motorised transport with NMT alternatives, including PBS: PBS offers an alternative for short trips that people would have otherwise made by private automobiles.

• ENVIRONMENTAL BENEFITS

- Improved urban environment: Bicycles are among the few modes of transport that are non-polluting, energy efficient and non-fuel consuming. Bicycle sharing creates new options for an alternative mode of transportation for shorter trips. Idling cars in traffic, millions of two-stroke motor powered vehicles, vehicles with low fuel economy standards, diesel buses, etc. are all contributing, not just to personal health risks, but to global climate change and a decrease in air quality.

- Reduce congestion and improve air quality: By dropping the number of trips made on automobiles, PBS schemes alleviate traffic congestion which in turn improves air quality of the city. By far the greatest environmental benefit of bicycling is that it enables public to avoid fossil fuels and the associated pollution.

• SOCIAL BENEFITS

- Improve the quality of public spaces: Taking away the space allotted to motorized personal vehicles and replacing them with bicycles will allow for creation of more spaces for parks and thus enabling people to interact socially and also enhances sense of community.

- Improve the health of people: In addition to alleviating pollution, bicycle sharing also contributes to health benefits such as longevity, reducing obesity and heart diseases and overall physical fitness.

- Change the common perception of bicycling as a low income mobility choice: PBS systems can help transform the bicycling culture in a city by proper branding and awareness campaigns.

• FINANCIAL BENEFITS

- Eliminate expenses: Bicycle sharing offers a cost effective mobility alternative for consumers by decreasing a family's transportation costs by reducing investment on fuel consumption, maintenance charges, parking taxes and license registration charges.

- Affordability: PBS offers an independent travel option at more economic rates in comparison to any other personalized vehicle. Depending on the terms of the bicycle share system, a user generally pays an direct membership fee and then receives free access to a bicycle for a short-trip spanning 30 minutes.

- Job Creation: Bicycle sharing programs assist in creating full-time jobs locally as these programs require staff to maintain the bicycles, redistribute them and administer and oversee the system's central computer network.

2.2 Uses of PBS system

It is estimated that about 35% of the vehicular trips in Indian cities are short trips. Apart from short trips, PBS could serve as an important sustainable mode of transportation for:

- Daily commuters using PBS as a feeder public transportation.
- Residents and office employees for short daily errands.
- •Tourists who need flexibility and independent in experiencing the city at their own convenience.
- School and college going students on a budget. The potential of this user group is already prevalent in multiple educational campuses around the country.
- Women, especially those who are dependent on IPT modes for commuting short distances.

Depending on the target user group, the approach to plan and design the PBS system will change. Planners will have to be sensitive to the different needs of each user group to ensure the success of the PBS scheme in their respective cities.

The following illustration maps the potential users and short trips in Indian cities that can be completed using a well-designed PBS system.

2.3 Elements of PBS system

A PBS system is defined by a set of key elements essential for planning, designing and operating PBS in a city. Derived from a study of global best practices and lessons learned from PBS initiatives in India, the following section presents 8 guiding elements & 7 supporting elements serving as the building blocks for launching PBS schemes. Each element is further elaborated in detail, complete with descriptive supporting strategies and relevant graphics in the following sections.

