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An Analysis of the Los Angeles Metropolitan Transportation Authority's Ability to Achieve Sustainability as Defined by the Transportation Index for Sustainable Places

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Creating a Sustainable Transportation Network: An Analysis of the Los Angeles Metropolitan Transportation Authority's Ability to Achieve Sustainability as Defined by the Transportation Index for Sustainable Places

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Chapter 1: Introduction, Background, and the Transportation Index for Sustainable Places Index (TISP)

An Introduction to Transportation in the United States and Methods for Evaluation Under TISP

Introduction

The purpose of this paper is to evaluate transportation programs put in place by Los Angeles County and determine whether or not they address the three domains of sustainability outlined by the Transportation Index for Sustainable Places (TISP). Following sections include a background on current emissions and impacts of transportation within the United States, descriptions of three different pieces of LAMTA's efforts to create a sustainable transit network, and analysis of these pieces to adhere to the TISP criteria.

Transportation is a very important aspect of everyday life, dictating one's livelihood and the activities that one is able to accomplish. When buying a new house or moving to a new country, state, or city, transportation options are always considered. For example, one may ask him or herself: Is this a location that has easy access to shops, stores, restaurants, and the workplace? This often requires an analysis of both private and public transportation options. This is especially true for a high-density urban area. For example, in a city environment, it is much more likely that commuters will be using forms of public transportation like the bus, train, or subway system. Planning life around the availability of services like this is critical and will only become even more important as development continues. With continued development, climate change considerations will dictate the direction that this development should take. This is especially true for transportation infrastructure as there is great potential for the sector to minimize impacts in the form of reduced emissions of greenhouse gases (GHGs) and, more specifically, carbon dioxide and reduced ecological impacts.

Background

Reductions in emissions have been achieved through the implementation of greater public transit by a reduction in overall vehicle miles traveled (ICF International 2008). Therefore, reducing the number of people who use their own vehicles to commute to work daily would eliminate the pollution their vehicles would have contributed. The American Public Transportation Association estimated that one individual switching his or her commute (assuming 20-miles round-trip) to public transit in one day could reduce their CO_2 emissions by 20lbs, or 4,800lbs in one year (2007). It was found that between 1990-2011 all transportation accounted for 27 percent of GHG emissions, only second to industry at 28 percent of GHGs (EPA Fast Facts 2013). This number includes all forms of transportation and not only direct emissions from the transportation itself but also emissions associated with electricity used for the purpose of transport. These numbers include these sectors of transportation: on-road vehicles, aircraft, ships and boats, rail, pipelines, and lubricants.

Passenger cars are defined as automobiles used primarily to transport fewer than 10-passengers. The total amount of these emissions of GHGs add up to 852.8Tg CO_2 equivalent (E) and more specifically total emissions of carbon dioxide from these sources amount to 821.2TG CO_2 E. The GHG emissions from transportation are mostly emissions of CO_2. Passenger cars are responsible for the majority of the emissions coming from these types of transport in urban areas (Chavez-Baeza 2013). Passenger cars are responsible for 787.4Tg CO_2 E of the total for these types (EPA Fast Facts 2013). Furthermore, passenger cars are responsible for 759.0Tg CO2 E of the total of CO_2 emissions coming from those sources. Thus, passenger vehicles are responsible for the greatest contribution to climate change in transportation. In comparison, buses and rail emissions are miniscule, totaling only 62.2Tg CO_2 E for the total of CO_2 emissions from those sources (EPA Fast Facts 2013).

Potentials for GHG reductions and sustainable mass transit systems will be further discussed, analyzed, and evaluated in this paper. This evaluation will determine the ability of Los Angeles (LA) transit policy and projects to adhere to the sustainability criteria put forth by the TISP. More specifically, this paper will focus on the environmental domain within the index. TISP will be further introduced and explained within the methods section of this paper. Ultimately, the purpose is to provide an evaluation of specific transit policies and projects to create the most sustainable transportation network within the city of LA. The TISP will be used to evaluate mass transit within LA, aiming to provide opportunities for the Los Angeles Metropolitan Transit Authority (LAMTA) to alter and improve existing policy and plans to adhere more closely to sustainability metrics. The Los Angeles' Metro Countrywide Sustainability Planning Policy & Implementation Plan (LAMSPP) will be presented and evaluated along with a direct analysis of the Regional Connector Transit Project (RCTP) and then recommendations will be made for further research.

