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EVALUATION OF SCORING METHODS FOR PRIORITIZING PEDESTRIAN AND BICYCLE PROJECTS

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EVALUATION OF SCORING METHODS FOR PRIORITIZING PEDESTRIAN AND BICYCLE PROJECTS

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
College of Engineering
at the University of Kentucky

By

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ABSTRACT OF THESIS

EVALUATION OF SCORING METHODS FOR PRIORITIZING PEDESTRIAN AND BICYCLE PROJECTS

To increase the number of pedestrian and bicycle facilities and to grow the number of people using those facilities in Kentucky more such projects need to be implemented. The Strategic Highway Investment Formula for Tomorrow (SHIFT) is a data-driven approach that Kentucky uses for prioritizing projects in the state, but its focus is auto-centric. The purpose of this study was to develop and evaluate a prioritization scoring approach for pedestrian and bicycle projects that could be implemented into SHIFT. The study used the SHIFT–2022 pedestrian and bicycle projects to develop and evaluate different scoring scenarios. After scoring each project on its proposed project type and existing facilities, a composite score was developed for both pedestrian and bicycle projects. The sensitivity analysis examined the impact of the proposed scoring scenarios on pedestrian and/or bicycle projects as well as all projects considered at the regional level. Each scoring scenario affected the boost points allocated to each project by the Metropolitan Planning Organization and District. The results showed that the scenario that reduced each boost by 5 points and allocating them to the pedestrian and bicycle projects retained all pedestrian and bicycle projects in any scenario of project selection percentage. This scenario also had the largest number of projects that ranked higher than in the existing method with the greatest average rank change.

KEYWORDS: Pedestrian and Bicycle Projects, Strategic Highway Investment Formula for Tomorrow (SHIFT), Project Prioritization

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CHAPTER 1. INTRODUCTION

1.1 Background

In recent times, a large increase in walking and biking has been noticed (USDOT, 2010). This creates a need to develop safe, adequate, and continuous facilities to accommodate these users. Traditionally, state Departments of Transportation (DOTs) have focused on developing projects that only improved motorized transportation resulting in a disadvantage for people who are not able or allowed to drive due to their age, health condition, income, etc. Litman (2022) found that in most communities 20% to 40% of the population cannot drive including young adults 12-24 years old who represent 10% - 25% of the population as well as seniors who are not able or should not drive representing 5% to 15% of the population. In addition, adults with disabilities (3%-5% of the population), low-income households (15% to 30% of the population) and others such as those who do not have driver license and having medical issues were noted as those who cannot drive. It is therefore desirable to provide these groups with alternative transportation options to complete their travel needs without having to use unsafe, underdeveloped, or discontinuous facilities and to create equal opportunities for those that are not able to drive.

The lack of adequate pedestrian and bicycle facilities has resulted in an increase in fatalities. In 1990, walking and biking accounted for 4.4% of commuting trips. Pedestrian and bicycle trips represent a very small portion of all commuting trips, but they account for 15% of all traffic fatalities (USDOT, 2010). In 1994, the US Department of Transportation (USDOT) developed the first national transportation policy to "increase use of bicycling, encourage planners and engineers to accommodate bicycle and pedestrian needs in designing transportation facilities for urban and suburban areas, and increase pedestrian safety through public information and improved crosswalk design, signaling, school crossings, and sidewalks." (USDOT, 2010)

The Kentucky Transportation Cabinet (KYTC) has recently developed the Complete Streets, Roads, and Highways Manual (KYTC, 2022a). The Manual noted that additional bicycle lanes can reduce crashes up to 49% on urban 4-lane and up to 30% on urban 2-lane undivided collectors and local roads while adding a sidewalk can reduce pedestrian crashes by 65-89% and the addition of paved shoulders by 71%.

The National Household Travel Survey estimated that in 2009 the share of pedestrian and bicycle trips out of all the trips was approximately 11.9% showing an increase in comparison to 2001 where they accounted 9.5% of all trips (USDOT, 2010). The National Association of City Transportation Officials (NACTO) completed a study across North American cities to identify if building protected bike lanes will provide more ridership. The study showed that by adding protected bike lane the increase in ridership ranged from 21% to 171% (NACTO, 2016)

Many studies have been completed to identify health and economic benefits resulting from using pedestrian and bicycle facilities. The Colorado Office of Economic Development and International Trade attempted to quantify the walking and biking economic and health benefits (BBC Research & Consulting, 2016). The study found that walking in Colorado helps prevent about 285 deaths per year which converts approximately to $2.7 billion in annual health benefits. An additional 10% (195,000) of people start walking will increase the health benefits by approximately $272 million. Biking in Colorado helps prevent 50 deaths per year which converts approximately to $511 million in annual health benefits. An additional 10% (46,000) of people start biking will increase the health benefits by approximately $51 million.

Bhattacharya et al. (2019) showed that 2,000 steps a day can decrease cardiovascular events such as heart attacks by 10%. The relationship between type 2 diabetes and physical activities have been also demonstrated. In Canada between 2001 and 2007, 20 studies showed that physical exercise can decrease the chances of developing type 2 diabetes. Physical activities not only provide benefits on physiological level, but also on mental including clinical depression, depressive indicators, and the severity of symptoms that relate to depression.

The increase in pedestrian and bicycle trips in the US over the past decades has been documented. Providing proper facilities for pedestrians and bicyclists can improve users' health, provide more economic benefits, provide people with modal choices, and create a safe environment for the users. To start improving, developing, and expanding facilities to address bicyclist and pedestrian demand, the manner with which projects are prioritized should be reconsidered and means to incorporate projects for addressing these needs should be identified. A process is therefore required that would allow for accounting for projects that include pedestrian and bicycle improvements and allow them to be scored in a manner that considers their impact and potential contribution in transportation, health, economic facets of society, and safety.

1.2 Problem Statement

KYTC has developed the Strategic Highway Investment Formula for Tomorrow (SHIFT) which systematically evaluates potential projects and identifies those with greatest potential for improving the state roadway network (KYTC, n.d.). SHIFT is a data-driven approach that, in general, objectively compares capital improvement projects and prioritizes them to result in a more effective use of the available limited funds. Projects are scored based on five key attributes including safety, asset management, economic growth, congestion, and benefit cost ratio. Each attribute has a specific objective that each project is scored on and after components are calculated, a weighted score is computed. Kentucky projects are divided into five regions (East, West, North, South, and Statewide) and projects within region are ranked based on their scores to determine those that will have a higher chance to be funded.

Currently, SHIFT is based only on addressing the needs of motorized users and does not account for non-motorized users, i.e., pedestrians, bicyclists, e-scooters, and wheelchairs. As funding for motorized users is limited and there is almost no funding available for multi-mode improvements, there is a need to develop a prioritization approach that can be implemented into SHIFT that will account for non-motorized users.

It is important to develop a prioritization approach for non-motorized users as it will allow projects that have pedestrian and/or bicycle improvements potentially to account for them and thus (possibly) boost them having a higher chance to be selected for funding. It is important to start improving and developing safe and continuous non-motorized user facilities that people can use for their daily activities. That will also attract currently non-users to use non-motorized transport means as their choice mode of transportation.

The main purpose of this study is to develop and evaluate a scoring system that could be incorporated into SHIFT to allow for proper accounting of pedestrian and bicycle projects. The objectives of this study are:

- Identify other DOTs efforts in prioritizing and scoring pedestrian and bicycle projects as well as metrics used.
- Propose possible metrics and scoring approaches to be used in SHIFT.
- Collect and review the data for Kentucky projects.
- Evaluate scoring approaches and propose a potential approach for SHIFT use.

1.3 Chapter Guide

The report documents the findings of the research completed to address the objectives noted above. The components of this report are as follows:

- Chapter 1 Introduction: presents an overview of the study and describes pedestrian and bicycle health benefits, trends in walking and biking trips, the needs for improvements, and the problem statement.
- Chapter 2 Literature Review: discusses the existing Kentucky policies related to pedestrian and bicyclists and presents efforts of other agencies in addressing prioritization systems for pedestrian and bicycle projects.
- Chapter 3 Methodology: presents the data collection approach for this study, the development of the scoring scenarios, and the analysis process.

- Chapter 4 Analysis Results: documents the results of the analyses conducted for evaluating the scoring scenarios.
- Chapter 5 Summary and Discussion: presents a summary of the work completed, discusses the results, recommends a scoring scenario, identifies the study limitations, and proposes future research efforts.

CHAPTER 2. LITERATURE REVIEW

2.1 KYTC Practices and Policies

The Commonwealth of Kentucky has laws and regulations for bicycle travel and pedestrians. KRS 189.010 defines bicycles as vehicles, and cyclists have the same rights and the same responsibilities to follow the rules of the road as motorists (KYTC, 2016). It also defines pedestrians as any person on foot or in a wheelchair. KRS 189.570 defines the right-of-way of pedestrians under different circumstances (KYTC, n.d.).

KYTC published the Pedestrian and Bicycle Travel Policy in 2002, which describes where and when it may be necessary to include pedestrian or bicycle facilities in roadway projects in urban and rural areas. The responsibility of maintenance of bicycle and pedestrian facilities is also discussed in the Policy. The Policy states that bicycle traffic may be expected on all roadways except interstate highways and other fully controlled-access highways since bicycles are human-powered vehicles. Each location considered for implementing a bicycle facility requires careful consideration and appropriate facility type based on the project needs and goals. The Policy indicates that KYTC will consider the accommodation of bicycles on all new or reconstructed state-maintained roadways. It also states that KYTC will consider accommodating bicycle transportation when planning the resurfacing of roadways, including shoulders.

A Complete Streets Policy has been recently developed that incorporates pedestrian and bicycle facilities as part of the overall policy (KYTC, 2022b). This new policy replaces the 2002 Policy. In addition, a Pedestrian and Bicycle Master Plan has also been developed establishing a framework for advancing pedestrian and bicycle projects within the various Kentucky agencies (KYTC, 2022c). In this Master Plan, benefits of active transportation for people in Kentucky are identified including mobility, health, livability, economic, and environmental. The Master Plan provides guidance on identifying the existing pedestrian and bicycle facilities in Kentucky to recognize those that must be improved. An important part of this effort is the identification of

available fundings and programs for the future projects. The goals for supporting this Master Plan are noted focusing on safety, connectivity, equity, health/environment, and thriving communities. A framework for accomplishing these goals is defined and specific actions and practices are discussed.

2.2 Project Evaluation and Scoring

A few states have incorporated pedestrian and bicyclist project prioritization into their statewide transportation prioritization programs. Those states are Florida, Virginia, and North Carolina. A review of these efforts will help identify the important factors that KYTC should consider for implementation into SHIFT to prioritize pedestrian and bicycle projects.

2.2.1 Hillsborough County

Hillsborough County Metropolitan Planning Organization (MPO) in Florida, which covers the Tampa Bay City and Bay area, is nationally recognized for promoting pedestrian and bicycle transportation and safety. The MPO conducted a comprehensive review of practices and provided a very detailed method for evaluating the pedestrian and bicyclist quality of service (Kittelson & Associates, 2019). Five methodologies for addressing quality of service are discussed in the report along with data input needs, challenges, and opportunities for its estimation. Figure 2.1 provides a visual assessment of the methods reviewed identifying whether each meets the need for estimating the quality of service provided.

Methodology	Mode				Analysis Level			Data Needs	Difficulty	Application (Project or Network Level)
	Ped.	Bicycle	Transit	Auto	Intersection	Corridor	Network			
HCM Multi-Modal Level Of Service (MMLOS)	●	●	●	●	●	●	●	High*	High	Project or Network
Level of Traffic Stress (LTS)	○	●	○	○	◖	●	●	High	High	Project or Network
Bicycle Network Analysis (BNA) Score	◖	●	○	○	○	○	●	Low	Low	Network
Transit Capacity & Quality of Service Manual (TCQSM)	○	○	●	○	●	●	●	Varies	Varies	Varies
Charlotte PLOS and BLOS	●	●	○	○	●	○	○	Low	Low	Project or Network

● Meets the Need ◖ Partially Meets the Need ○ Does Not Meet the Need

*Agencies can rely on default values for many inputs to reduce the data requirements.

Figure 2.1 Summary of Multimodal Methodology Applications

The MPO used a level of traffic stress analysis to identify corridor conditions and adapted the Charlotte Pedestrian Level of Service (PLOS) and Bicycle LOS (BLOS) intersection methodology in Hillsborough County. This new method includes a series of decision-making flow charts to evaluate the quality of service for bicycle and pedestrian facilities, including the corridor and intersection projects. An example of pedestrian Level of Traffic Stress (LTS) methodology is shown in Figure 2.2.

