Overall thoughts/notes:

* Limited combination of propensity analysis (raster) and optimization. Many require preselection of zones or candidate locations.
* Big difference is that many models are in larger cities, and are focused on improving job accessibility for “demand coverage”. Smaller towns may have other objectives for placement (ie promoting health/recreation/tourism, connecting to transit lines, serving needs of those without other modes)
* Lots of policy goals can be conflicting—maybe do AHP for different scenarios (ie for commuting, for first/last mile connection, for recreation/tourism, for installation efficiency (ie low cost), for improving transportation equity)
  + With evaluation done through accessibility of different demand points (ie job locations, transit stops, park/trail entrances and entertainment/retail/dining category jobs, publicly owned land and potential PPP campuses, disadvantaged community census block groups and low income jobs)
  + Compare these metrics to each other, to generic ITDP siting process (Pareto frontier graphs for each objective compared to others)

**Station Siting Optimization**

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| Title | Methodology | Notes/Outcomes |
| A GIS-based MCDM approach for the evaluation of bike-share stations  (Mehmet Kabak et al) (Journal of Cleaner Production) (2018) (Karsiyaka, Izmir) | Twelve conflicting criteria, weighted using Analytic Hierarchy Process (AHP). Multi-objective optimization by ratio analysis (MOORA). | Very very similar to my approach!  MOORA is interesting – provides a ranking of candidate locations based on multiple criteria, with no spatial coverage constraints |
| Boise Bike Share Location Analysis (Thomas Wuerzer et al) (Boise State University Department of Community and Regional Planning) (2012) | Ten criteria with arbitrary weights, hand picked candidate locations, separate optimization model for # of stations (two different sizes) and # of bicycles (dependent on specified vacancy rate) based solely on unit cost of installation, looking at different budgets. | Similar to my approach, but optimization is just about cost (not dependent on location)  Determining a variable cost for candidate locations could be valuable (new) |
| Equitable distribution of bikeshare stations: An optimization approach (Xiaodong Qian et al) (Journal of Transport Geography) (2022) (Chicago) | Looked at candidate intersection locations, identified trips generated and attracted at each station (which was categorized by advantaged or disadvantaged population). Considers two objectives: maximizing revenue (trip user fees\*trips – cost of all stations and bikes) and maximizing accessibility to demand points. A genetic algorithm was used to generate a Pareto frontier of optimal solutions. | Look at trip generation/attraction studies referenced  Genetic algorithm is interesting!!!  Pareto frontier for multiobjective optimization  Look into Kodranksy and Lewenstein (2014) |
| Station Site Optimization in Bike Sharing Systems (Junming Liu et al) (IEEE International Conference on Data Mining) (2015) (NYC) | Extracted input features from existing mobility data, Artificial Neural Network based prediction model for station demand, balance prediction according to extracted features. THEN optimization problem for maximizing station demand and minimizing the number of unbalanced stations. | Also uses genetic algorithm for solving optimization problem |
| Bike-sharing stations: A maximal covering location approach (Ines Frade, Anabela Ribeiro) (Transportation Research Part A) (2015) (Coimbra, Portugal) | Maximal covering location approach with demand coverage (trips between two zones at a specific time of day), budget as a constraint. Define dimensions of the system (# stations, bicycles) with operational decisions (relocating bicycles) | High detail about budget (ie both initial and operating costs, revenue predictions, variable cost of a station), requires a lot of input  Zones as candidate locations (less specificity than raster) |
| Dimensioning of a Bike Sharing System (BSS): A study case in Nezahualcoyotl, Mexico (Javier Garcia-Gutierrez et al) (Procedia - Social and Behavioral Sciences) (2014) (Nexahualcoyotl, Mexico) | Dimensioning approach (determining # of bicycles and parking spaces from dynamic simulation procedure during typical labor day). Model uses utility functions for foot, bike, transit, car modes dependent on age, gender, income, and travel time. For optimization, O-D matrix is recalculated under different BS site conditions until no more mode switch is possible. Then simulation discretely determines number of bikes and parking spaces needed for each station at every hour using four-step model.  Optimization for station locations minimizes cost (combined user cost, operational, network externalities, etc) | Took mobility patterns from a questionnaire, LOS of street segments as inputs to utility model.  Zones, not specific locations  The only method I found using mode choice modeling |