<u>Los Angeles County</u>

Los Angeles County has a population of 10.02 million and is 4,850 sq. miles (U.S. Census Bureau 2009). LA County is the most populous in the United States (U.S. Census Bureau 2009). High population can cause a number of issues, but one that is very well known in LA County is that of congestion. The region of LA has the most severe traffic congestion in the

United States (Sorensen 2008). According to the 2009 American Community Survey, 84 percent of commuters in the Los Angeles-Long Beach-Santa Monica area commute to work in their own vehicles (U.S. Census Bureau). Of the remaining amount of commuters who do not commute with their own private vehicles, only 6.2 percent use public transit (American Community Survey, U.S. Census Bureau 2009).

In comparing the percentage of those who take private vehicles versus those who take public transit, it becomes clear as to why congestion is such an issue in LA. LA does have existing transit lines, but, as shown, they are not being utilized enough to reduce congestion within the city. Sorensen (2008) presents potential reasons for these under-utilized transit systems: lack of investment in a world-class transit network, the extreme complexity of the political system, complex jurisdictions, and the polycentric nature of LA. Worthy of further exploration is the fact that LA has a polycentric nature. Polycentric, as defined by Sorensen, is a reduction in the density of activity in a single location; this translates into limited use of transit lines (2008). LA's polycentric development means that more than one trip is necessary for an individual to complete daily errands. In LA, transit is not the most appealing option for providing the best options for multiple trips because public transit is typically slower than traveling by car (Sorensen 2008). Even though adding highways will provide some relief from issues of congestion, it will not offer any environmental benefits. Instead of adding highways and roads in areas already stretched for space, it is time to look towards other options for relieving congestion that also contribute to reducing the environmental impact of transportation.

Air pollution is a well-known negative externality of increased car use in the world and it is extremely prominent in LA. With such high private transportation use in LA it follows that there would be negative environmental consequences. In 2011, there were 105 days with an Air Quality Index (AQI) over 100 in the Los Angeles-Long Beach-Anaheim area [U.S. Department of Transportation, Bureau of Transportation Statistics 2014]. Continuous use of private transportation has undoubtedly contributed to air pollution above 100 AQI. LA has the highest number of days over 100 AQI than almost any other area in CA; only Riverside-San Bernardino has a higher number at 121 days over 100 AQI. It is for these reasons that LA presents itself as a perfect candidate in need of sustainable transportation, to provide a solution to congestion and prevent further air pollution. An evaluation of their current sustainability plan, policy, and projects will determine if the city is poised to sufficiently tackle the task of implementing a sustainable transit network under the TISP index.

The majority of LA uses private transportation to get around due to the lack of a transit network that meets all of the needs of the population. Public transport should aim to meet the needs more adequately and provide the transportation necessary for hundreds of thousands of people to commute both in and out of the city every single day. This is just one very important benefit of public transport; another very important and increasingly important in recent decades is its ability to reduce the amount of pollution that transportation contributes to. Transporting a massive number of individuals who would otherwise be using their own private vehicles greatly decreases the number of vehicles on the road and reduces the emissions of GHGs into the atmosphere (SAIC 2007). If no transit service existed, and everyone commuted with his or her own personal vehicle, the total amount of carbon emission would be at an extreme high of 16.2mmt of CO_2 (SAIC 2007).

There are a number of commuters who either walk or bike to their places of work and, thus, are using forms of transport that have even less of an impact on the environment. In LA, 0.86 percent of commuters bike to work and an even greater amount, 2.63 percent, walk to work (American Community Survey, U.S. Census Bureau 2009). While these are not extremely significant values in comparison to the number of those who commute by private vehicle, the number of commuters who are biking specifically has grown 67 percent from 2005 to 2012 (The League of American Bicyclists 2014). In the world, the number of bike trips has risen from 1.7 billion in 2001 to 4 billion in 2009, more than double the trips (2009). This is significant growth in bicycle ridership and represents an additional shift towards cleaner forms of transportation. While this paper will not discuss these forms any further, they represent other important alternatives to private vehicle use and options for reducing pollution from transportation.