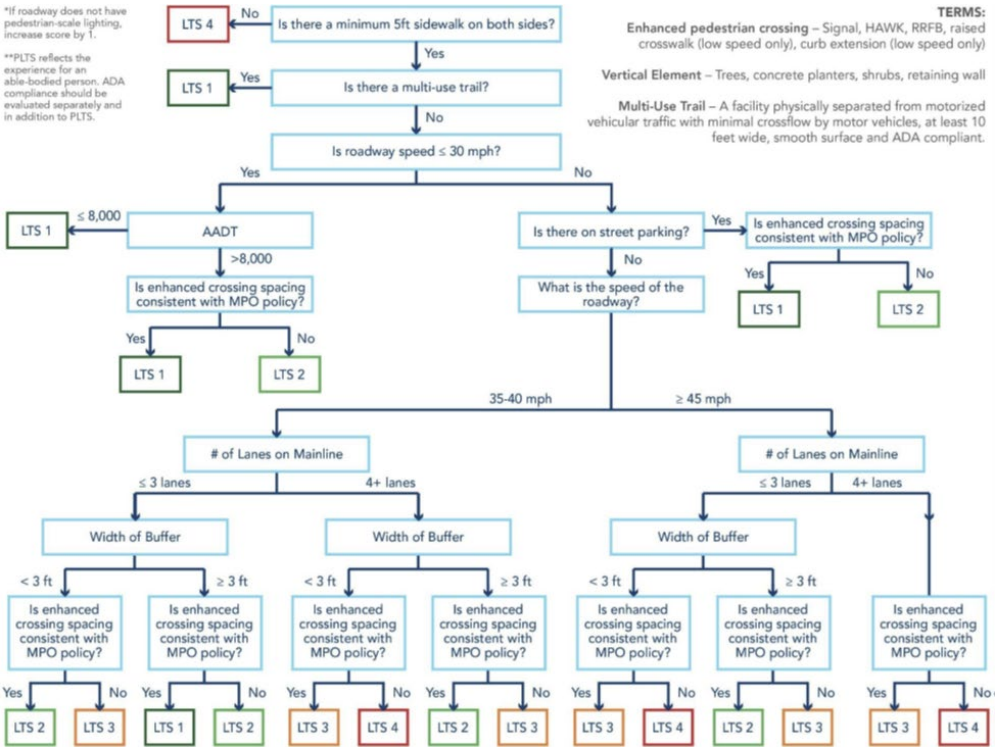

Figure 2.2 Hillsborough MPO Pedestrian LTS Methodology

2.2.2 Virginia DOT

The Virginia DOT has also developed a statewide program for scoring and ranking transportation projects for funding called SMART SCALE (VDOT, 2021). This is based on developing scores for each project based on six evaluation categories that are Safety, Congestion Mitigation, Accessibility, Environmental Quality, Economic Development, and Land Use Coordination. VADOT recognizes the diverse needs among each area of the state and has divided the state into four area categories using input from their MPO and Planning District Commission as well as other entities. The weights used in the final scoring are different for each of the four area categories. Pedestrian and bicycle improvements projects are eligible for SMART SCALE funding. Pedestrian and bicycle elements could add points to several evaluation categories of the SMART SCALE calculation of scores for a project instead of acting as an independent scoring component. The affected evaluation categories involving pedestrian and bicycle scoring are Safety, Accessibility, Environmental Quality, and Economic Development. The criteria and scores added

are different for each category. The following summarizes the pedestrian and bicycle considerations for each of the evaluation categories.

Safety: The metric used is an estimation of the equivalent property damage only crashes expected to be avoided due to project implementation and measured both in number and rate per 100 million VMT. For pedestrian and bicycle projects, crash modification factors (CMFs) are used to define the gains from pedestrian and/or bicycle elements included in the project.

Accessibility: The metrics used are estimating access to jobs, access to jobs for disadvantaged populations and access to multimodal choices. Access to jobs is based on changes to jobs that can be reached within a 45-minute radius of the project (or 60-minute radius for transit) and is estimated based on Census block. The access to jobs is measured based on the difference between existing and new opportunities due to the project, but without any specific mention to pedestrian or bicycle projects. Access to multimodal choices is based on a point system, where some points could be awarded if a bicycle and/or pedestrian component is present. The table with a point system is presented in Table 2.1.

Table 2.1 Scoring Approach for Access to Multimodal Choices (Source: VADOT)

Project Type (Mode) and Characteristics	**Points (If Yes)**
Project includes transit system improvements or reduces delay on a roadway with scheduled peak service of 1 transit vehicle per hour.	5
Project includes improvements to an existing or proposed park-and-ride lot. Ex. New lot, more spaces, entrance/exit, technology (payment, traveler information).	4
Project includes improvements to existing or new HOV/HOT lanes or ramps to HOV/HOT	2
Project includes construction, enhancement, or replacement of bike facilities. For bicycle projects, off-road or on-road buffered or clearly delineated facilities are required.	1.5
Project includes construction, enhancement, or replacement of pedestrian facilities. For pedestrian projects, sidewalks, pedestrian signals, marked crosswalks, refuge islands, and other treatments are required (as appropriate).	1.5
Project provides real-time traveler information or wayfinding specifically for intermodal connections (access to transit station or park&ride lot).	1
Provides traveler information or is directly linked to an existing TMC network/ITS architecture.	1
Total Points Possible	**5 points maximum**
Measure Scaling: Points are multiplied by the number of new peak period non-SOV users	

Environmental Quality: The metrics are improvements to air quality and energy and minimization of impacts to natural and cultural resources within the project buffer. A point system is used to assess air quality impacts and some points could be awarded for bicycle and/or pedestrian projects. The table with a point system is presented in Table 2.2. A slightly more complicated approach is used for estimating impacts to natural and cultural resources.

Table 2.2 Scoring for Air Quality and Energy Environmental Effect (Source: VADOT)

Project Type (Mode) and Characteristics	**Points (If Yes)**
Non-SOV Project Characteristics	
Project includes improvements to rail transit or passenger rail facilities.*	3
Project includes construction or replacement of bike facilities. For bicycle projects, off-road or on-road buffered or clearly delineated facilities are required.*	2
Project includes construction or replacement of pedestrian facilities. For pedestrian projects, sidewalks, pedestrian signals, marked crosswalks, refuge islands, and other treatments are required (as appropriate).*	2
Project includes improvements to an existing or proposed park-and-ride lot. Ex. New lot, more spaces, entrance/exit, technology (payment, traveler information).*	2
Project includes bus facility improvements or reduces delay on a roadway with scheduled peak service of 1 transit vehicle per hour.*	1
Project include special accommodations for hybrid or electric vehicles, or space or infrastructure for electric vehicle parking/charging).*	0.5
Project includes energy efficient infrastructure or fleets, including: hybrid or electric buses, electronic/open road tolling, alternative energy infrastructure (e.g., roadside solar panels).*	0.5
Total Points Possible	**8.5 points maximum***
Measure Scaling: *Points are multiplied by the number of peak period non-SOV users.	
Freight Transportation Project Characteristics	**Points (If Yes)**
Project reduces traffic delay at a congested intersection, interchange, or other bottleneck with a high percentage of truck traffic (greater than 8 percent of AADT). ***	1
Project includes improvements to freight rail network or intermodal (truck to rail) facilities/ports/terminals.**	0.5
Total Points Possible	**1.5 points maximum****
Measure Scaling: **Points are multiplied by daily truck volumes ** Points awarded for projects with a decrease in person hour delay greater than zero and with truck traffic greater than 8% AADT	

Economic Development: The metrics include consistency with regional and economic development plans, enhancement of intermodal access and efficiency, and improvement in travel time reliability. Pedestrian and bicycle projects are eligible for consideration but must be within a

0.5-miles buffer of the project. A scoring approach is used for consistency with development goals that considers various inputs such as level of plan detail, type of development, and location of the project. For intermodal access and efficiency, scores are assigned based on whether the project enhances multimodal options and whether it will support them efficiently. Finally, the travel time reliability is estimated based on whether a project has the potential to reduce impacts (i.e., incidents, work zones, capacity bottlenecks) and their frequency through a scoring approach. Table 2.3 shows site eligibility for economic development consideration.

Table 2.3 Site Eligibility for Economic Development Consideration (Source: VADOT)

Transportation Project Tier by Feature Type Selected	Distance from Transportation Project to be an Eligible ED Site
Tier 1 Add/Construct Bike Lane, Bike/Pedestrian Other, Construct or Convert Existing General Purpose or Parking Lane to Bus-only Lane, Construct or Improve Bus Stop / Shelter, Construct Shared-Use Path, Construct Sidewalk, Highway Other, Improve Bike/Pedestrian Crossing (At Grade), Improve Bike/Pedestrian Crossing (Grade Separated), Improve Park and Ride Lot, Improve Rail Crossing, Improve/replace existing bridge(s), Increase Existing Route Service – Additional Vehicles or Increased Frequency, ITS Improvement(s) / Adaptive Signal Control, New Intersection, New Park and Ride Lot, New Route/Service, New Traffic Signal, New/Expanded Vanpool or On-Demand Transit Service, Other Transit Technology Improvements, Rail Transit Other, Ramp Improvement(s), Right-of-Way/Easements acquisition required, Road Diet, Roadway Reconstruction/Realignment, Shoulder Improvement(s), TDM Other, Traffic Signal Modification, Turn Lane Improvement(s), Widen Existing Lane(s) (No New Lanes)	Up to 0.5 mile buffer
Tier 2 Access Management, Constuct/Expand Bus Facility, Innovative Intersection(s) / Roundabout(s), Intercity Passenger Rail Service Improvements, Intersection Improvement(s), Managed Lane(s) (HOV/HOT/Shoulder), New Interchange-Non-Limited Access Facility, Rail Service Improvements	Up to 1.0 mile buffer
Tier 3 Add New Through Lanes(s), Freight Rail improvements, Improve Grade-Separated Interchange, New Bridge, New Interchange-Limited Access Facility, New Intercity Passenger Rail Station or Station Improvements, New Station or Station Improvements, Roadway on New Alignment	Up to 3.0 mile buffer

Congestion Mitigation Measures: The metrics used are an increase in total (multimodal) person throughout and decrease in person hours of delay due to the project. The increase in person throughout is estimated based on a quantitative analysis (no specific approach is defined). It should be noted that no benefits in delay hours are assumed for pedestrian and/or bicycle projects despite their potential contribution to this evaluation category.

Land Use Coordination: The metrics include the potential for supporting employment and increase in population and employment for areas with high non-work accessibility. A scoring method is developed for possible work access options and points are calculated for these metrics. There is no consideration for pedestrian and bicycle projects in this evaluation category.

2.2.3 North Carolina DOT

NCDOT has developed a program, Prioritization 6.0, that prioritizes infrastructure projects based on a systematic approach (NCDOT, 2019). This effort considers three main areas to be addressed as part of their Strategic Transportation Investments (STIs). The three main areas are statewide mobility, regional impact, and division needs. The statewide mobility is based exclusively on data input to assess highway, rail, and aviation needs. The regional impact projects are those that address all modes, but bicycle and pedestrian projects and they are based 70 % on data scores and 30 % on local input. It should be noted that NCDOT is comprised of 14 Divisions and every two Divisions form a Region that is addressed through the regional impact STIs. Finally, the division needs to address all other projects including pedestrian and bicycle projects using 50 % data-based scores and 50 % local input scores. Local input scores are based on population of Metropolitan Planning Organizations (MPOs), Rural Planning Organizations (RPOs), and Division. There is a maximum number of local points that can be awarded for a project. The STI law allows for funds to be used from one category to the next, i.e., a project not funded in one category could be funded in the next. The one exception is the division project cannot be funded from any other funds. 40 % of the funds are allocated towards statewide mobility projects while the remaining are split evenly between regional and division projects. It should be noted that the new version of the prioritization scheme considers multimodal projects at the statewide mobility level where points for bicycle and pedestrian improvements can be included.

Bicycle and pedestrian projects are scored at the division level. A list of possible projects is provided to guide the process in Figure 2.3. The four criteria are weighted to develop a project

score and they account for the 50 % of the division needs data-based score. The four criteria are safety, accessibility/connectivity, demand/density, and cost-effectiveness. Figure 2.4 shows the scores for each criterion. It should be noted that the entries with red are new elements used in computing the scores for each criterion added in the latest version of the prioritization. A brief discussion for each component is provided in the following.

Figure 2.3 NCDOT Bicycle and Pedestrian Improvement Projects

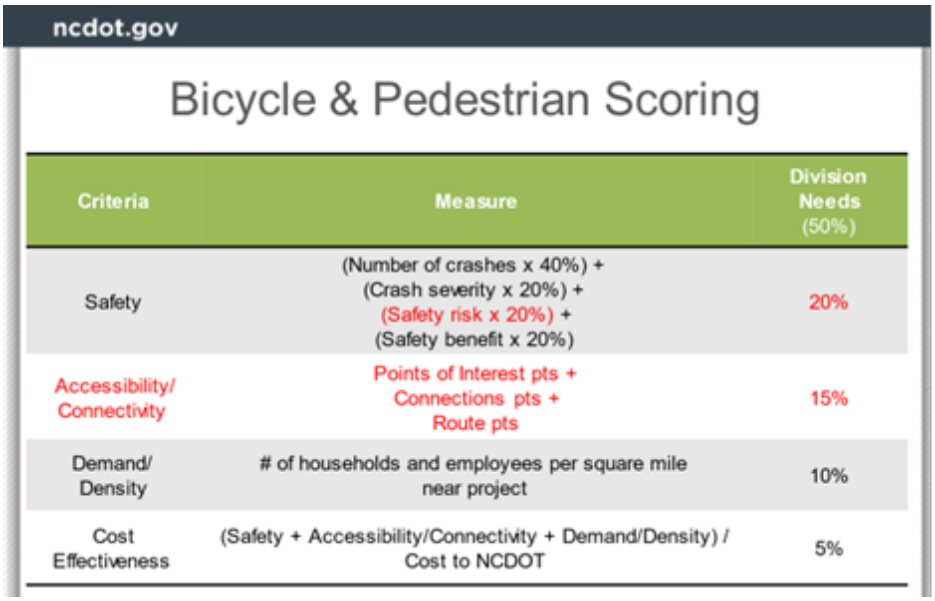

Figure 2.4 NCDOT Bicycle and Pedestrian Project Scoring

Safety: The metrics used include the number of crashes, their severity, the safety risk for each segment considered, and the safety benefit from the improvement. The crashes consider the pedestrian and bicycle crashes over the last 5 years along the corridor considered. The safety risk is estimated based on various factors of the project surroundings and crash history while the safety benefit is estimated based on the type of project to be implemented.

Accessibility/Connectivity: The metrics used are the quantity of destinations near the project, the quantity of connections to existing or planned bicycle/pedestrian facilities, and whether the project improves or connects to a designated bicycle route. The quantity of destinations is calculated manually based on the accessible points of interest within 1.5 miles for bicycles and 0.5 miles for pedestrians. Connectivity is based on points awarded for connections to bicycle/pedestrian facilities and are also calculated manually. Points are also awarded for improving the national/state/regional bike routes or designated state/federal trails. All three components are added to provide the score.