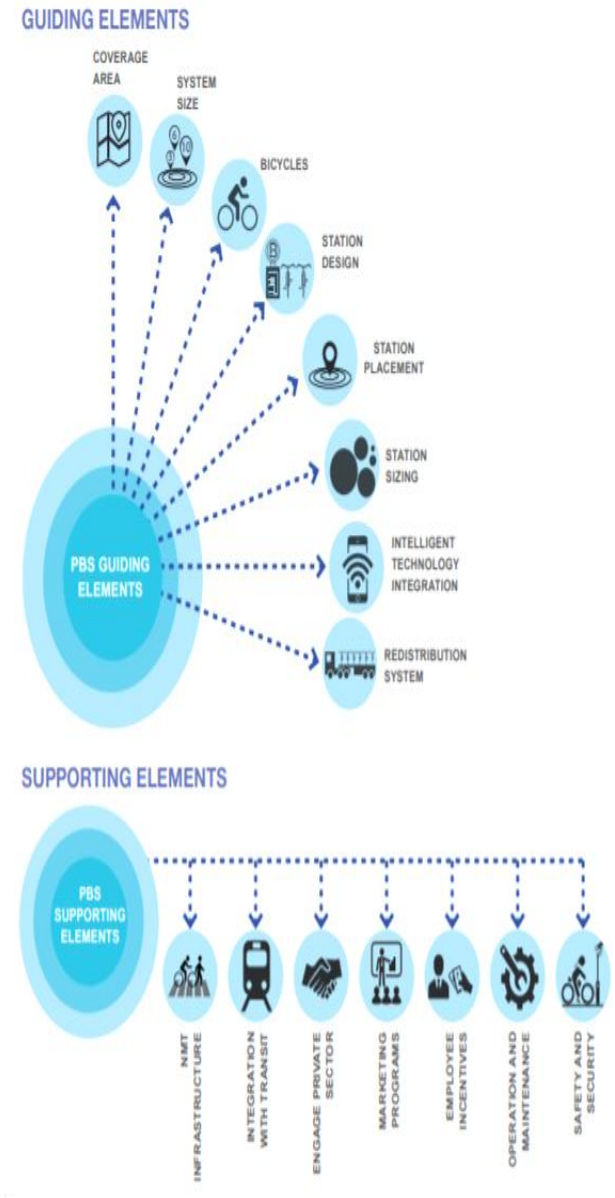

Fig -2: Elements of a PBS System

3. LITERATURE REVIEW

1. The human infrastructure of a cycling city: Amsterdam through the eyes of international newcomers

In this paper a qualitative exploration of what makes Amsterdam a "cycling city". Through semi-structured interviews, the article explores the main factors which encourage cycling uptake among international newcomers to

Amsterdam. Instead of relying on a separation between "hard" and "soft" factors, the approach the city as a socio-technical system, arguing that the material and social factors which encourage cycling in Amsterdam are co-constitutive.

• What makes a cycling city?

Based on interviews with 28 international newcomers to Amsterdam, identified the following seven main factors encouraging cycling uptake among newcomers: 1) access to a bicycle is easy and inexpensive; 2) cycling is more competitive than other forms of transport; 3) cycling is part of the Amsterdam lifestyle; 4) there exists a social pressure to cycle; 5) the city is built for cycling; 6) cycling is fun and enjoyable; and 7) cycling is indispensable for grocery shopping and school trips.

• Existing cyclists as human infrastructure:

On the one hand, this human infrastructure encourages cycling through social mechanisms, such as by handing over cheap bicycles to newcomers and by exercising pressure on them to cycle. On the other hand, this human infrastructure is also a profoundly material one. Through their physical presence on Amsterdam's streets, existing cyclists give to shape the city's infrastructural resolution in a way which forces other road users to defer to cyclists, so contributing to make cycling safer and more attractive.

• Cycling uptake as a dynamic temporal process:

The factors which encourage cycling in mature urban cycling environments not as inert forces, but as part of a active temporal process which operates both at an individual and city-wide level. The mature cycling city such as Amsterdam is considered by spatial and social conditions which encourage cycling throughout the different stages of one's relationship with the exercise of cycling. For cities seeking policy recommendations to increase the modal share of cycling, the case of Amsterdam suggests that require paying attention not only to the factors which encourage initial cycling uptake, but also to the evolving dynamics of cycling uptake and maintenance over time.

2. Planning of Public Bicycle (Bike) Sharing System (PBSS): A Case Study of Surat City

PBS system design

An important consideration while designing the PBS System for the city should be the convenience of bicycle and PBS Stations to the potential users, which would impact the acceptance of the system largely. To address this, the station density should be such that a bicycle is available at all potential origins and destinations across central zone also sufficient bicycles are presently based on the area under PBS such that potential users require not walk for more than 4 to 5 minutes in search of a PBS Station anywhere in the coverage area. Even though the detailed plan for the entire area has been prepared, but due to budgetary constraints, a phase-wise implementation would be, more result oriented and successful in long term.