Public transportation in the form of buses and rail contribute very little to emissions of CO_2 and for this reason it is a viable solution for reducing emissions. If use of passenger cars can be reduced through increases in public transportation, then CO_2 emission reductions could be realized (SAIC 2007). As reported by the American Public Transit Association (APTA) public transportation has played an extremely important role in reducing national energy use and GHG emissions (2014). Further, more than 4 billion gallons of gasoline are saved, which translates to an avoidance of 37 million metric tons of carbon dioxide emissions (American Public

Transportation Association 2014). These reductions result from a number of savings: reduction from the substitution of private transit with public transit, the reduction in fuel use by public transit vehicles, congestion reductions overall, and reductions due to reduced travel distance. In order for these benefits to continue to be realized it is critical that the entire system is sustainable.

However, it is not as simple as determining that public transport is the solution; there are many more characteristics that must be considered. For example, while public transportation is beneficial because its emissions are low, it can be highly crowded, underfunded, and slow to adapt to existing transportation needs. In order to sustain the benefits of increased use of public transportation, these systems must address these weaknesses. There are plenty of opportunities for improvements in Los Angeles' current transit network. If done correctly these transit agency plans should address the areas of sustainability that are set forth by the TISP.

The Transportation Index for Sustainable Places (TISP)

This paper will evaluate future transportation plans set forth by LAMTA. Evaluation will be for the purpose of determining the relative sustainability of the Metro Countywide Sustainability Planning Policy and Implementation Plan and the planned Regional Connector Transit Project as it adheres to the 4 environmental criteria set forth in the TISP index. The TISP index was developed by Jason Zheng to provide the appropriate metrics for planning and developing policies that create sustainable transportation networks. This index presents important factors and criteria that can inform transportation management and infrastructure decisions (Zheng 2013). Currently, a widely recognized standard of indicators for sustainable transportation does not exist in the U.S. The TISP index offers metrics of measurement for determining the true sustainability of either an existing or planned policy project, informing decisions on recommendations, adjustments, and future projects (Zheng 2011). The TISP framework was originally used to evaluate the sustainability of an entire state's transportation system. Methods used here will evaluate transit systems in the same way but at a local level, in the county of Los Angeles. This will allow results of the evaluation to provide more accurate representations, as it will not be averaged over a number of different cities in one state.

Criteria of evaluation fall into one of three domains: social, economic, or environment. Zheng, the creator of TISP, considers three domains that must be addressed to consider a transportation plan or system sustainable under the TISP index (2011). Each of the three domains contains further elements that define what should be addressed. There are 12 elements total, four within each domain. The index's measures include elements that can be both quantitatively and qualitatively analyzed. Each element is further broken down into indicators to determine a quantitative data for those particular elements. This paper will focus on a qualitative evaluation on the environmental domain of the TISP, as the data to do quantitative measurements for the County of Los Angeles is not readily available for the policy plan and project studied.

The environmental domain focuses mainly on the type of fuels being used for the transportation system. Environmental sustainability of a system will be evaluated on the following criteria; these are taken directly from Zheng's publications on TISP:

1. Minimize consumption of renewable & non-renewable resource for transportation
2. Transportation system is designed to maximize land-use efficiency
3. Minimize transportation system's impact on ecological systems
4. Limit transportation related wastes and pollution

The environmental domain elements can be evaluated quantitatively if measures of reductions and/or changes of these elements are readily available. Transportation systems that aim to change from conventional fuels to cleaner fuels will contribute positively to the sustainability measure. Maximization of land-use can be determined through the ability of the plan to create the most efficient route over the area in which it serves. This will be evaluated through the use of visuals and deciphering if the routes go in the direction that is most direct. Impacts on ecological systems will be more difficult to measure. However, if transportation routes are closer to ecologically sensitive areas they will be determined to contribute negatively to the sustainability of this domain. Waste and pollution reductions and limitations can be quantitatively evaluated. Systems that integrate new waste and pollution reduction strategies that were not previously implemented would create a more environmentally sustainable system.

Assessing the four criteria above will help determine the relative sustainability of the transit plan, policy and project in LA. Areas of improvement will be noted as well as areas where improvement is not needed. Comparisons will not be made, as there are other confounding factors that could prevent one particular city from attaining the same type of system as another. LAMTA's sustainability plan, policy and project will be presented and evaluated on each criterion. Improvements will be discussed as they pertain to each criterion. Recommendations for future programs will be given based on the areas of weaknesses within the current plan, policy and project.