Demand/Density: The metric used is the population and employment density within a walkable or bikeable distance of the project. Each contributes equally to the score and densities are estimated within 1.5 miles for bicycles and 0.5 miles for pedestrians from the project.

Cost Effectiveness: The metric is based on the total Safety, Accessibility/Connectivity, and Demand/Density criteria scores compared to the cost of the project to NCDOT.

2.3 State DOT Practices for Selecting Pedestrian and Bicycle

A recent NCHRP Synthesis documented and summarized state DOT practices for selecting pedestrian and bicycle projects (Perrin et al., 2021). The report identified four steps in selecting bicycle and pedestrian projects. These include establishing policy goals, objectives, and performance measures, identifying pedestrian and bicycle projects to be proposed for implementation, evaluating, and prioritizing proposed pedestrian and bicycle projects, and selecting pedestrian and bicycle projects for the awarded funds. There are two methods in ranking the selected projects depending on whether they are only for pedestrian-focused projects or for both bicycle and pedestrian projects. For the pedestrian-focused projects, the report identified the approach suggested by Litman (2022) that uses four factors: magnitude of impact, demand (number/type of users and destinations), support of special objectives such as improving mobility for individuals with disabilities, and network/synergetic effects. For the combined projects, they recommend using the ActiveTrans Priority Tool (APT) that was developed specifically for ranking and prioritizing pedestrian and bicycle projects.

The report also provides a list of available funding sources that could be used for pedestrian and bicycle facilities. Such funding sources include Congestion Mitigation and Air Quality Improvement (CMAQ), Federal Lands Access Program, High-Risk Rural Roads (HRRR) Program, Highway Safety Improvement Program, National Highway Performance Program, Section 402 State and Community Highway Safety Grant Program, Surface Transportation Block Grant Program (non-Transportation Alternatives), Transportation Alternatives (TA), and U.S. DOT Discretionary Grants Program.

2.4 Prioritization Tool

The APT is a step-by-step tool for prioritizing pedestrian and bicycle improvements along existing roads (Lagerwey et al., 2015). The APT is used to prioritize pedestrian and bicycle locations by establishing a clear prioritization process. The APT was designed to address the needs of each mode separately. State and regional agencies can use this tool to evaluate proposed improvements based on policy objectives. The APT is an online tool that everyone can use and modify based on project needs. A two-phase process is used to accomplish this. The first focuses on scoping the project and relies on six steps. The first step is to define purpose. This step's goal is to identify the clear purpose of the project. What type of facility will be improved? Bicycle, pedestrian, or both. What type of improvement? Sidewalk, bike lanes, or something else? How many improvement locations will be prioritized and what types (intersection, roadway segment, or corridors)? The second step is to select factors. This step focuses on identifying what factors will make the most out of limited resources and provide the most benefits to the community. Those factors are stakeholder input, constraints, opportunities, safety, existing conditions, demand, connectivity, equity, and compliance. The third step is to establish factors weights. The goal for this step is to assign weight to each of the selected factors that were selected in step two. Weights identify the factors' importance based on community values and the prioritization purpose. The fourth step is to select variables for the factors that were selected in step two. Those variables are the core components of the prioritization process. The variables must be measurable such as for cost/benefit factor one of the variables could be cost/benefit of public health due to increased bicycle mode share. The fifth step is to assess data. This step's goal is to provide those variables that were selected in step four with available data. The availability of data will vary across cities, towns, counties, MPOs, and state DOTs. The last step is to assess technical resources. This step is used to identify a technical platform that will be used to implement the prioritization process. Some of those platforms are GIS, spreadsheet, or manual tabulations.

Once these steps are defined, the second phase focuses on prioritization through a series of additional steps. The first step is to set up a prioritization tool based on all the information that has been collected in phase one. This tool will likely use one of the technological platforms that was selected in step six of the first phase. The second step is to measure and input data. The purpose of this step is to measure and insert data into a prioritization tool that was developed in step one. The third step is to scale variables. The purpose of this step is to ensure all the variables are comparable. That means that we need to convert non-numeric values (such as “no", "yes”, or “high”) to numeric values, select a common numerical scale, and adjust raw values to fit the common scale. The last step is to create a ranking list. The purpose of this step is to sum the weighted values for each factor or variable to get a prioritization score for each improvement location.

2.5 Literature Review Summary

This literature review identified the recently completed *Complete Streets, Roads and Highways Manual* and the *Statewide Bicycle and Pedestrian Master Plan* for KYTC. Both efforts underscore the emphasis placed in non-motorized user mobility at the state level and establish a framework for advancing pedestrian and bicycle projects. These new documents lay the foundation for providing adequate and safe facilities for the communities and thus emphasize the need for developing an approach for incorporating non-motorized user projects in the project planning and programming efforts.

Furthermore, the literature review identified a few studies that developed a data-driven project prioritization approach. Those studies can be beneficial when developing a new scoring system for pedestrian and/or bicycle projects to incorporate into SHIFT. The two states that developed a scoring approach for pedestrian and bicycle projects are North Carolina and Virginia and both have unique aspects that SHIFT could benefit from. The NCDOT effort has developed a detailed process for scoring bicycle and pedestrian projects utilizing safety outcomes, accessibility and connectivity, demand and density, and cost effectiveness of the proposed improvements. However, these are considered mainly at the Division level. The VDOT approach does not

specifically score bicycle and pedestrian projects but rather considers them indirectly in their safety, accessibility, environmental quality, and economic development criteria. Another study has been found that focuses on evaluating quality of service. The Hillsborough County method of evaluating (quality of service) uses a process similar to the Level of Service (LOS) concept. The flow charts developed could be used to determine the Level of Traffic Stress (LTS) for pedestrian and bicycle projects and could be beneficial for SHIFT.

Finally, there is a tool for prioritizing pedestrian and bicycle improvements along existing roads which is an online tool that users can modify based on project needs.

CHAPTER 3. METHODOLOGY

3.1 Data Collection

KYTC provided the SHIFT-2022 projects consisting of 1,182 projects. A description of each project was included along with its purpose and need, region, location (County, City, Route, and Beginning and End Mile Points), costs, and an indication of potential pedestrian and/or bicycle improvements. For this study, the focus was on projects that include pedestrian and/or bicycle improvements and the projects with a "Yes" in the appropriate field were identified as such.

Among the 1,182 projects, 274 projects were identified as having pedestrian and/or bicycle improvements. The first step was to review each of these projects and understand its setting. This was accomplished through an initial project identification and a review of the project description and purpose and need. Among the 274 projects, 31 were identified as proposed routes indicating that there was no project corridor, and the purpose of the project is to build a new road. Out of those 31 projects, 26 did not have any mile point information resulting in impossible identification of the project location. Those 26 projects were excluded from the study due to lack of information.

The KYTC Interactive Statewide Traffic Counts Map was used to identify the project location, and this allowed for virtually driving through the project. A virtual drive for all 248 projects was undertaken to better understand the location and context of each project and to collect additional information about the project. This process allowed for identifying project context and land use, e.g., commercial, residential, rural, etc., potential attractions for pedestrian and bicyclist activities, speed limit, Annual Average Daily Traffic (AADT), and existing pedestrian and bicycle facilities by mile points. Several projects were not available to be virtually driven and Google Maps were used to collect the same information as for the other projects. An issue with using Google Maps was the lack of AADT and accurate mile points of existing pedestrian and bicycle facilities. For each project, a walk score heat map was attempted to estimate the walkability and bikeability of the project's surrounding area. These scores indicate how easy it is to walk and bike at the area's

attractions to complete errands as well as the presence of these attractions. A score of 0 indicates that all errands require a car while a score of 100 indicates that it is a very walkable and/or bikeable location and all errands could be done on foot or by bike. An example of such a heat map is shown in Figure 3.1 and the associated walk and bike score distribution is shown in Table 3.1.

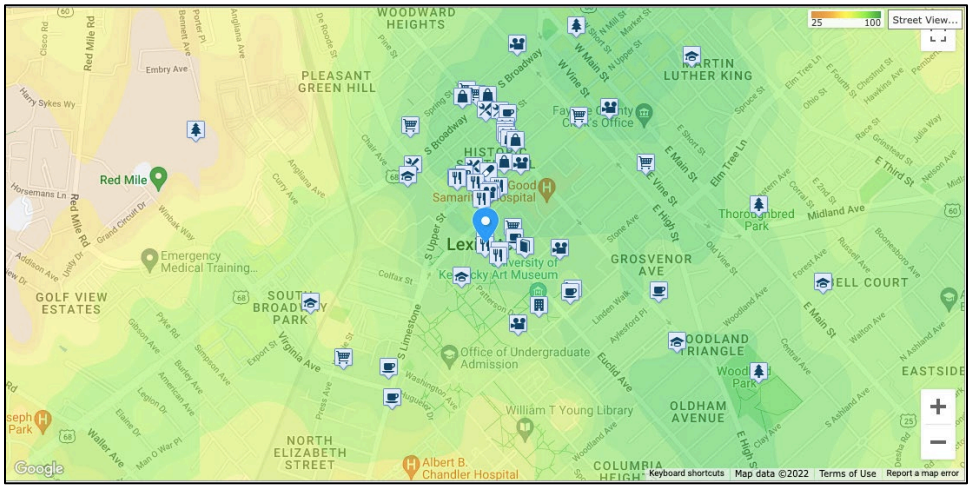

Figure 3.1 Heat map of University of Kentucky

Table 3.1 Walk and Bike Score Distribution

	0-24 score	25-49 score	50-69 score	70-89 score	90-100 score
Walk	Almost all errands require a car	Most errands require a car	Some errands can be accomplished on foot	Most errands can be accomplished on foot	Daily errands do not require a car
Bike	Minimal bike infrastructure		Some bike infrastructure	Biking is convenient for most trips	Daily errands can be accomplished on a bike

For each project, a summary document was created providing all pertinent information. This document provided a map of the project along with its purpose and need, AADT, speed limit, existing pedestrian and bicycle facilities by mile points, a walk score heat map, and description of the project's surrounding land uses. Upon completion of this summary documentation, it was determined that projects could be grouped in broad purpose or need categories.

The 248 projects were grouped into five categories as follows and their frequency is summarized in Table 3.2:

- Pedestrian and bicycle: including pedestrian and bicycle improvements, multi-mode accommodation, new pedestrian and bicycle facilities construction, and complete streets implementation.
- Sidewalks: focusing only on sidewalk improvements and construction of new sidewalk facilities.
- Safety improvements: including projects indicating safety improvements including road widening, road reconstruction, and improvements addressing safety/mobility/congestion.
- Non pedestrian and bicycle: including intersection or interchange improvements.
- Existing pedestrian and bicycle: including projects with existing facilities throughout the corridor and in both directions of travel. It was anticipated that these projects would replace the existing facilities.

Table 3.2 Walk and Bike Score Distribution

Project Category	Specific Project Type	Number of projects
Pedestrian/bicycle	Pedestrian/bicycle improvements	3
	Include multi-mode	6
	Pedestrian improvements	9
	Multi-modal improvements	11
	Pedestrian/bicycle Include facilities	15
	Pedestrian/bicycle accommodation	16
	Complete streets	1
Sidewalk	Sidewalk Improvements	11
Safety improvements	Road widening	19
	Road reconstruction	23
	Improve mobility, safety, and/or congestion	107
Non pedestrian/bicycle	Intersection or interchange improvements	18
Existing pedestrian and/or bicycle	Existing pedestrian/bicycle facilities	9

The results showed that most of the projects were in the safety improvement category. Even though those 248 projects were all marked as including pedestrian and/or bicycle improvements, only 81 of the projects included some type of pedestrian and/or bicycle improvement. That showed that most of the projects were focusing on improving the motorized vehicle network lacking specific information on what should be improved for the non-motorized users.

3.2 Scoring Approach

Before developing the scoring approaches, it was decided to first determine the type of pedestrian and/or bicycle improvement to be considered for each project. To identify whether such information was available with the existing data, a review of a small sample of projects was undertaken selecting randomly 20 projects. The first step in defining the project type that will be implemented was a review of their project description, existing facilities, and surrounding area.

This review revealed that there was not enough information available on each project to allow to define with certainty what pedestrian and/or bicycle project type will be implemented. To find more information available on those projects, the KYTC Districts were queried to identify

those who submitted the project request and establish their original intent regarding the pedestrian and/or bicycle project to be considered. Unfortunately, this did not provide any new information as there was no way of tracking those who submitted each project.

For all 20 projects, the project type has been identified only based on the available information and the research team's judgment. To ensure that the assumptions made were reasonable, additional feedback was solicited from two professionals at KYTC asking them to provide their opinion on the pedestrian and/or bicycle project type to be implemented for each of the projects. The two professionals used the same available information to the research team for each project to evaluate each project as well as their knowledge and experience in working on SHIFT projects.

Upon completion of the KYTC review, the three judgments (i.e., research team and professionals) regarding the project types were reviewed to determine difference of opinions and consolidate them into a single proposed project type. This effort also helped the research team to understand how to accurately determine the potential pedestrian and/or bicycle project type for the rest of the projects. The results showed that one of the professionals evaluated each project with respect to accounting for pedestrian and/or bicycle improvements, whereas the second professional analyzed each project based on project potential, i.e., what might be implemented for each project based on the project description. It was decided to evaluate each project based on its project description rather than accounting for possible pedestrian and/or bicycle improvements

Following the evaluation of these first 20 projects, another 40 projects were evaluated for determining the pedestrian and/or bicycle project type and sent to the KYTC team for feedback. The team's assessment this time was more in line with the KYTC assessment and most of the projects had identified the same project type. This provided more clarity and accuracy on how the pedestrian and/or bicycle project type for each project should be identified. Next, all 248 projects were evaluated to identify the pedestrian and/or bicycle project type to be considered.