Station Location Criteria:

The result of HH survey gives a very brief guideline and clear vision to the planners for design formation of any system with respect to citizens' perception. With the help of respondents' response and standard guidelines provided by international practices planners finalize various parameter of the system. According to the standard guideline for station distance, 300 m is preferable by users and in results; 100-200 meters are preferred by most users. But the reason behind this is respondent may not judge walking distance directly so we consider 300 m as station distance. The distance between stations is directly affecting the system coverage. With this regards, the minimum coverage includes 10 PBS stations per sq km which are standardized by international guidelines.

A study demonstrates the planning of PBSS in the central zone of Surat city by Integrating two methods i.e. minimum impedance and maximum coverage in ArcGIS platform. The Phase-1 is considered as a pilot project so to identify station location, the concept of minimum impedance method in ArcGIS adopted while for Phase-2 and phase-3 probable trip generation activity points and coverage of the area is taken as constraints and by using Max coverage approach in ArcGIS bicycle station are identified.

The proportion of large, medium and small stations has been developed to put up the necessary fleet size of 1920 bicycles. Large, medium and small stations are proposed for the docking capacity of 40, 20 and 15 cycles respectively. Results from mode shift analysis bring very optimistic information for the planners, analysis shows that 72%, 2-W users & 76%, Car users are willing to shift from their private mode to PBS if it implemented. This mode shift from personalized mode to the PBS will lead the cities towards sustainable transportation and make the cities climate resilience.

3. STUDY AREA

Navsari, one of the oldest cities of Gujarat, has an inspiring history of over 2000 years. According to the Greek historical writings, a celebrated Egyptian astronomer and geographer named Ptolemy mentioned Navsari's port in his book written about 150 A.D. The geographic location he showed as Narispa is in fact the Navsari of today.

3.1 Location of Navsari

Navsari is located at 20.95°N 72.93°E. It has an average elevation of 9m (29') above sea level. The city is located in southern Gujarat and is situated near the Purna River, within a few kilometres of the river's delta, which is west of the city and empties into the Gulf of Khambhat.

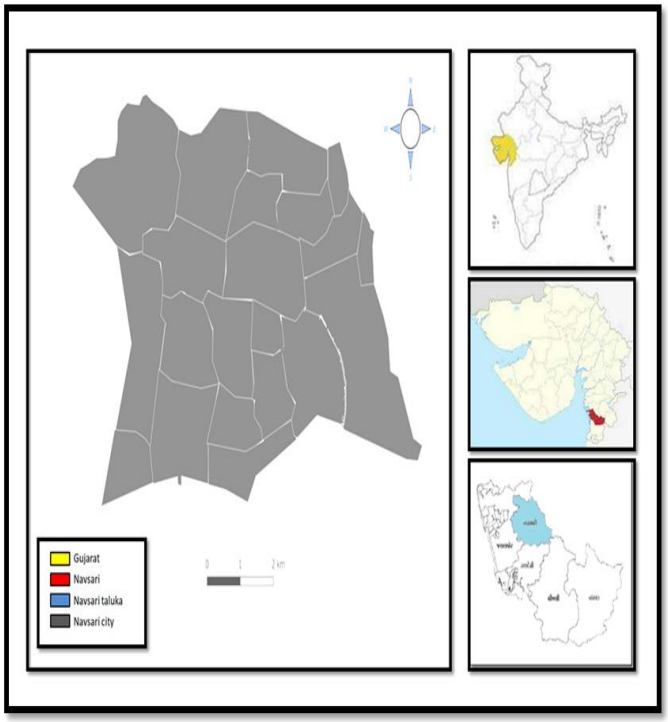

Fig -3: Location of Navsari city

3.2 Regional linkage

Navsari is an important station of broad gauge railway line between Mumbai and Ahmadabad. Through Ahmadabad, Mumbai National Highway No.8, Navsari is connected to big cities of Gujarat and is related to Parivaahan Nigam. Before freedom Navsari was the main city of old Vadodara State.