Chapter 2: Los Angeles County Metropolitan Transportation Authority (LAMTA)

Transportation Plans, Policies, and Project Descriptions

Los Angeles Metropolitan Transportation Authority (LAMTA) Plans

LAMTA has enacted a number of plans to follow through with achieving a sustainable transportation system within the region. This section will describe the Sustainable Rail Plan, the Los Angeles Sustainable Implementation Plan, and the Regional Connector Transit project. Each contributes to a sustainable transit network within the region. These descriptions act to inform the TISP analysis that follows these descriptions.

Sustainable Rail Plan (SRP)

In May of 2013, LAMTA enacted the Sustainable Rail Plan (SRP). The SRP aims to reduce consumption of energy from rail operations in tandem with the Energy Conservation and Management Plan (ECMP), which was enacted by the LAMTA in September 2011. LAMTA's plan aims to implement sustainable strategies and by doing so, "maximize the efficiency, access, safety and performance" of the existing transit system in that Los Angeles (Sustainable Rail Plan 2013). The plan also aims to minimize energy use, consumption, pollution, and waste generation. As of 2013, LAMTA has spent $33 million on electricity to contribute to creating a transportation system that is sustainable. $21 million was spent on propulsion of heavy and light-rail and $12 million was spent on facility operations (Sustainable Rail Plan 2013).

The ECMP addresses energy consumption within the entire metro network in LA, while SRP focuses solely on options for energy reduction technology within existing rail lines, specifically related to the equipment and operations (Sustainable Rail Plan 2013). These operations have to do more specifically with vehicle propulsion and strategies for improved management of propulsion systems. Additionally, the SRP builds upon plans within the LASIP and serves as a supplement for pursuing energy goals outlined within the LASIP. Thus, the SRP informs LAMTA on the best options for reaching energy consumption and reduction goals as outlined by already existing policies and plans. Projects have already been developed with the intention of using these suggested forms for greater energy efficiency. Wayside storage systems will be used at the Red Line's Westlake/Macarthur Park station and a 1MW flywheel system will be added to the Gold Line in Highland Park. These forms of technology will be described in detail in coming sections. To determine the best strategies for recommendations various energy saving options were simulated on the existing Gold Line alignment from Union Station to Sierra Madre. Energy savings will be realized but the best options will be determined through analysis of efficiency and cost-effectiveness (Sustainable Rail Plan 2013).

The plan emphasis different technologies for achieving energy efficiency to reduce consumption and explains the trade-offs and challenges with each. LAMTA provides recommendations based on their own evaluations of these technologies. Technology evaluations within this section are all highlighted within the SRP itself as a way to inform future decisions for the best energy efficiency technology. This section is simply a description of what is included within the SRP. The actions of LAMTA directly feed into reducing current consumption of the sources of energy the system currently uses. Energy efficiency strategies are proposed as potential opportunities for reducing energy consumption. Different energy sources and sinks are identified as opportunities for reducing the consumption of energy. Potential options for energy storage and capture are explored for increasing the efficiency of the current transit system, which would address the issue of losses of energy throughout the rail system.

For increasing efficiency a number of different options include: flywheels, batteries, increasing onboard storage, wayside energy storage substations, reducing vehicle weight, and changing vehicle operations. Flywheels are an option that can provide a great storage opportunity to increase the energy that can be utilized by the vehicle. Flywheels capture energy when a vehicle breaks and then generates energy during discharge. This will create additional energy for the system; it is also a lightweight system in comparison to the amount of energy that it could potentially create. However, these types of systems are best suited for wayside storage, because, if placed within the vehicle, they could interfere with vehicle movement and operations of the vehicle.

Batteries are another option explored in the SRP for potential energy storage implementations. However, like flywheels, batteries would be a more suitable option in wayside storage substations because of the size. In order for batteries to be a useful storage option they must be able to store a significant amount of energy. To store this significant amount would require a large size battery, which could not feasibly be placed onboard the transit vehicles. For this reason, batteries can be costly if it is decided to begin maintenance and work on a wayside substation to support batteries. In order to successfully implement these alternative forms of storage, costs would be incurred.