Three scoring approaches were developed to capture all the potential impact and importance of pedestrian and bicycle facilities. The three scoring approaches considered were existing facility type, project type, and project potential. The existing facility and project type have been already identified for each project. To identify the project potential, information on surroundings, future development, density, context, and other similar information must be available. Currently, there is not enough information available to identify the project potential and the value added from this effort was deemed low at this stage of the SHIFT approach. It was therefore determined that the scoring for each project will be based on the existing facility and project type.

The score for the existing facilities captures all existing pedestrian and bicycle facilities in the project. These scores evaluate the level of infrastructure that is available for pedestrians and bicyclists for each project and assign a value based on a 5-point scale scoring system for both pedestrians and bicyclists. A score of 5 was assigned for projects that have a facility present throughout the project corridor in both directions and in good condition. A score of 1 is given to projects that have less than 25% of the facility present over the length of the corridor and the project corridor is greater than 1 mile. A score of 0 is given to projects that have no existing pedestrian and/or bicycle facilities. Table 3.3 shows the description for the existing pedestrian and bicycle facilities scores. It should be noted that each project is scored separately for its pedestrian and bicycle facilities using the same scale and resulting in two separate scores.

Table 3.3 Scores for Existing Pedestrian and Bicycle Facilities

Score	Existing
5	The facility is present and in good condition
4	The facility is present and in poor condition (improvement); some facility is present for ≥ 75% of project length
3	Some facility is present for < 75% of project length
2	Some facility is present for <25% of project length; project length ≤1 mile
1	Some facility is present for <25% of project length; project length >1 mile
0	No facilities

The project type to be implemented identifies the anticipated pedestrian and bicycle improvements for the project. A 5-point scale scoring approach was used for this as well and is used for scoring separately pedestrian and bicycle project types, since they are different in nature. High scores represent new facilities or significant improvements while low scores represent minor improvements. A score of 0 indicates no project definition. Table 3.4 represents the scores and project types for pedestrian and bicycle projects.

Table 3.4 Scores for Proposed Project Type

Score	Bicycle Project	Pedestrian Project
5	New bicycle multi- or shared-use path, buffered bicycle lane, separated bicycle lanes, rail-trail	New pedestrian multi- or shared-use path, sidewalk
4	New bicycle lane	Sidewalk widening; Sidewalk improvement/reconstruction; Trail improvement
3	Reconstruct bicycle facility; Paved shoulder	Crossing island, curb extensions, streetscape
2	Signalization for bicycles; Sharrows	Signalization improvements
1	Bicycle amenities (parking, wayfinding, shared system)	Wayfinding
0	No project defined	No project defined

The 248 projects were scored based on existing facilities and project type approaches, thus resulting in each project receiving four scores. Two scores for existing pedestrian and bicycle facilities and two scores for pedestrian and bicycle project type. To further develop a scoring system, it was deemed appropriate to only have one score for pedestrians and one score for bicycles

for each project. A few calculations were developed to combine those scores into one. The first considered summing up the proposed project type and existing facilities scores for pedestrian and bicycle projects. Another used the difference between the existing facilities score from the proposed project type score and a third one utilized a weighted average. After much consideration, it was decided to calculate the score for pedestrian and bicycle projects by using the subtraction method i.e. (Proposed project type – Existing facilities), since this captures most of the impending change in the facility status.

The subtraction method was selected because it gives the most reasonable results. For example, if the project that has as proposed project type "new pedestrian sidewalk" but the project has already existing sidewalks throughout the project corridor that are in good condition, both of those types get a score of five. So, when the subtraction method was used the total pedestrian score was zero. That is reasonable because there is no need for this project to get a high score as this project already has an existing facility that is in good condition. An example of a scoring approach is shown in Table 3.5. In Table 3.5, six random projects are presented. The first column represents the Project ID. The following four columns show the score distribution for each project for pedestrian and bicycle projects. The last two columns show the results of using the subtraction method i.e. (Proposed project type – Existing facilities)

Table 3.5 Scoring Approach Example

	Scores					
Project ID	Existing Facilities		Proposed Project		Difference (Proposed - Existing)	
	Pedestrian	Bicycle	Pedestrian	Bicycle	Pedestrian	Bicycle
IP20130059	1	0	5	0	4	0
IP20180079	0	0	0	0	0	0
6-446.00	5	0	5	0	0	0
IP20080275	3	0	3	3	0	3
IP20080348	0	0	5	4	5	4
IP20210059	0	0	0	0	0	0

It should be noted that it was assumed that at a minimum, each project will replace the existing facilities in kind, i.e., with the same type and length as they are currently in place. In these

cases, the score will be zero. If the project does not have any proposed pedestrian and/or bicycle projects the calculated score will be zero as no proposed project has been determined. In the next section, the development of the scoring scenarios for use in SHIFT will be discussed. The distribution of project scores by region is shown in Table 3.6.

Table 3.6 Number of Projects by Facility Score and Region

Score	East		North		West		South	
	Pedestrian	Bicycle	Pedestrian	Bicycle	Pedestrian	Bicycle	Pedestrian	Bicycle
5	0	0	17	1	17	1	2	1
4	1	1	14	27	6	10	1	2
3	0	1	5	26	3	9	1	0
2	2	0	27	0	9	0	2	0
1	0	0	9	5	6	2	2	0
0	14	15	64	77	28	47	16	21
Total	17	17	136	136	70	70	24	24

3.3 Development of SHIFT Scoring Scenarios

The proposed SHIFT-2024 approach will introduce a score for the pedestrian and/or bicycle projects aiming to provide additional weight and importance for these projects in the overall scoring approach. As noted above, projects will be scored based on the existing and proposed facilities. The first step in developing the scoring system was to find how many total points can be allocated to the pedestrian and bicycle projects from the existing total points. On the regional level, SHIFT has a total of 100 points with 70 points allocated among congestion, safety, benefit-to-cost ration, asset management, and economic growth and 30 points allocated to MPO and District boosts. These 30 points are evenly distributed between MPO and District boosts. It has been decided that the points to be allocated for pedestrian and bicycle projects will be from the MPO and District boosts.

Three scenarios were developed that would incorporate the pedestrian and bicycle scores. As noted above, each project received a score for its pedestrian and bicycle facilities ranging from 0 to 5. The approaches considered here included two scenarios that retained the maximum of 5 points allocated to pedestrian and bicycle projects and a third scenario which

allocated 2.5 points for pedestrian and 2.5 for bicycle projects. In essence, the first two scenarios reduce the overall boost scores by 10 points (total possible maximum) while the third one reduces the total boost score by 5. Scenario 1 reduces the District boost to 5 while retaining all 15 points for the MPO boost. Scenario 2 reduces both the MPO and District boosts by 5 points. Finally, Scenario 3 reduces the District boost by 5 points and retains the 15 MPO boots points. Table 3.7 summarizes the three scenarios considered.

Table 3.7 Points Distribution for Three New Scoring Scenarios

Scenario	Existing Boosts Points		New Boosts Points		Points	
	MPO	District	MPO	District	Pedestrian	Bicycle
1	15	15	15	5	5	5
2	15	15	10	10	5	5
3	15	15	15	10	2.5	2.5

To determine the impact of each scoring scenario it was decided to score all SHIFT-2022 projects that have been provided as part of this study. This would allow for the most accurate evaluation of the scoring scenarios considering how the scores for pedestrian and bicycle projects impact the ranking of all projects. In addition, it was deemed appropriate to consider projects within each of the five regions separately to account for local variability. The five regions were East (204 projects), North (388 projects), South (245 projects), West (293 projects), and Statewide (52 projects).

For every region, each project was scored based on the existing scoring method and the new scoring scenarios. The existing scoring method is currently used to score SHIFT projects. The next step was to rank each project within each of the four scoring approaches (i.e., existing and three scenarios) and for each region. Within each region and scenario, the projects that had pedestrian and/or bicycle improvements have been identified to allow for tracking them in each scenario and evaluate the scoring scenario impact in their rank order. The difference in rank was estimated for each scoring scenario subtracting the new scoring rank from the existing, i.e., existing

rank – new scoring rank. An example of the process is shown in Table 3.8 demonstrating the top six projects for the East Region, Scenario 1 based on the existing scoring.

Table 3.8 Scoring Example; East Region, Scenario 1

Project ID	Existing Boosts		Scores			Rank		Difference
	MPO	District	Total	Existing	New	Existing	New	
9-8903.00	15	15	53.31	83.31	73.31	1	1	0
9-8406.00	15	15	51.78	81.78	71.78	2	2	0
9-8509.00	15	15	50.99	80.99	70.99	3	4	-1
9-204.00	15	15	50.33	80.33	70.33	4	5	-1
12-195.00	15	15	49.82	79.82	69.82	5	6	-1
9-8400.00	0	15	59.21	74.21	64.21	6	10	-4

The existing MPO and District boost scores are shown in Table 3.8 for the top six projects as ranked using the existing scoring method. The Total Score is the one obtained based on the 70 points accounting for congestion, safety, benefit-to-cost ratio, asset management, and economic growth. The Existing score is the sum of the Total, MPO and District boosts. The New score is computed using the adjusted MPO and District boosts, and for Scenario 1 only the District boost will be reduced by 10 points. Each rank is based on the corresponding scores. The difference in rank order between the existing and new scoring is estimated by subtracting the new rank from the existing. Negative scores indicate a decrease in ranking while positive scores indicate an increase in ranking when considering the new scoring. For example, the project that was ranked 6^{th} in the existing scoring is ranked 10^{th} with the new scoring, indicating that it was downgraded by 4 positions in the rank order in the new scoring method. For each scoring scenario, an average change in rank order is estimated. This is based on the values noted in the difference and allow for understanding the overall impact of the scenario in the ranking of the projects.

After completing the rank difference for all five regions and all three new scenarios, the results showed that the Statewide region had no change in rank for all 52 projects. This was because there were no District or MPO boosts and thus no changes could be recorded in the existing scoring system. Moreover, the Statewide region had only one project that had pedestrian and/or bicycle

improvements that did not receive any points for both pedestrian and bicycle projects because there were no existing facilities, and no pedestrian and bicycle improvements were identified.

To evaluate the impacts of each scenario on the overall scoring and ranking of all projects, three detailed analyses were developed. The next section will provide the results of those analyses. It has been decided to exclude the Statewide region from the analyses as all projects for all three new scenarios have the same scoring rank as the existing rank.

The first analysis focused on evaluating the impact of each new scoring scenario to the ranking of the projects that include pedestrian and/or bicycle improvements as compared to the existing scoring, i.e., without any dedicated scores for pedestrian and/or bicycle projects. This analysis would allow to determine which scenario affected the most the ranking of the projects with pedestrian and/or bicycle improvements. This analysis was conducted for the top 50% ranked projects for the remaining four regions. Once the top 50% ranked projects for each scoring scenario based on the existing scoring were determined, a second review was conducted to identify if the pedestrian and/or bicycle projects identified in the top 50% of the existing scoring remained in the new scenarios. The next step was to compare each project's existing rank with the new rank to determine how many projects had a higher, lower, or the same rank in each of the new scenarios. As noted above, positive values indicate that the project had a higher rank than the existing rank, negative values indicate that the project had a lower rank than the existing rank, and a zero indicates no change in rank order.

The second analysis focused on a similar approach to the first one but examined all projects that were included in the top 50% of the ranking. The purpose of this analysis was to examine the change in ranking and retention in the top 50% of the projects for all projects irrespective as to whether they were identified as pedestrian and/or bicycle projects. Therefore, the rank order for each project in each of the new scenarios was compared to the existing and similar data were collected regarding change in rank and retention rate in the top 50% of the projects.

The third analysis examined the sensitivity of the new scoring scenarios using different percentages of project selection. The previous two analyses were conducted assuming that 50% of the projects of a region have a chance to be funded. However, this is not always the case and different percentages could be selected from any of the four regions. To evaluate the sensitivity of each of the scoring scenarios, varied percentages were used from 10% to 50% with a 10% increment step, i.e., 10%, 20%, 30%, 40%, and 50%. The same process as outlined for the previous two analyses was utilized and each step was repeated for each of the five percentages selected. Similar metrics were developed here as well, also including the percentage of projects remaining within the corresponding percentile considered. Graphs were developed to represent the changes in inclusion within the percentile and they were generated for both pedestrian and/or bicycle projects only and all projects for four regions.

The Spearman's rank-order correlation test was conducted for the first two analyses. The purpose of this test was to identify the statistical correlation between the existing rank and the ranks for each scenario and determine whether they are similar. The null hypothesis assumes that there is correlation. The test was conducted at the 95% confidence level ($\alpha = 0.05$). The null hypothesis H_0 ($\rho = 0$) states that there is no monotonic relationship between the ranks of the two variables. The alternative hypothesis H_1 ($\rho \neq 0$) states there is a monotonic relationship between the ranks of two variables. For this test the correlation coefficient (r_s), p-value, and confidence interval (CI) were found to evaluate the rank relationship between each pair. If the correlation coefficient is close to zero, that means that there is a significant difference in ranks between the existing and the scenario tested. If the correlation coefficient is close to 1, that means that there is no significant difference in ranks. A p-value greater 0.05 indicates that the null hypothesis cannot be rejected and thus there is no correlation between the ranks of existing and scenario. Finally, if the correlation coefficient falls between the lower and upper limit of the confidence interval and the confidence interval does not contain zero, then it can be concluded that there is strong relationship between the ranks.

CHAPTER 4. ANALYSES RESULTS

The following section presents the findings of the three analyses discussed in Chapter 3. First, the effects of the three scoring scenarios on the rank of only the pedestrian and/or bicycle projects are discussed followed by the evaluation of the effects of the scoring scenarios on all projects. These two analyses were conducted for the top 50% of the projects within each of the four regions. The third evaluation focuses on examining the effects of the scoring scenarios for different percentiles of projects selected within each region.