The details showing connectivity is shown below:

Table -1: Linkage of Navsari city

Sr. No.	Important Station	Distance By Rail (Km.)	Distance By Road (Km.)
1	Ahmadabad	259	300
2	Surat	30	35
3	Vadodara	159	185
4	Mumbai	233	260

3.3 Demographic profile

Navsari is a municipality + outgrowth city situated in Navsari taluka of Navsari district. The Navsari city is divided into 17 wards for which election are held every 5 years. Gujarati is the main language spoken in Navsari. The other languages spoken are Hindi and Marathi.

Table -2: Demographic profile of Navsari city

Description	Census data (2011)
Population	171,109
Total Number of Family	38,477
Total males	88,486
Total females	82,623
Total children (age 0-6 years)	17,340
Density	7223 p/ha
Total area	23.69(ha)
Literacy	88.2 %
Sex ratio	934
Main workers	62,774
Cultivators	519
Agriculture labourer	2,179
Household industries	587
Other workers	59,489
Marginal workers	3,217
Non working	105,118

(Source: Census, 2011)

3.4 Road network

Navsari is well connected to rest of the country by Road, and Rail. The transportation system of the city is predominantly dependent on roadway system. The vehicular growth has been rapid and there is a strong need to control the increasing traffic congestion.

This chapter provides an overview of the existing transportation system in terms of road network, public transport, pedestrian and non-motorized transport facilities, parking, and signage and way finding, vehicular growth and assessing the existing scenario of land use transportation integration in the city.

4. DATA COLLECTION AND ANALYSIS

Primary data collection includes survey of study area and questionnaire. The survey of study area includes traffic and travel Characteristics and land use and transportation integration along major roads/Streets.

Secondary data collection includes census data and vehicular data. Planning the traffic and transportation systems in Navsari city involves interacting with several agencies including the Municipal Corporation, National Highway Authority of India (NHAI), Public Works Department (PWD), State Highways, Indian Railways, interstate bus operators, and private bus operators.

4.1 Transportation characteristics

Navsari is the center for many social, cultural, commercial, political, industrial and educational activities for the whole of South Gujarat Region and has experienced many material changes in its physical structure. The major industrial development is on Navsari Grid Road.

The major commercial activities are in Lunsikui Area. This has resulted in most unsatisfactory relationship between places of working and living areas. A large number of people have to commute from one living areas.

4.2 Land use and transportation integration along major roads/Streets

In Navsari mixed use type of development exists along the streets. However, these streets do not offer any safety to the pedestrians & cyclists, forming a missing link in the land use transportation integration.

Presently it is seen that the road width affects the height and scale permissible for development within any given plot.

4.3 User perception survey

Survey Sample appended in annexure for user perception survey.

For any type of survey, sample size is very important to get proper result.

Sample size calculation:

For deciding the sample sizes a formula used is of Hogg and Tannis 2009.

$$n = \frac{m}{1 + \frac{m-1}{N}}$$

So, the sample size for user perception survey is 346.

Table -3: User perception survey and results

Variable	Descriptions	Value
Number of respondents	Total Male and female	350 No.
	Male	50.3%
	Female	49.7%
Purpose of trips	School / college	34.5%
	Commercial labour	0.6 %
	Industrial labour	0.3%
	Self employment/business	37.1%
	Government employee	26%
	Other	80.3%
Type of private vehicle usage	Car	52.3%
	Bike	89.1%
	Bicycle	5.1%

	Other	12.6%
Trips (per day)	0-2	21.1%
	2-4	74.6%
	4-6	3.4%
	> 6	0.9%
Willingness to use PBSS	Yes	90.3%
	No	9.7%
Trip distance preferred with PBS system by users	0.1 km	13.7%
	0.3 km	76.9%
	0.5 km	9.1%
	>0.5 km	0.3%

5. PBS SYSTEM DESIGN

The simple technique used in selecting sites for the bicycle sharing project in Navsari city was based on the following parameters:
Level 1: Area suitability and terrain
Level 2: Land use
Level 3: Existing public transport corridors
Level 4: Existing spots of high public level transport usage (Ticket sales)
Level 5: Areas of public interest like parks etc
Level 6: Student population spots
Level 7: Selected spots for PBS system

Delineation based on the 7 levels of sieving has been indicated in the schematic (Figure) below.