| Optimal location of bike-sharing stations: A built environment and accessibility approach  (Richard Mix et al) (Transportation Research Part A) (2022) (Santiago de Chile) | Demand modeled from existing stations based on built environment and accessibility-based variables. Optimized to maximum demand coverage. | Optimization results did not match existing locations, claim a 65% increase in demand met. |
| Fuzzy-based GIS approach with new MCDM method for bike-sharing station site selection according to land-use types  (Ezgi Eren, Burak Yigit Katanalp) (Sustainable Cities and Society) (2022) (Izmir, Turkey) | Fuzzy GIS approach with AHP, VIKOR, and new Psychometric-VIKOR methods to determine suitable BSS station locations according to different land use types.  AHP to determine weights of transportation network, built environment, and natural environment inputs for spatial criteria.  Fuzzy approach for uncertainty in passenger tendencies to start a trip at stations within optimal/tolerable distances from facilities.  VIKOR and Psychometric-VIKOR gis-based MCDM techniques to assess performance of existing and potential station locations. | Optimal and tolerable distances from Shu et al. (2019)  Lit review Table 1  I like the fuzzy logic for buffers from station  Did use AHP for two scenarios (recreation and transportation)  No actual optimization function presented, but candidate alternatives are selected from AHP weights similar to mine, then evaluated using VIKOR and Psychometric-VIKOR for determining “most suitable” locations |
| An optimization approach for equitable bicycle share station siting (Lindsey Conrow et al) (Journal of Transport Geography) (2018) (Phoenix, Arizona) | Bi-objective maximal coverage of bikeshare network segments and user demands |  |
| Optimizing the location of stations in bike-sharing programs: A GIS approach  (Juan Carlos Garcia-Palomares et al) (Applied Geography) (2012) (Madrid, Spain) | Minimize impedance (P-median) between stations and demand points, or maximizing coverage of demand points within specified impedance cutoff |  |
| Locating of Bicycle Stations in the City of Isfahan Using Mathematical Programming and Multi-Criteria Decision Making Techniques (Mahsha Ghandehari et al) (International Journal of Academic Research in Accounting, Finance, and Management Sciences) (2013) (Isfahan, Iran) | AHP input weights calculated through SAW method, combination model developed  Minimize deviance from goal, with specified utility and cost standards and number of stations and min distance between two stations | Four main factors (bike path closeness, transportation networks, demand, use type)  Predefined candidate locations  Expert Choice, Excel, Lingo as potential AHP tools |
| Bicycle sharing system design with capacity allocations (Dilay Celebi et al) (Transportation Research Part B) (2018) (Istanbul Technical University Ayazaga Campus) | Minimize the amount of unsatisfied demand for bicycle pick-ups and returns, using a set covering model and a queuing model to address service levels for selected stations | Used survey data about frequency, occupation, bike ownership, OD, time of day, etc. Modeled price level as well.  Poisson distribution of demand model makes it non-linear, which is more complex to solve as the problem size increases. (couldn’t work as well for raster instead of candidate points) |
| BIKE SHARING STATION SITE SELECTION FOR GAZIANTEP  (Cihan Cetinkaya) (Sigma Journal of Engineering and Natural Sciences) (2017) (Gaziantep, Turkey) | Fuzzy AHP for selection criteria with uncertainty and TOPSIS for station site rankings | Very similar inputs, again discretely selected candidate locations |
| An equality-based model for bike-sharing stations location in bicycle-public transport multimodal mobility (Leonardo Caggiani et al) (Transportation Research Part A) (2020) | Minimize inequalities among population groups while maintaining levels of accessibility and coverage at the same time  Theil index used as inequality metric  Multimodal BSS-Public Transport Accessibility (MBPTA)  Genetic algorithm used | When compared with maximizing accessibility approach or maximizing coverage approach, may lead to unequal distribution of accessibility among the population  Predefined candidate locations, O/D zones |
| A new method for determining optimal locations of bike stations to maximize coverage in a bike share system network (Rabab Salih-Elamin and Haitham Al-Deek) (Canadian Journal of Civil Engineering) (2020) (Washington, DC) | AHP used for bike station importance criteria based on topology (BC, CC, and DC). TOPSIS ranking applied. |  |