4.1 Rank Change for Pedestrian and/or Bicycle Projects

4.1.1 East Region

The East region had a total of 204 projects, including 17 projects that had pedestrian and/or bicycle improvement. For this analysis, only the top 50% of the projects, i.e., 102 were analyzed including 15 of the 17 with pedestrian and/or bicycle improvements. The other two projects were in the remaining 102 projects.

Scenarios 2 and 3 had all 15 projects remained from the existing method. Whereas in Scenario 1, only 14 projects retained in the top 50%. For all three scenarios, there were no additional projects in the top 50% when ranked with new scenarios. The differences in ranks between the existing and new scoring scenarios are presented in Table 4.1.

Table 4.1 Rank Changes by Scenario for Pedestrian and/or Bicycle Projects; East Region

Scenario	Number of Projects		Rank			Total Avg.
	Existing	Retained/New	Higher	Lower	Same	
1	15	14/0	7 (Avg: 11)	7 (Avg: -17)	1	-2
2	15	15/0	10 (Avg: 8)	4 (Avg: -7)	1	4
3	15	15/0	7 (Avg: 5)	6 (Avg: - 7)	2	0

The results showed that the biggest change in ranking was in Scenario 2 where there were more pedestrian and/or bicycle projects that were ranked higher in the new scoring than in the

existing. Scenario 1 showed the highest average increase in ranking as well as the greatest decrease. Scenario 3 had similar results regarding the numbers of projects ranked higher or lower than Scenario 1 but with smaller average increase and decrease. Scenario 2 had the largest overall average rank change of 4, i.e., on average a pedestrian and/or bicycle project increased its ranking by four spots, where Scenario 1 had an average overall reduction of 2 and Scenario 3 had no change in the average ranking.

The Spearman tests showed that the rank order between the existing and each scenario is similar with correlation coefficients of 0.79 for scenario 1 and 0.93 for scenarios 2 and 3. The p-values were low (0.0005 or lower), and confidence intervals do not contain zero thus supporting the finding that the ranks are statistically similar.

4.1.2 North Region

The north region had a total of 388 projects, including 136 projects that accommodate pedestrians and/or bicycles. Among the 194 projects considered, i.e., the top 50% of the projects, 102 had pedestrian and/or bicycle improvement.

Scenario 1 had the least number of projects retained in the top 50% from the existing method but when the projects were ranked with just new scenario, three more projects got to the top 50% of the new scenario. Which makes total of 103 projects in the top 50% when new scenario is used. Scenarios 2 and 3 had 101 projects remained in the top 50% from the existing method and when the projects were scored with the new scenarios one extra project got to the top 50%. Table 4.2 shows the changes in rank order between the existing and new scoring scenarios.

Table 4.2 Rank Changes by Scenario for Pedestrian and/or Bicycle Projects; North Region

Scenario	Number of Projects		Rank			Total Avg.
	Existing	Retained/New	Higher	Lower	Same	
1	102	100/3	67 (Avg: 27)	31 (Avg: - 18)	4	12
2	102	101/1	70 (Avg: 25)	29 (Avg: - 13)	3	14
3	102	101/1	66 (Avg:12)	31 (Avg: - 9)	5	5

The results showed that the biggest change in ranking was in Scenario 2. There were more pedestrian and/or bicycle projects that were ranked higher in the new scoring than in the existing. Scenario 1 showed the highest average increase in ranking as well as the greatest decrease. Scenario 3 had similar results regarding the numbers of projects ranked higher or lower compared to Scenario 1 but with smaller average increase and decrease. Scenario 2 had the largest overall average rank of change 14 where Scenario 1 had 12 and Scenario 3 had 5.

The Spearman tests showed statistically similar ranks between the existing and each scoring scenario with correlation coefficients close to 1 (0.91 scenario 1, 0.92 scenario 2, and 0.98 scenario 3) and low p-values (0.0001).

4.1.3 South Region

The south region had 245 projects, including 24 projects that accommodate pedestrians and/or bicycles. Among the 123 projects, i.e., the top 50% of the projects, there were 18 pedestrian and/or bicycle projects.

All three scenarios had all 18 projects retained in the top 50% from the existing method. Whereas only scenarios 1 and 2 had two extra projects in the top 50% when just those scenarios were used to rank the projects. The differences in rank order between the existing and new scoring scenarios are shown in Table 4.3.

Table 4.3 Rank Changes by Scenario for Pedestrian and/or Bicycle Projects; South Region

Scenario	Number of Projects		Rank			
	Existing	Retained/New	Higher	Lower	Same	Total Avg.
1	18	18/2	11 (Avg: 12)	5 (Avg: -2)	2	7
2	18	18/2	12 (Avg: 13)	5 (Avg: -1)	1	8
3	18	18/0	10 (Avg: 5)	1 (Avg: -1)	7	3

The data in Table 4.3 showed that the biggest change in ranking was in Scenario 2. There were more pedestrian and/or bicycle projects that were ranked higher in the new scoring than in the

existing. Scenarios 1 and 2 had the highest change in rank for the projects that ranked higher. Scenario 1 had the highest change in rank for the projects that ranked lower, whereas scenarios 2 and 3 had the lowest change in ranks for projects that ranked lower. Scenario 2 had the largest overall average rank change of 8 where Scenario 1 had 7 and Scenario 3 had 3.

The Spearman tests showed statistically similar ranks between the existing and each scoring scenario with correlation coefficients close to 1 (0.97 scenario 1, 0.96 scenario 2, and 1.00 scenario 3) and low p-values (0.0005 or less).

4.1.4 West Region

The west region had 293 projects, including 70 projects that accommodate pedestrians and/or bicycles. Among the 147 projects, i.e., the top 50% of the projects, 54 projects had pedestrian and/or bicycle improvement.

Scenarios 2 and 3 had all 54 projects remained in the top 50% from the existing method. Scenario 2 had five extra projects in the top 50% when the new scenario was used, whereas Scenario 3 had only three extra projects. Scenario 1 had 53 projects remained in the top 50% from the existing method and five extra projects when Scenario 1 was used to rank the projects. Table 4.4 summarizes the rank difference between the existing and new scoring scenarios.

Table 4.4 Rank Changes by Scenario for Pedestrian and/or Bicycle Projects; West Region

Scenario	Number of Projects		Rank			Total Avg
	Existing	Retained/New	Higher	Lower	Same	
1	54	53/ 5	38 (Avg:16)	14 (Avg: - 14)	2	8
2	54	54/5	41 (Avg: 15)	11(Avg: -11)	2	9
3	54	54/3	38 (Avg: 9)	16 (Avg: - 5)	0	5

The results showed that the biggest change in ranking was in Scenario 2. There were more pedestrians and/or bicycle projects that were ranked higher in the new scoring than in the existing. Scenario 1 showed the highest average increase in ranking as well as the greatest decrease. Scenario 3 had similar results regarding the number of projects ranked higher or lower compared to Scenario

1 but with a smaller average increase and decrease. Scenario 2 had the largest overall average rank change of 9 whereas Scenario 1 had 8 and Scenario 3 had 5.

The Spearman tests showed statistically similar ranks between the existing and each scoring scenario with correlation coefficients close to 1 (0.92 scenario 1, 0.95 scenario 2, and 0.980 scenario 3) and low p-values (0.0005 or less).

4.1.5 Summary

The main purpose of this analysis was to identify which new scoring scenario had the greatest impact on all projects with a greater emphasis placed on those including pedestrian and/or bicycle improvements. This analysis focused on determining the changes in ranking as well as changes in the inclusion of the pedestrian and/or bicycle projects to the top 50% of all projects. A greater emphasis was placed on whether the ranking of pedestrian and/or bicycle projects increased as well as when more projects were included in the top 50% of the ranked projects.

The analysis of all four regions showed that Scenario 2 (i.e., both Regional and District boosting was reduced to 10 points) was more advantageous when considering the rank and number of pedestrian and/or bicycle projects for all regions. For the east, south and west regions, Scenario 2 always had the greatest number of projects in the top 50% when that scenario was used. Also, scenarios 2 and 3 always had the greatest number of projects ranked in the top 50% when compared to the existing scoring method. Moreover, Scenario 2 had the most projects that were ranked higher than in the existing scoring, with an average increase in ranking ranging from 8 to 25. Furthermore, Scenario 2 had the highest total average score considering the rank change for all four regions. At the same time, projects in Scenario 2 had also a lower average decrease in ranking than the other two scenarios. The statistical analysis indicated that all scenarios result in statistically similar ranks as the existing rank order. It should be noted that Scenario 3 had the highest correlation coefficient indicating a closer relationship between the existing and scenario ranks. This was anticipated since

this scenario applies the least change in the boosts and there is a small impact to the final scores due to adjusting only 5 points in the total score.

The results showed that when Scenario 2 is used to score the projects, more projects that include pedestrian and/or bicycle improvements get higher ranking and potentially can have a higher chance to be selected for future funding.

4.2 Rank Change for All Projects

4.2.1 East Region

In the east region, there were 102 projects in the top 50% when ranked by using the existing scoring method. The new scoring scenarios resulted in different numbers of projects in the East region. All 102 projects from the existing scoring remained in Scenario 3 in the top 50%, while 100 projects remained in Scenario 2 and 99 in Scenario 1. The rank differences for all projects as compared to the existing are shown in Table 4.5.

Table 4.5 Rank Changes by Scenario for All Projects; East Region

Scenario	Number of Projects		Rank			Total Avg.
	Existing	Retained	Higher	Lower	Same	
1	102	99	57 (Avg: 10)	42 (Avg: -14)	3	0
2	102	100	58 (Avg: 7)	38 (Avg: -12)	6	0
3	102	102	55 (Avg: 4)	37 (Avg: -6)	10	0

The results showed that the biggest change in ranking occurred in Scenario 2. Scenario 2 had the greatest number of projects that ranked higher than in the existing scoring. Scenario 1 showed the highest average increase in ranking as well as the greatest decrease. Scenario 3 had the lowest number of projects that ranked higher and lower with the smallest average increase and decrease. All three scenarios had an overall average rank change of 0 indicating no significant change in ranking.

The Spearman tests showed statistically similar ranks between the existing and each scoring scenario with correlation coefficients close to 1 (0.89 scenario 1, 0.93 scenario 2, and 0.98 scenario 3) and low p-values (0.0001).

4.2.2 North Region

The north region had 194 projects in the top 50% of the original ranking. For all new scoring scenarios fewer projects remained in the top 50% with scenarios 1 and 2 retaining 191 projects and Scenario 3 retaining 192 projects from the existing scoring. The changes in rank order between existing and new scoring scenarios are presented in Table 4.6.

Table 4.6 Rank Changes by Scenario for All Projects; North Region

Scenario	Number of Projects		Rank			Total Avg.
	Existing	Retained	Higher	Lower	Same	
1	194	191	72 (Avg: 27)	111 (Avg: -18)	11	-1
2	194	191	76 (Avg: 24)	112 (Avg: -17)	6	0
3	194	192	74 (Avg: 12)	114 (Avg: -8)	6	0

The results showed that the biggest change in ranking occurred in Scenario 2, having the greatest number of projects that ranked higher than in the existing scoring. Scenario 1 showed the highest average increase in ranking as well as the greatest decrease. Scenario 3 had the smallest average increase and decrease. Scenarios 2 and 3 had an overall average change of rank of 0, where Scenario 1 had the overall average rank change of –1.

The Spearman tests showed statistically similar ranks between the existing and each scoring scenario with correlation coefficients close to 1 (0.90 scenarios 1 and 2, and 0.98 scenario 3) and low p-values (0.0001).

4.2.3 South Region

The south region had 123 projects in the top 50% of the original scoring. For all new scoring scenarios fewer projects remained in the top 50% with Scenario 3 retaining 121 projects, Scenario

2 included 120 projects and Scenario 1 included 119 projects from the existing scoring. The rank differences between the existing and new scoring scenarios are summarized in Table 4.7.

Table 4.7 Rank Changes by Scenario for All Projects; South Region

Scenario	Number of Projects		Rank			Total Avg.
	Existing	Retained	Higher	Lower	Same	
1	123	119	60 (Avg: 10)	56 (Avg: -11)	7	0
2	123	120	61 (Avg: 9)	56 (Avg: -10)	6	0
3	123	121	53 (Avg: 4)	34 (Avg: -7)	36	0

The results showed that the biggest change in ranking occurred in Scenario 2, having the greatest number of projects that ranked higher than in the existing scoring method. Scenario 1 showed the highest average increase in ranking as well as the greatest decrease. Scenario 3 had the smallest average increase and decrease. All three scenarios had an overall average change of rank of 0.

The Spearman tests showed statistically similar ranks between the existing and each scoring scenario with correlation coefficients close to 1 (0.93 scenarios and 2, and 0.99 scenario 3) and low p-values (0.0001).

4.2.4 West Region

The west region had 147 projects in the top 50% of the original scoring. For all new scoring scenarios fewer projects remained in the top 50% with scenarios 1 and 2 retaining 142 projects and Scenario 3 retaining 144 projects from the existing scoring. The changes in the rank order between the existing and new scoring scenarios are shown in Table 4.8.

Table 4.8 Rank Changes by Scenario for All Projects; West Region

Scenario	Number of Projects		Rank			Total Avg.
	Existing	Retained	Higher	Lower	Same	
1	147	142	73 (Avg: 13)	72 (Avg: -17)	2	-2
2	147	142	66 (Avg: 13)	76 (Avg: -14)	5	-1
3	147	144	69 (Avg: 7)	76 (Avg: -7)	2	0

The results showed that the biggest change in ranking occurred in Scenario 1 having the greatest number of projects that ranked higher than in the original rank. Scenario 2 had the least number of projects that ranked higher but similar results regarding average increase and decrease as Scenario 1. Scenario 3 had the smallest average increase and decrease. Scenario 3 had an overall average of 0 where Scenario 1 had an average of –2.