Certain on-board systems use technologies to reduce the amount of electricity used while the train is running. These can result in a 15% reduction in electricity used by the system but this reduction will differ between systems (Sustainable Rail Plan 2013). On-board systems are subject to more variability in terms of effectiveness because their ability to reduce electricity use depends on the particular operations of the vehicle (Sustainable Rail Plan 2013). For example, the amount of time that the rail car spends in transit, breaking, and in the station all have impacts on how effective certain technologies will be. On-board systems could therefore be extremely effective in some systems but not in others. Another beneficial opportunity of on-board storage systems is the ability to reduce energy loses and the need for energy demanded from substations, which will cut costs associated with losses and substation generation. Further, reductions in costs are realized because there is no requirement for additional maintenance on the area.

However, disadvantages could potentially outweigh the benefits. It can be difficult to install on-board storage systems because of the potential impacts it could have on vehicle movement. On-board storage also makes the vehicle heavier, which not only impacts vehicle movement but will also increase the weight of the vehicle. Increased vehicle weight means that in order to do the same trip more energy is needed. Thus, when exploring on-board options for energy storage it is crucial to understand the trade-offs that exist in choosing certain sustainable strategies over others.

All of the improvements discussed thus far have to do with system-related energy storage and improving energy efficiency. Other options for reductions of energy storage exist in reducing other operations of the vehicles themselves. The biggest opportunities here deal with the heating-ventilation-air-conditioning (HVAC) systems, lighting, and vehicle operations. Most often reductions in these areas are the first steps towards reducing consumption, as reductions here can be seen immediately and are cost-effective.

Altering the HVAC system schedule can help in reducing energy consumption. There are times of day in which the vehicles do not require a fully operational HVAC system but they are still running at maximum operations. Alterations can be made here that can contribute significantly to reducing energy consumption. When the vehicle is not in use by customers this is an opportune time to reduce energy use. Turning off the heating and air systems allows a lot more energy to go towards the operation of the vehicle and therefore much less energy is needed. During times when the vehicle is not in use another cost-effective and quick solution for reducing energy use is to turn off the lights in the vehicle. Vehicle lights are often left on when the vehicle is not in use. This is a complete waste of energy and alterations in these operations would reduce an extreme amount of energy use.

Even though adjustments are being made within the environmental domain, changes only focus on one element: minimizing energy consumption. Since the SRP focuses solely on energy reduction strategies it will not contribute much towards the other criteria of the TISP analysis.

Los Angeles Sustainable Implementation Plan (LASIP)

The LASIP was enacted in 2012 to aid in the ongoing improvement of the LA transportation system. More importantly this plan outlines LAMTA's goal to provide an efficient, effective, and sustainable transportation network for the county of LA. Sustainability is to be achieved through this plan by implementing a number of strategies with the common goal of reducing greenhouse gas emissions and increasing energy efficiency. LAMTA is aligning transit system plans to regional, state, and national goals to improve air quality through reductions in the transportation sector's contribution to volatile organic compounds (VOCs) and GHG concentrations in the air. Improvement of mobility and access are also important goals of the plan, which help to create a more sustainable transit system within the social and economic arenas. However, focus will remain on the environmental contributions towards sustainability.

LA's implementation plan focuses on three principles and priorities: connect people and places, create community value, and conserve resources, thereby creating three themes: "Connect, Create, and Conserve" (Sustainability Planning Policy 2012). These principles are to be embedded into future planning activities within LAMTA. They are meant to align and optimize transportation strategies through various programs with a common vision towards sustainability and guide and communicate sustainability performance (Sustainability Planning Policy 2012). Within these three principles each further aims to address a social, economic, and environmental dimension:

> **Connect**: Green Modes. Promote clean mobility options to reduce criteria pollutants, greenhouse gas emissions, and dependence on foreign oil.
>
> **Create**: Urban Greening. Enhance and restore natural systems to mitigate the impacts of transportation projects on communities and wildlife, and ecosystems.
>
> **Conserve**: Environmental Stewardship. Plan and support transportation improvements that minimize material and resource use through conservation, re-use, re-cycling, and re purposing.