15 optimization methods

**Input Factors/General Siting Guidance**

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| Bike-sharing stations: A maximal covering location approach  (Edoardo Croci and Davide Rossi) (IEFE ‐ The Center for Research on Energy and Environmental Economics and Policy at Bocconi University) (2014) (Milan, Italy) | Analysis of bikeshare station use in relation to proximity to attractors |  |
| How to Save Bike-Sharing: An Evidence-Based Survival Toolkit for Policy-Makers and Mobility Providers (Alexandros Nikitas) (MDPI Sustainability) (2019) (Gothenburg, Sweden and Drama, Greece) | Surveyed travel behavior, views on cycling, public bikeshare/suitability for the city, and sociodemographic characteristics for small/medium urban areas in Europe.  Case studies of successful and failure systems | Surveyed usage rates smaller than acceptance rates, with major barriers being road safety concerns and lack of adequate cycling infrastructure.  Tailoring to city-specific needs/norms is essential  Should be user-centric, not profit-centric  Public private partnerships can work  Supply should mirror travel demand  Dock-based systems have better long-term viability than many dockless schemes |
| Modeling Bike Share Station Activity: Effects of Nearby Businesses and Jobs on Trips to and from Stations  (Xize Wang et al) (ASCE) (2015) (Minneapolis/St Paul, MN) | Analysis of bikeshare station activity (sum of trip origins/destinations) in relation to specific attractors and built environment | High population densities and higher number of destinations accessed are related to strong activity. Proximity to campus, water, parks, trails, other stations also important |
| NACTO Bike Share Station Siting Guide | National guidance on bike share station siting | Proximity to bike lanes, transit, and stores/restaurants mentioned |
| ITDP Bikeshare Planning Guide | Best practices from bikeshare experts for new/expanding bikeshare system guidance  Bikes per residents, station density targets given | Provides metrics for performance evaluation (mode share %, accessibility by low income users, avg daily trips per bike, etc)  Proposes siting method using grid approach, hand select stations one per grid (uniform density approach)  Field approach also developed (identify spots, look at half mile buffers and identify where additional density is needed) |
| Providing Equitable Access to Sacramento’s Bike Share System (Brianna Goodman and Susan L. Handy)) (UC Davis Institute of Transportation Studies) (2015) (Sacramento, California) | Stakeholders selected locations, and proximity to specific trip generators and population types were analyzed. |  |
| Bike Sharing: a review of evidence on impacts and processes of implementation and operation  (Miriam Ricci) (University of the West of England Centre for Transport & Society) (2015) | Review of potential metrics of success for objectives of bikesharing | Convenience consistently emerges as key motivating factor for bike sharing us  Mode shift is more likely to occur from transit/walking than from personal vehicle usage  Mixed results on whether BSS competed with or complimented transit systems  “develop innovative evaluation frameworks and methods that are specific to bike sharing, able capture their full range of impacts and not just those which are directly and more easily quantifiable. Multi-criteria analysis could be a useful starting point.”  “Secondly, it is essential that bike sharing evaluations begin from identifying the objectives that a scheme seeks to achieve, through an in-depth consultation of all the stakeholders, rather than undertake generic assessments without a clear operational, and agreed upon, definition of ‘success’.” |
| What is the best catchment area of bike share station?  A study based on Divvy system in Chicago, USA  (Gong Zhang et al) (The 5th International Conference on Transportation Information and Safety) (2019) (Chicago, IL) | Compared different service boundaries as catchment areas and compared bikeshare inputs (ie employers, transit, socioeconomic variables) to determine best catchment area to use for BSS planning | Smaller ranges than 0.5 miles tend to be suitable, but all distances fairly similar results |
| Built Environment Factors Affecting Bike Sharing Ridership: Data-Driven Approach for Multiple Cities (David Duran-Rodas et al) (Transportation Research Record) (2019) (Germany, Chicago, Montreal) | Modeled impacts of various built environment factors on bike station activity | City population, distance to city center, bakeries, memorials, colleges played important roles |
| [Bikeshare Solutions for Small Cities & Towns](https://www.nlc.org/article/2022/06/03/bikeshare-solutions-for-small-cities-towns/) | Guidance on small cities/towns network design | Most important factor to feasibility and usage is the location of bikeshare stations in relation to important destinations such as schools, parks, business districts  Partnerships with local organizations such as Business Improvement District, private hotels, businesses, resorts, and restaurants may be helpful for funding |
| Successfully Initiating a Bike Share Program in Smaller Communities: The College or University as a Focal Point (Mason S Gilbert et al) (Journal of Educational Research) (2021) | Guidance on small town system design | Proximity to food destinations, variety of income levels, seek local business/corporate support, proximity to jobs and public transit, access to bike lanes/paths |

13 on input factors

**Propensity Methods**

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| Capital Bikeshare Development Plan Update  (Kittelson & Associates, Foursquare Integrated Transportation Planning) (2020) (Washington DC) | Propensity analysis for expanded network station placements (raster cells with many inputs, weighted arbitrarily). Divided propensity analysis into three categories: “Ridership” (regular use/commuting), “Revenue” (casual use/tourism), and “Public Need” (disadvantaged communities) |  |
| High impact prioritization of bikeshare program investment to improve disadvantaged communities' access to jobs and essential services (Xiaodong Qian and Deb Niemeier) (2019) (Chicago, Illinois and Philadelphia, Pennsylvania) | ACS inputs, identify zones that are disadvantaged, how multimodal (carless) accessibility could be improved with installation of bikeshare system, and developed equity metric for zones and assigned each a priority |  |
| FINAL DRAFT Mobility Hubs Siting Methods and Analysis (Meredith Klekotka and Kelly Morrell) (Met Council) (2021) (Minneapolis/St Paul, Minnesota) | Multiple publicly available inputs, arbitrarily weighted, candidate mobility hub locations determined from transit stops/other criteria, divided into hub typology dependent on urban/suburban/activity/area for investment opportunity, value assigned from various outcome objectives (connect region, integrate multiple modes, advance equity, enhance neighborhoods, increase travel safety) |  |
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3 propensity analysis methods