The Spearman tests showed statistically similar ranks between the existing and each scoring scenario with correlation coefficients close to 1 (0.91 scenario 1, 0.94 scenario 2, and 0.98 scenario 3) and low p-values (0.0001).

4.2.5 Summary

The main purpose of this analysis was to identify which new scoring scenario had the greatest impact on all projects. This analysis focused on determining the changes in ranking in the top 50% of all projects. A greater emphasis was placed on whether the ranking of all projects increased as well as when more projects were included in the top 50% of the ranked projects.

The analysis of all 4 regions showed that scenarios 2 and 3 were more advantageous when considering the rank and number of all projects for all regions. Scenario 3 always retained the greatest number of projects ranked in the top 50% when compared to the existing scoring method. It should be noted that the other two scenarios had a small number of projects (one to three) excluded. Scenario 2 had the most projects that were ranked higher than in the existing scoring method, with an average increase in rank change ranging from 7 to 24 for east, north, and south regions. For most of the regions, scenarios 2 and 3 had the total average rank of 0; the only exception was Scenario 2 for the west region. The statistical analysis indicated again that all scenarios result in statistically similar ranks as the existing rank order. As it was the case for the pedestrian and/or bicycle projects, Scenario 3 had the highest correlation coefficient indicating a closer relationship between the existing and scenario ranks; an anticipated outcome since this

scenario applies the least change in the boosts and there is a small impact to the final scores due to adjusting only 5 points in the total score.

4.3 Change in Percentiles

4.3.1 East Region

For this analysis, 10th, 20th, 30th, 40th, and 50th percentiles were analyzed for pedestrian and/or bicycle projects and for all the projects. The east region had a total of 204 projects including 17 projects that had pedestrian and/or bicycle improvements. In Table 4.9, the number of pedestrian and/or bicycle projects for each Scenario, each percentile and overall average rank is shown. The data in Table 4.9 shows that Scenario 2 retained all pedestrian and/or bicycle projects from the existing scoring for almost all percentiles.

Table 4.9 Number of Projects by Percentile for Pedestrian and/or Bicycle Projects; East Region

Percentile	Pedestrian and/ or Bicycle Projects (Avg. rank change)			
	Existing	Scenario 1	Scenario 2	Scenario 3
10%	2	2 (Avg: 3)	2 (Avg: 6)	2 (Avg: 1)
20%	6	4 (Avg: -9)	6 (Avg: 2)	4 (Avg: -2)
30%	10	8 (Avg: -5)	9 (Avg: 3)	10 (Avg: -1)
40%	12	12 (Avg: -2)	12 (Avg: 5)	12 (Avg: 0)
50%	15	14 (Avg: -2)	15 (Avg: 4)	15 (Avg: 0)

Figure 4.1 shows the plot of the percentage of pedestrian and/or bicycle projects remained within each percentile considered for all three new scoring scenarios. The results showed that Scenario 1 had the greatest change in the 20th and 30th percentiles. In the 20th percentile only 4 of the 6 (66.67%) projects from the existing scoring were included in scenarios 1 and 3. For the 30th percentile only 8 of the 10 (80%) projects were the same as the projects from existing scoring for Scenario 1. The results from the change in the average rank for each percentile showed that the greatest change in Scenario 1 was noted in the 20th and 30th percentiles with the average of -9 and

–5. In Scenario 2 the greatest change was noted in the 10th and 40th percentiles with the average of 6 and 5. Scenario 3 had the lowest rank change in all quartiles.

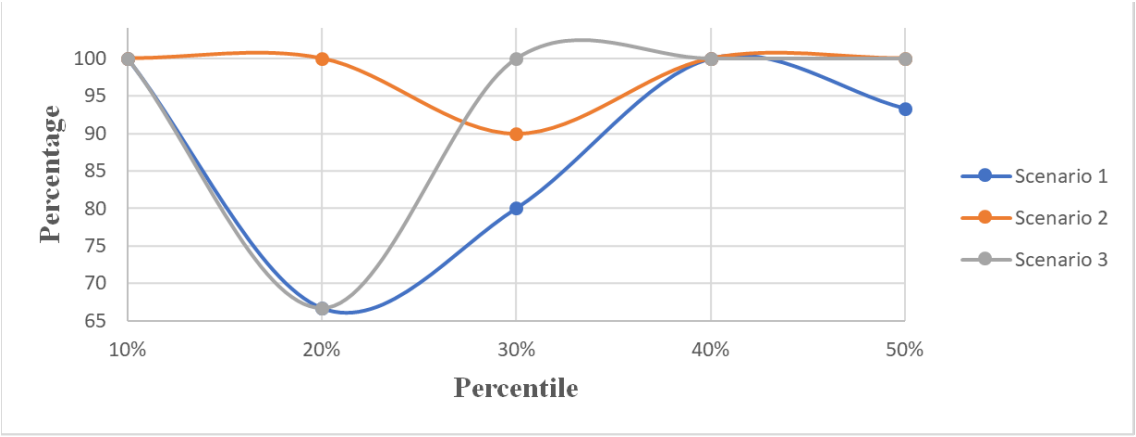

Figure 4.1 Change in Pedestrian and/or Bicycle Project Retention by Scoring Scenario; East Region

Table 4.10 shows the number of all projects for each Scenario using each percentile and denotes the overall average rank change.

Table 4.10 Number of Projects by Percentile for All Projects; East Region

Percentile	Number of Projects (Avg. rank change)			
	Existing	Scenario 1	Scenario 2	Scenario 3
10%	20	18 (Avg: -1)	17 (Avg: -1)	18 (Avg: 0)
20%	40	32 (Avg: -5)	35 (Avg: -3)	35 (Avg: -1)
30%	61	52 (Avg: -3)	53 (Avg: -2)	58 (Avg: 0)
40%	81	75 (Avg: -1)	76 (Avg: -1)	79 (Avg: 0)
50%	102	99 (Avg: 0)	100 (Avg: 0)	102 (Avg: 0)

Figure 4.2 plots the percentage of projects retained within each percentile and shows that Scenario 1 had the greatest change in the 20th and 30th percentiles. In the 20th percentile only 32 of the 40 (80%) projects from the existing scoring were included for Scenario 1, while 35 projects (87.5%) were included for Scenarios 2 and 3. For the 30th percentile, 52 of the 61 (85%) projects from the existing scoring remained in Scenario1 while more projects were included in Scenario 2 (53 projects) and Scenario 3 (58 projects). The results from the average rank change for each percentile showed that the greatest change in Scenario 1 occurred in the 20th and 30th percentiles with an average of -5 and –3. Scenario 2 had the greatest change in average in the 20th and 30th

percentile with an average of –3 and –2. Scenario 3 had the lowest rank change in all percentiles. Furthermore, for all three scenarios, the 50th percentile had an average rank change of 0.

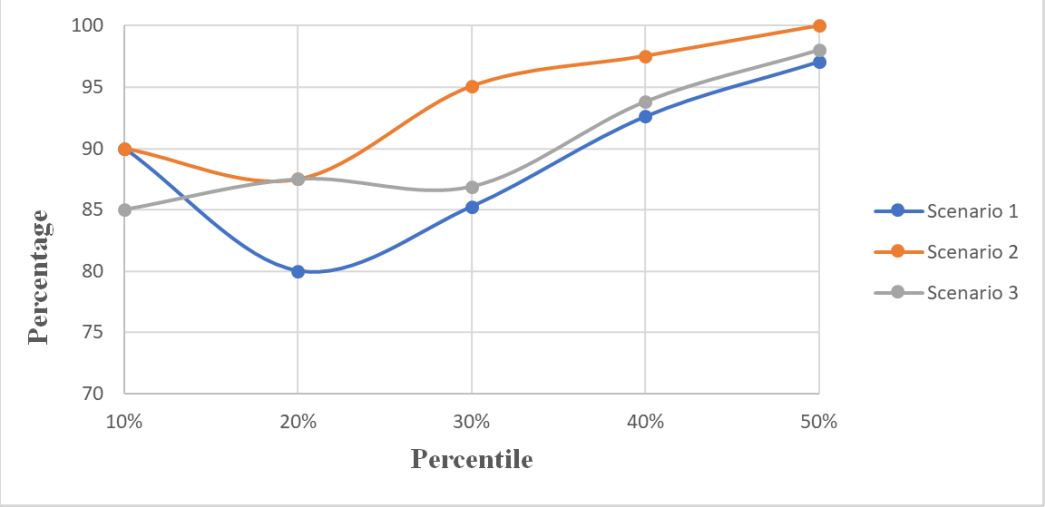

Figure 4.2 Change in All Project Retention by Scoring Scenario; East Region

4.3.2 North Region

The north region had a total of 388 projects including 136 projects that had pedestrian and/or bicycle improvements. The effects of each percentile considered on the number of pedestrian and/or bicycle projects for each scenario and their overall change in average rank are shown in Table 4.11.

Table 4.11 Number of Projects by Percentile for Pedestrian and/or Bicycle Projects; North Region

Percentile	Pedestrian and/ or Bicycle Projects (Avg. rank change)			
	Existing	Scenario 1	Scenario 2	Scenario 3
10%	15	12 (Avg: 2)	13 (Avg: 2)	14 (Avg: 3)
20%	32	29 (Avg: 4)	30 (Avg: 5)	30 (Avg: 4)
30%	54	53 (Avg: 13)	54 (Avg: 13)	54 (Avg: 7)
40%	77	74 (Avg: 13)	74 (Avg: 14)	74 (Avg: 6)
50%	102	100 (Avg: 12)	101 (Avg: 14)	101 (Avg: 5)

Figure 4.3 shows the percentage of projects retained within each percentile from the existing scoring method indicating that Scenario 1 had the greatest change in the 10th and 20th percentiles. In the 10th percentile, only 12 of the 15 (80%) projects from the existing scoring remained while in

the 20th percentile 29 of the 32 (90%) existing scoring projects were included in the new scoring. Scenario 2 had the greatest change for the 10th percentile retaining 13 of the 15 (85%) projects from the existing scoring. The results from the average rank change showed that the most change occurred in the 30th, 40th, and 50th percentiles for all three scenarios. The average rank change ranged between 5 and 14. The 10th and 20th percentiles had the lowest overall average for all three scenarios.

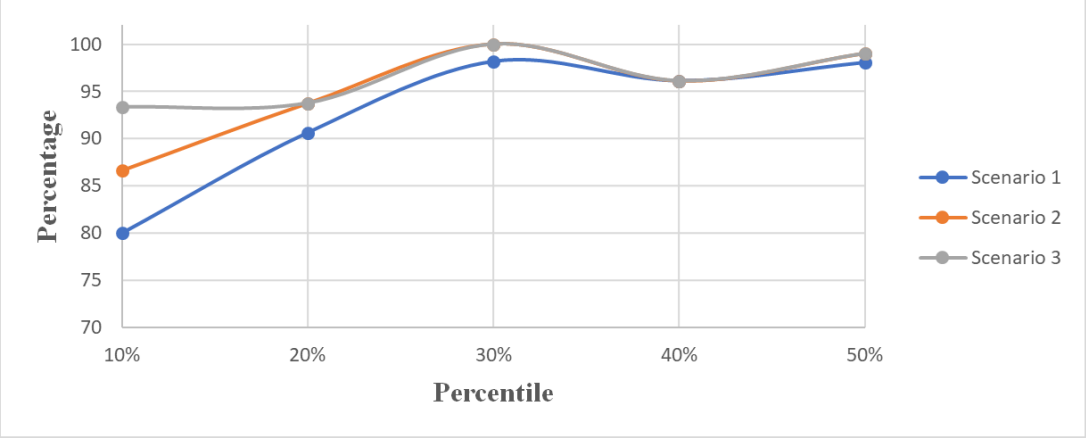

Figure 4.3 Change in Pedestrian and/or Bicycle Project Retention by Scoring Scenario; North Region

Table 4.12 presents the number of projects retained for each new scoring scenario as compared to the existing scoring method for each percentile and the overall average rank change.

Table 4.12 Number of Projects by Percentile for All Projects; North Region

Percentile	Number of Projects (Avg. rank change)			
	Existing	Scenario 1	Scenario 2	Scenario 3
10%	39	29 (Avg: -5)	31 (Avg: -4)	36 (Avg: -1)
20%	78	60 (Avg: -8)	61 (Avg: -7)	69 (Avg: -2)
30%	116	105 (Avg: -4)	106 (Avg: -4)	112 (Avg: -1)
40%	155	141 (Avg: -2)	141 (Avg: -2)	148 (Avg: 0)
50%	194	191 (Avg: -1)	191 (Avg: 0)	192 (Avg: 0)

Figure 4.4 depicts the percent change of all project retention as compared to the existing scoring method for each percentile. The data shows that Scenario 1 had the greatest change in the 10th and 20th percentiles. In the 10th percentile, 29 of the 39 (77%) projects in the existing scoring remained while for the 20th percentile 60 of the 78 (77%) existing scoring projects remained in the

new scoring. Scenario 2 had the greatest change for the 20th percentile retaining 61 of the 78 (78%) projects from the existing scoring. Scenario 3 had the least change in the number of projects retained for each percentile. The results from the average rank change showed that the most change occurred in the 10th, 20th, and 30th percentiles for all three scenarios. The average range change was –1 and -8. Furthermore, the 50th percentile for scenarios 2 and 3 had an average rank change of 0.