These three themes are the backbone of LAMTA's environmental sustainability goals and will ultimately determine whether or not LAMTA's plan is sustainable compared to the TISP criteria. Not only does this plan focus on modes of public transit but also it sets forth goals to encourage active transportation, defined as walking and bicycling. These are forms of transportation that contribute no emissions to air pollution and therefore completely eliminates the emissions of one entire trip. Additionally, because private transportation is still a huge part for the majority of commuters in LA, the LASIP recognizes that in order to achieve goals of air pollution reduction, cleaner forms of transportation must be encouraged for private vehicles as well as public.

Establishing goals that will be attainable requires knowledge of the different regions within LA. LA is quite diverse in its landscape, and thus, there are a number of different types of communities. The LASIP uses three different areas of evaluation to group different cities in LA into specific clusters; this allows LAMTA to focus policy strategies, in particular areas based on their unique layout. The three important components include: residential density, job centrality, and the average annual vehicle miles traveled (VMT). Clusters are developed based on these criteria and encompass particular characteristics. By dividing these same characteristic neighborhoods into similar categories it is easier to understand what particular goals are feasible in an area and what isn't. Refer to Table 1 for a description of the identifying characteristics for each cluster.

Table 1: Cluster Characteristics

Density	Summary	Residential Density	Job Centrality	Avg. Annual VMT Per HH
Cluster A	Higher density residential patterns, not well connected to economic centers, good candidate for sustainable local travel. Ex: Agoura Hills, Claremont	Medium-High	Low	20,477
Cluster B	Low average residential density, auto oriented, transit investments for nearby downtowns and compact neighborhoods. Ex: Bel Air, Granada	Low	Low-High	23,275
Cluster B Special Areas	High job centrality, large industrial zones, places serving	None/Very Low	High	23,275

	recreational or entertainment purposes. Ex: LAX, Long Beach Port			
Cluster C	Mixed-use areas near centers of economic activity, active transportation and transit, compact feel. Ex: Van Nuys, Venice	Medium-High	Medium-High	18,717
Cluster D	Concentrations of economic, entertainment, and cultural activity, high capacity transit stations and corridors.	High	High	15,988

Los Angeles Sustainable Implementation Plan (2012)

Placing each particular city within LA into a specific cluster will guide the policy approaches for transportation. These clusters are of course general descriptions, and each city within LA County will be different, but in order to provide the most effective and focused transit options these are critical. Useful sustainability strategies will be attained through applications based on cities cluster identification. In some areas it is possible that they will identify with more than one particular cluster. While all areas have potential for increased transit solutions some areas will prove to be more effective for increasing transit ridership. These will be ideal for increased transit projects. These will be the areas that have higher population densities coupled with a central work location where the majority of commuters will be headed.

LAMTA goes on to describe which policy approaches will be pursued heavily in each cluster. Overall, the LASIP states that in order to reach these goals of greater transit sustainability LAMTA must simply provide the opportunity for people to drive less, and in more efficient vehicles (Sustainability Planning Policy 2012). Through implementation, the LASIP aims to achieve these stated environmental benefits:

1. Reduced fuel use
2. Reduced traffic congestion, particularly during rush hour
3. Reduced emissions of criteria pollutants
4. Reduced greenhouse gas emissions (GHGs)
5. Increased use of active transportation and transit

6. Reduced infrastructure costs and associated environmental benefits accrued from energy, waste, water reduction, and land preservation.

These benefits are not just specific to improvements in transit options and increased transit ridership. Much of this can also be achieved through the promotion of zero-emission vehicles. LAMTA includes this in the SIP because of the significant percentage of those in LA County who commute by single-occupancy vehicle. Even with increases in transit projects it will take an extended amount of time for riders to transition and for projects to be built, thus, promotion of cleaner fuels for single-occupancy vehicles also plays a role in creating a sustainable transportation system in LA (Sustainable Planning Policy 2012). Transit ridership will play an important role as well, from 2001 to 2009 VMT by people ages 16-34 decreased from 10,300 miles to 7,900 miles, indicating a shift among the younger generation (Sustainable Planning Policy 2012).

Regardless of the fact that certain strategies will only work in certain areas there are universal policies that have relevance across all areas. Universal policies will focus land-use growth in areas that are currently well served by transit, known as High-Quality Transit areas, and focus growth along main streets and downtowns. Universal transportation strategies will focus on tripling the resources available for Active Transportation, and provide resources for Transportation Demand Strategies. In the area of green design policies, techniques will be used that minimize the environmental impact of transit projects and/or support local greening. Fleet services and transit vehicles will transition to zero and near-zero emission vehicles. Demand management systems will seek to optimize transit service by increasing its competiveness with automobiles through regional planning, infrastructure investments, and supportive local policies. Transit-oriented development will be scalable across rail and bus corridors and project development will follow local sustainability policies.