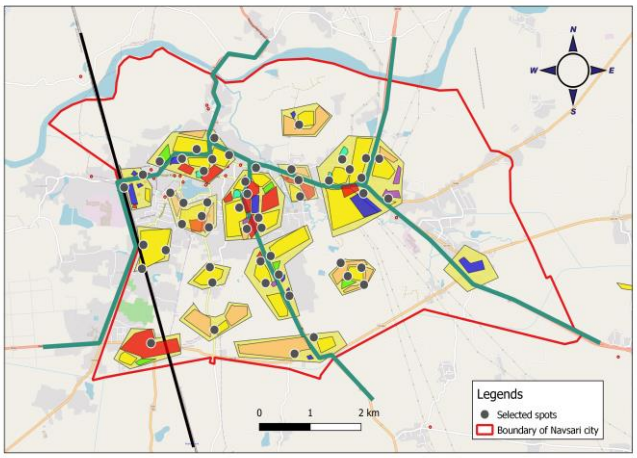

Fig -4: Identify location spots

5.1 Docking station location

The result of survey gives a very brief guideline and clear vision to the planners for design configuration of any system with respect to citizens' perception. With the help of respondents' response and standard guidelines provided by international practices planners finalize various parameter of the system. According to the standard guideline for station distance, 300 m is preferable by users and in the results; 100-300 meters are preferred by most users. But the reason behind this is respondent may not judge walking distance directly so we consider 300 m as station distance.

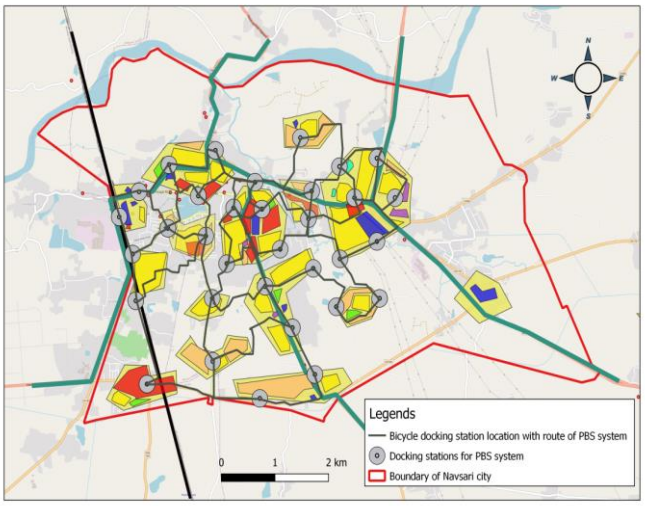

Fig -5: Docking station location

The distance between stations is directly affecting the system coverage. With this regards, we taking Minimum coverage includes 10 PBS stations per sq km which are standardized by international guidelines. Stations location will be near mass transit stations or IPT/transit stops and near bicycle lanes/tracks if present. Stations should be

located preferably near or on NMC/ Government property, Multi-Level Parking, On major arterials like grid road, chhapra road, and Surat-Navsari road and places along the street that are safe to access by bicyclists. Stations should be located inside residential cores and near important public institutions or places like school, colleges, parks, markets, commercial areas and other activity nodes.

Preliminary identification has resulted in 41 stations out of which 30 stations are within the Phase I area, to maintain a density of 10 stations per sq.km. Large, medium and small stations are proposed for the docking capacity of 40, 20 and 15 cycles respectively. Based on the detailed study following PBS system size for coverage area is 4 sq km. The number of docking stations is 30.

6. CONCLUSION AND RECOMMENDATION

A study demonstrates the planning of PBS system in the Navsari city by Integrating two methods i.e. minimum impedance and maximum coverage in ArcGIS platform. Overall PBS station locations are delineated on the basis of population density, road network, transit nodes and activity map. Preliminary identification has resulted in 41 stations out of which 30 stations. Large, medium and small stations are proposed for the docking capacity of 40, 20 and 15 cycles respectively. Results from mode shift analysis bring very optimistic information for the planners, analysis shows that 89.1%, 2-W users & 52.3%, Car users are willing to shift from their private mode to PBS if it implemented. This mode shift from personalized mode to the PBS will lead the cities towards sustainable transportation and make the cities climate resilience.

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