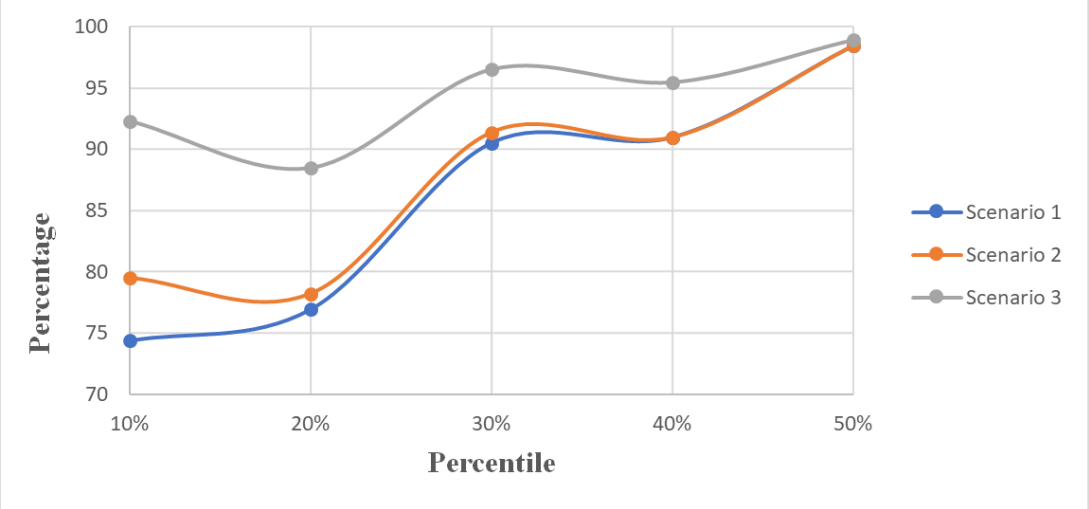

Figure 4.4 Change in All Project Retention by Scoring Scenario; North Region

4.3.3 South Region

The south region had a total of 245 projects including 25 projects that had pedestrian and/or bicycle improvements. Table 4.13 shows the number of pedestrian and/or bicycle projects for each Scenario and overall average rank change for each percentile considered.

Table 4.13 Number of Projects by Percentile for Pedestrian and/or Bicycle Projects; South Region

Percentile	Pedestrian and/ or Bicycle Projects (Avg. rank change)			
	Existing	Scenario 1	Scenario 2	Scenario 3
10%	6	6 (Avg: 0)	6 (Avg: 0)	6 (Avg: 1)
20%	9	9 (Avg: 0)	9 (Avg: 1)	9 (Avg: 0)
30%	10	10 (Avg: 1)	10 (Avg: 3)	10 (Avg: 1)
40%	16	16 (Avg: 8)	16 (Avg: 9)	16 (Avg: 3)
50%	18	18 (Avg: 8)	18 (Avg: 9)	18 (Avg: 3)

The data in Table 4.13 shows that for all pedestrian and/or bicycle projects were retained for all three scenarios for each percentile considered. The results from the average change in rank showed that the most change occurred in the 30th, 40th, and 50th percentiles for all three scenarios with an average rank change between 1 and 9. The 10th and 20th percentiles for all three scenarios had the lowest average rank change.

Table 4.14 shows the number of all projects retained for each Scenario compared to the existing scoring and overall average rank for each percentile considered.

Table 4.14 Number of Projects by Percentile for All Projects; South Region

Percentile	Number of Projects (Avg. rank change)			
	Existing	Scenario 1	Scenario 2	Scenario 3
10%	25	24 (Avg: -1)	24 (Avg: 0)	25 (Avg: 0)
20%	49	41 (Avg: -3)	42 (Avg: -2)	45 (Avg: 0)
30%	73	63 (Avg: -3)	64 (Avg: -3)	69 (Avg: 0)
40%	98	94 (Avg: -1)	94 (Avg: -1)	96 (Avg: 0)
50%	123	119 (Avg: 0)	120 (Avg: 0)	121 (Avg: 0)

Figure 4.5 shows the percent retention rate for each scoring scenario for the various percentiles considered. The graph shows that Scenario 1 had the greatest change in the 20th and 30th percentiles. In the 20th percentile, only 41 of the 49 (84%) existing scoring projects remained, while for the 30th percentile 63 of the 73 (86%) existing scoring projects were the same. Scenario 2 had the greatest change for the 20th percentile with 42 of the 49 (85%) existing scoring projects remaining. Scenario 3 had the least change in the number of projects for each percentile. The results from the average rank change showed that for scenarios 1 and 2 the most change occurred in the 20th and 30th percentiles with an average of -2 and -3. The average rank change for all three scenarios in the 50th percentile was 0. Furthermore, the average change in Scenario 3 for all percentiles was 0.

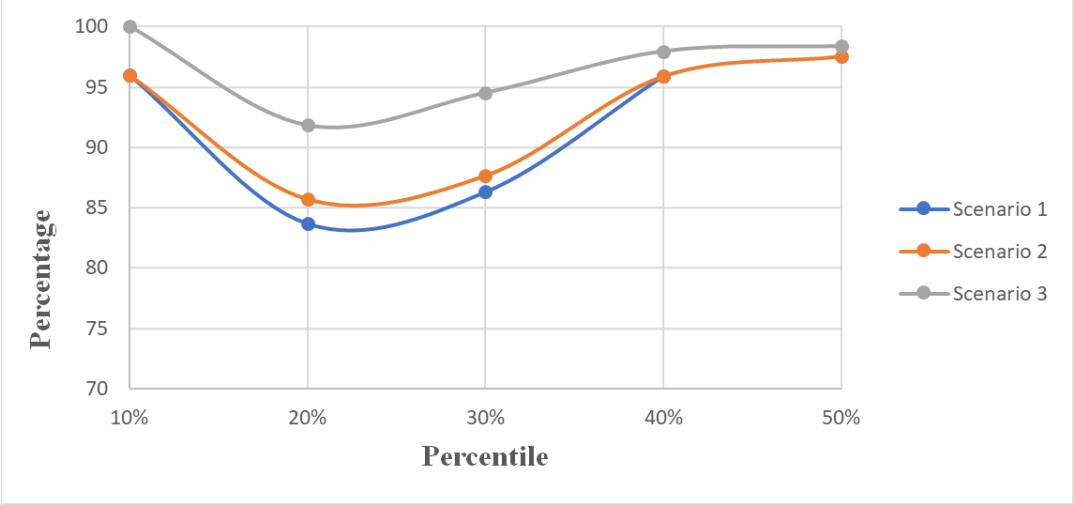

Figure 4.5 Change in All Project Retention by Scoring Scenario; South Region

4.3.4 West Region

The west region had a total of 293 projects including 69 projects that had pedestrian and/or bicycle improvements. Table 4.15 presents the number of pedestrian and/or bicycle projects for each Scenario retained as compared to the existing scoring and overall average rank change for each percentile.

Table 4.15 Number of Projects by Percentile for Pedestrian and/or Bicycle Projects; West Region

Percentile	Pedestrian and/ or Bicycle Projects (Avg. rank change)			
	Existing	Scenario 1	Scenario 2	Scenario 3
10%	12	11 (Avg: 1)	11 (Avg: 3)	11 (Avg: 2)
20%	25	21 (Avg: -1)	23 (Avg: 3)	23 (Avg: 1)
30%	34	33 (Avg: 3)	33 (Avg: 5)	33 (Avg: 3)
40%	43	42 (Avg: 8)	42 (Avg: 9)	43 (Avg: 5)
50%	54	53 (Avg: 8)	54 (Avg: 9)	54 (Avg: 5)

Figure 4.6 plots the percent retention rate for each scoring scenario as compared to the existing scoring for each percentile considered. The data shows that Scenario 1 had the greatest change in the 10th and 20th percentiles. In the 10th percentile, 11 of the 12 (92%) projects were from the existing scoring while for the 20th percentile 21 of the 25 (84%) projects were the same as the projects from the existing scoring. Scenario 2 had the greatest change for the 10th percentile with

11 of the 12 (92%) existing scoring projects remaining. The results from the average change in rank showed that the most change occurred in the 30th, 40th, and 50th percentiles for all three scenarios with an average rank change range between 3 and 10. For all three scenarios, the 10th and 20th percentiles had the lowest average rank change.

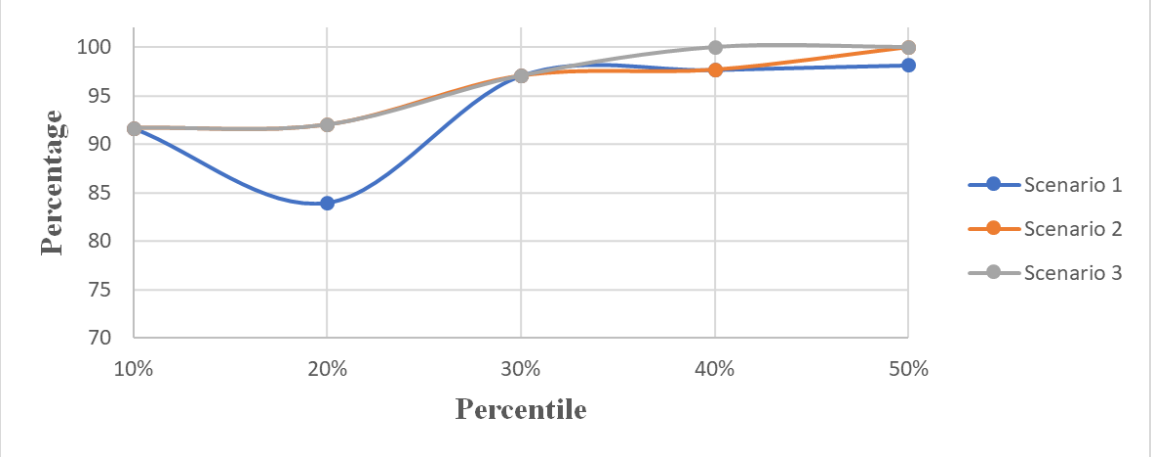

Figure 4.6 Change in Pedestrian and/or Bicycle Project Retention by Scoring Scenario; West Region

Table 4.16 shows the number of all projects retained for each Scenario compared to the existing scoring and overall average rank for each percentile considered.

Table 4.16 Number of Projects by Percentile for All Projects; West Region

Percentile	Number of Projects (Avg. rank change)			
	Existing	Scenario 1	Scenario 2	Scenario 3
10%	29	26 (Avg: -1)	24 (Avg: -2)	26 (Avg: -1)
20%	59	49 (Avg: -4)	52 (Avg: -3)	54 (Avg: -1)
30%	88	77 (Avg: -3)	77 (Avg: -3)	82 (Avg: -1)
40%	117	106 (Avg: -2)	106 (Avg: -2)	113 (Avg: -1)
50%	147	142 (Avg: -1)	142 (Avg: -1)	144 (Avg: 0)

Figure 4.7 shows the percent retention rate for each scoring scenario of the existing scoring for each percentile considered. The graph shows that Scenario 1 had the greatest change in the 10th and 20th percentiles. In the 10th percentile, 26 of the 29 (90%) projects were the same as those from the existing scoring while for the 20th percentile 49 of the 59 (83%) existing scoring projects were the same in the new scoring. Scenario 2 had the greatest change for the 10th percentile with 24 of

the 29 (83%) existing scoring projects remaining in the new scoring. Scenario 3 had the least change in the number of projects for each percentile. The results from the average change in rank showed that the most change occurred in the 20th and 30th percentiles for all three scenarios with an average rank change range between -1 and -4. The average change for Scenario 3 in the 50th percentile was 0.

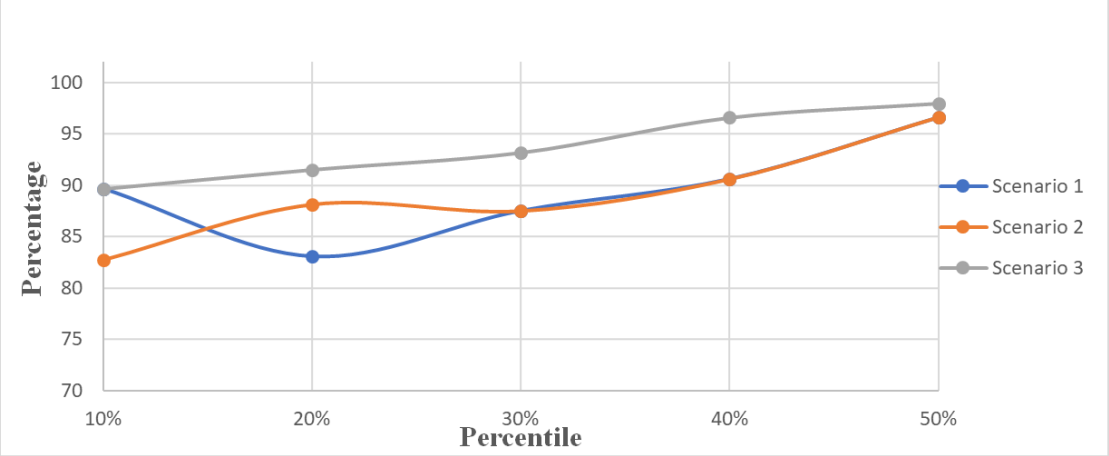

Figure 4.7 Change in All Project Retention by Scoring Scenario; West Region

4.3.5 Summary

The main purpose of this analysis was to identify which percentile had the greatest impact on all projects for the three new scoring scenarios. This analysis focused on determining the retention changes in all the projects as compared to the existing scoring method for the 10th, 20th 30th, 40th, 50th percentiles for each region and each scenario. A greater emphasis was placed on identifying the percentiles where the most changes occurred for each of the new scoring scenarios.

The analysis of all 4 regions for pedestrian and/or bicycle projects and all the projects showed that the greatest change (i.e., lowest retention of projects from the existing scoring method) occurred in the 10th, 20th, and 30th percentiles. For pedestrian and/or bicycle projects in the East, West, and North regions the greatest change occurred in the 10th and 20th percentiles. The South region retained all pedestrian and/or bicycles from the original scoring in all percentiles for all three scenarios. For all projects, most of the changes for all regions and scenarios occurred in the low

percentiles, i.e., 10th, 20th, and 30th percentile. The least changes happened in 40th and 50th percentile for all 4 regions, where frequently 95% or more of the projects were the same as those from the original scoring method.

The analysis of the average rank change showed that for pedestrian and/or bicycle projects the greatest change for all three scenarios occurred in the 30th,40th, and 50th percentiles, while the 10th and 20th percentiles had the lowest rank change. For all projects, i.e., the greatest average rank change for all three scenarios occurred in 10th, 20th, and 30th percentile and lowest in the 40th and 50th percentiles. The results showed that in the 50th percentile for all projects in all four regions and for most of the scenarios the average rank change was 0.

CHAPTER 5. SUMMARY AND DISCUSSION

5.1 Conclusion

There is a need to provide adequate and safe pedestrian and bicycle facilities in the state of Kentucky to allow people to have modal choices for completing their mobility needs. To increase the number of pedestrian and bicycle facilities and to grow the number of people using those facilities, there is a need to prioritize and fund those projects. The Kentucky SHIFT program is a data-driven approach that evaluates and prioritizes projects in the state, but its focus is auto-centric. The purpose of this study was to develop and evaluate a scoring approach that could be implemented into SHIFT and aid in the prioritization of the pedestrian and bicycle projects.

The literature review facilitated the identification of potential scoring approaches that other DOTs are using and provided the basis for the approach considered here. The SHIFT– 2022 pedestrian and bicycle projects were utilized in evaluating different scoring scenarios. Scores for pedestrian and/or bicycle projects were developed for the existing facilities and the proposed facility type separate for each mode. A composite score was developed by subtracting the score of the proposed type from the existing facility score. Three scoring scenarios were evaluated, and they were as follows:

1. Pedestrian project 5 points; Bicycle project 5 points; MPO boost 15 points; District boost 5.
2. Pedestrian project 5 points; Bicycle project 5 points; MPO boost 10 points; District boost 10.
3. Pedestrian project 2.5 points; Bicycle project 2.5 points; MPO boost 15 points; District boost 10.

In this study, three analyses were conducted to identify the impact of each scenario on project selection as well as the scenario that would have the most positive impact on pedestrian and bicycle projects. Since the number of projects to be selected is unknown, it was decided to assume first that

50% of the projects in a region could be funded and then considered different percentiles of projects selected for funding. The analysis was conducted at the region level.

The first analysis focused on identifying the impact of each scenario on pedestrian and bicycle projects by comparing the existing rank (i.e., within the top 50% of the projects in a region) of these projects with the rank they will have within each of the scenarios. This analysis showed that for three regions, scenarios 2 and 3 had the largest number of projects in the top 50% of the projects retained from the existing approach. Whereas, Scenario 2 had the largest number of projects that ranked higher than in the existing ranking. The total average rank change was higher in Scenario 2 than in the other scenarios for all four regions ranging from 4 to 14. Moreover, when the projects just ranked with Scenario 2, additional pedestrian and/or bicycle projects get to the top 50% for three out of 4 regions. (i.e., not compared to the existing rank).

The second analysis was like the first one, but it focused on analyzing all projects in the top 50% of the regional projects. The results showed that Scenario 2 in the east, north, and south had the greatest number of projects that got higher rank when the new scenario was used in comparison to the existing rank. Scenario 3 always had the greatest number of projects in the top 50% of the existing method in all four regions. It should be noted that for almost all regions and all scores the average rank change was 0.

The third analysis was conducted assuming that different percentages of projects would be selected and examined the potential impact of selecting 10%, 20%, 30% 40%, or 50% of the projects to be funded. This analysis showed in which percentiles there has been the greatest impact on the pedestrian and bicycle projects as well as all projects. The results showed that for pedestrian and/or bicycle projects and all the projects for all four regions and all three new scoring scenarios the most change (i.e., lowest retention of projects from the existing scoring method) occurred in the 10^{th}, 20^{th}, and 30^{th} percentile. The least changes occurred for the 40^{th} and 50^{th} percentile, which means that most of the projects from the existing scoring stayed in the top 40% and 50% of the new scorings.

The analysis of the average rank change showed that for pedestrian and/or bicycle projects the greatest change for all three scenarios occurred in the 30th, 40th, 50th percentiles, while the 10th and 20th percentile had the lowest rank change. For all projects, the greatest average rank change for all three scenarios occurred in 10th, 20th, and 30th percentile while the lowest occurred in the 40th and 50th percentiles. The results also showed that in the 50th percentile for all projects in all four regions and for most of the scenarios the average rank change was 0.

The sensitivity analysis indicates that Scenario 2 is the most beneficial to the pedestrian and/or bicycle projects. Scenario 2 showed the greatest influence on those projects (i.e., the greatest number of projects remained in the top 50%). The scoring approach for Scenario 2 reduced equally both the MPO and District boosts assigning them a score of 10 points out of original 15. This created a more balanced score distribution. Scenario 3 only had total of 5 points allocated to pedestrian and/or bicycle projects, which showed almost no change in rank order of the projects. The score distribution for MPO and District boosts for Scenario 1 was not balanced. MPO boost retained all 15 points from the existing method whereas the District boost only retained 5 points. That created an unbalanced distribution of points which led to Scenario 1 having the largest number of projects in most regions that scored lower in the new scenario when compared to existing rank as well as it always had the largest average rank decrease.

5.2 Study Limitations

This study has some limitations that should be addressed in the future. The first limitation was due to the lack of information regarding what type of pedestrian and/or bicycle facilities would be implemented for the projects that were marked as having pedestrian and/or bicycle improvements. The project documents provided had minimum to no project description on what type of pedestrian and /or bicycle facility will be implemented on the project corridor. This limitation required assumptions on what potential projects could be implemented for each project and this could be completely different than what the original proposed may have had in mind. It must be noted that all assumptions were based solely on the research team's understanding of the

project, review of the project corridor, and suggestions from KYTC representatives. Moving forward, it was recommended to develop a system where project proposers will provide specific information and allow for a more objective scoring of the proposed facility type.

This limitation resulted in many projects that got a score of zero due to not being able to properly determine the proposed project facility and thus assume that some of the projects did not have any pedestrian and/or bicycle facilities implemented. Out of 248 pedestrian and/or bicycle projects, 56 scored zero for both scoring approaches as those projects did not have any existing facilities and no proposed pedestrian and/or bicycle improvements were identified. The lack of those project scores and the lack of proper description of each project might have influenced the outcome of this study.

The scoring approach used here, i.e., subtracting the existing facility score from the proposed project type which does not allow for differentiating between those projects that have no facilities and projects that replace existing facilities in-kind since both receive an equal score (i.e., zero for both). This places a disadvantage of the projects that in essence replacing the facilities in kind.

Another limitation that occurred while completing this study was the lack of information on project potential. Originally, three scoring approaches (i.e., proposed project type, existing facilities, and project potential) were developed to capture all the potential importance of pedestrian and bicycle projects. Unfortunately, due to lack of information on project potential, this scoring approach had to be eliminated until more information can be found. This scoring approach was focusing on identifying the future developments, future density increase, information about surrounding areas, nearby attractions, and possible origins/destinations. This scoring approach would possibly provide more importance to those projects that have the greatest potential for pedestrian and bicycle users such as existing/future shopping centers, parks, job locations, grocery/

local stores, markets, etc. It is possible that those projects would have got a higher score because of its potential benefits to pedestrian and bicycle community.

5.3 Future Work

This study evaluated three new scoring scenarios that could potentially be used in SHIFT–2024 and recommended Scenario 2 for inclusion. Future work should utilize the recent development of specific project types so that will eliminate the missing information for all the projects and the proposed project type is specified. This will provide the most accurate results and will show which scenario has the most benefits to pedestrian and/or bicycle projects if there is further need for scoring evaluations. The second suggestion is to potentially create a protocol of what must be included in each project description. That will allow to review those projects without having to make assumptions about what has been planned to be implemented for this project and why this project was marked as pedestrian and/or bicycle project. Once proper documentation is obtained and project types are defined, then it would be beneficial to reexamine these three scoring approaches and determine which one may be more appropriate.

The third suggestion is to potentially continue with the study of the third scoring approach (i.e., project potentials) as it might discover more benefits to pedestrian and bicycle users for some of the projects. It might be more beneficial to use all three scoring approaches when evaluating a final score for each project as it might give an extra score to those projects that maybe did not have any existing facilities already but have a lot of attractions in the project corridor that people can walk or bike to. Some potential ways of getting the projects' potential are to contact county government to identify if any potential developments will be done on the specific project corridor, use U.S Census Data to get information on density and population of that project corridor, and possibly complete a travel demand model to identify trip generation, trip distribution, mode choice and route assignment for that project corridor.

The fourth suggestion is to potentially reexamine the three scenarios with a different scoring approach (i.e., addition of proposed project type and existing facilities). For this study the

two scoring approaches were proposed: project type and existing facilities. To calculate the score of each project, the existing facilities score was subtracted from the proposed project type. As was discussed in this study, it was assumed that if the project does not have any proposed project type, the score for this project is zero. Moreover, it was assumed that at a minimum, each project will replace the existing facilities already in place, which still will result in giving a zero for this project. To avoid not prioritizing those projects that already have some type of pedestrian and/or bicycle facilities, it is suggested to reexamine the three scoring scenarios by using the addition method (Proposed project type + Existing facilities). The maximum score that each project can get by using addition method is 10 points. To keep the score consistent, it is suggested to divide the score by 2 which will keep the score consistent with the 5-point system that has been developed for the three scenarios. By using the addition method, potentially fewer projects will get a score of zero as if the project has already some type of existing facilities since that score will be averaged assuming that no proposed project type was assigned. This potentially can provide a larger data set as more projects will have a score to test the three scenarios.

The fifth suggestion is to potentially reduce the score weights of the five elements (i.e., safety, asset management, economic growth, congestion, and benefit cost ratio) by 2 points each instead of reducing MPO and District boosts. This will still allow for allocating 5 points for pedestrian and 5 points for bicycle projects. MPO and District boosts are responsible for providing additional point increase for each project and "boost" them to have a higher chance of being funded. When the points are taken from the MPO and District boosts, the projects lose these additional scores and may have a lower total score with the new scoring system than when was scored with the existing scoring system. To avoid decreasing the projects boosts and projects having lower scores, it is suggested to take 2 points from each of the five elements to allocate to pedestrian and bicycle projects. By taking points from the five elements, the boosts scores will be still given to each project to assure the proper accommodation of the issues occurring in the area.

REFERENCES

BBC Research & Consulting (2016). *Economic and Health Benefits of Walking and Biking*. https://www.codot.gov/programs/bikeped/building-a-bike-ped-friendly-community/bike-walk-study/assets/report-economic-and-health-benefits-of-bicycling-and-walking-in-colorado-2016-report

Bhattacharya, T., Mills, K., J. D., & Mulally, T. (2019). *Active Transportation Transforms America: The Case for Increased Public Investment in Walking and Biking Connectivity* https://www.railstotrails.org/media/869945/activetransport_2019-report_final_reduced.pdf

Kittelson & Associates, Inc. (2019). *Evaluating Bicycle and Pedestrian Quality of Service*. https://planhillsborough.org/wp-content/uploads/2019/04/Bicycle-Pedestrian-Evaluation-Final-Report_March-2019.pdf

KYTC. (n.d.). *Strategic Highway Investment Formula for Tomorrow.* https://transportation.ky.gov/SHIFT/Pages/default.aspx

KYTC. (n.d.). *Kentucky Laws and Regulations for Pedestrians*. https://transportation.ky.gov/BikeWalk/Documents/Kentucky%20Laws%20and%20Regulations%20for%20Pedestrians.pdf

KYTC. (2016). *Kentucky Laws and Regulations for Bicycle Travel*. https://transportation.ky.gov/BikeWalk/Documents/KY%20Laws%20and%20Rules%20for%20Bicycle%20Travel_updated_2016.pdf

KYTC. (2022a). *Complete Streets, Roads, and Highways Manual*. https://transportation.ky.gov/BikeWalk/Documents/Complete%20Streets,%20Roads,%20and%20Highways%20Manual.pdf

KYTC. (2022b). *Complete Streets Policy* https://louisvilleky.gov/public-works/document/complete-streets-ordinance-2022

KYTC. (2022c). *Bicycle and Pedestrian Master Plan*.

Lagerwey, P. A., Hintze, M. J., Elliott, J. B., Toole, J. L., & Schneider, R. J. (2015). *Pedestrian and bicycle transportation along existing roads - ActiveTrans priority tool Guidebook.* https://planhillsborough.org/wp-content/uploads/2019/04/Bicycle-Pedestrian-Evaluation-Final-Report_March-2019.pdf

Litman, T. (2022). *Evaluating Active Transport Benefits and Costs*. https://www.vtpi.org/nmt-tdm.pdf

NACTO. (2016). *Highw-Quality Bike Facilities increase Ridership and Make Biking Safer.* Retrieved from https://nacto.org/2016/07/20/high-quality-bike-facilities-increase-ridership-make-biking-safer/

NCDOT. (2019). *Prioritization 6.0 Scoring Criteria, Weights, and Normalization for All Modes* Retrieved from https://connect.ncdot.gov/projects/planning/MPORPODocuments/P6.0%20Scoring%20Overview%20for%20BOT%206-6-2019.pdf

Perrin, R., Huff, B., Flynn, M., Brown, C., & Vinyl, C. (2021). *Practices for Selecting Pedestrian and Bicycle Projects*. https://doi.org/10.17226/26177

USDOT. (2010).*The National Bicycling and Walking Study: 15-Year Status Report*. Retrieved from https://www.pedbikeinfo.org/cms/downloads/15-year_report.pdf

VDOT. (2021). *SMART SCALE Technical Guide*. Retrieved from https://smartscale.org/documents/2020documents/technical-guide-2022.pdf

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