Next, the LASIP presents place-based policies that are directed specifically towards certain clusters. Refer to Table 2 for a description of place-based policies.

Table 2: Place-Based Policies

Place	Policies (Focus on Environment)

Cluster A	**Sustainable transportation**: Support the use of green modes, active transportation, rideshare, transit, and low impact vehicles **Transit services:** Focus on commute and lifeline services to employment centers, key corridors, and feeder services **Street operations:** Create attractive conditions for active transportation, transit use, and encourage integrated trips with transit and active modes.
Cluster B	**Sustainable transportation:** Support use of active transportation for local trips and motorized green modes for longer distance trips through development of services **Local government planning:** Identify specific transportation needs that can be met with green modes as well as opportunities to improve efficiency and safety of passenger travel **Street operations:** Encourage integrated trips with transit and active modes and prioritize projects that increase efficiency of existing transit
Cluster C	**Sustainable transportation:** Provide mobility options to support car-free and one-car living through development of services promoting active transportation and transit use for all types of trips (rideshare and car share included) **Transit services:** Provide and encourage local transit coverage, frequency, and reliability within close proximity to homes and businesses with short headways and timed transfers, connect local service to high-quality transit areas
Cluster D	**Sustainable transportation:** Promote very high levels of active transportation and transit use for all types of trips **Local government planning:** Planning and development focuses on transit supportive densities and design features **Transit services:** Provide and encourage local transit coverage, frequency, and reliability within close proximity to homes and businesses, connect local services to high-quality transit areas, improve first-last mile connections to transit **Street operations:** Sponsor projects that give priority to transit and active modes

Los Angeles Sustainable Implementation Plan (2012)

These are the specific policies that LAMTA has laid out for achieving a more sustainable transportation system in the entire county. Certain metrics have been developed to evaluate whether or not these policies have been implemented and are delivering the desired results. Because the focus of this paper is a comparison of LAMTA's sustainability plans, policies, and projects to the TISP the metrics underlined in the SIP will not be described in detail; however, these are available for reference in Appendix A.

In order to make sure that these policies and programs have adequate funding the government needs to support of the public in passing funding initiatives. Measure-R has provided a funding source for new transit projects and programs and the acceleration of projects already in the pipeline. This created a half-cent sales tax specifically for transit and took effect on July 2009 and will fund approximately $40 billion worth of transportation projects in Los

Angeles County over the next 30 years (Final EIR 2012). However, the tax alone will not provide all of the funding necessary. Thirty-five percent of Measure-R funding will go towards new rail and bus rapid transit projects and twenty percent to bus operations, which will aid in providing clean fuel buses.

Regional Connector Transit Project (RCT)

The RCT is a project partially funded through the Measure-R tax and therefore must adhere to the policies and programs set forth in the LASIP as they pertain to sustainability. The RCT will extend from an already existing rail line at the Little Tokyo/Arts District station to the 7th Street Metro Center in downtown Los Angeles. The project links the Metro Blue, Expo, and Gold Lines to reduce the number of trips required. This will allow access to a number of other existing lines by adding 1.9 miles that will allow for a number of existing trips to require only a one-seat ride for travel across LA County. Transit riders will be able to transition current trips that require a transfer to a single-ride trip, improving convenience and accessibility. Some rides will still require a transfer and the RCT will create additional transit connectors, providing connections to stations that were not previously connected, an improvement in the connectivity of LA's transportation network. Connections that can be made are to Blue, Expo, Red and Purple Lines, bypassing Union Station and accessing a number of employment centers. Mobility and transit ridership will increase connectivity (Final EIR 2012). Not only will the project improve connectivity and accessibility but it will also provide an option for reducing congestion on roadways and provide environmental benefits through making transit options more convenient than current options (Metro – Regional Connector Transit Project 2015). The area in which the project will be built is a major population and employment center in the downtown LA area. With expectations of growth and population increases within the transit system this project will aim to alleviate congestion and accommodate increasing transit ridership in the year 2035. This project aims to correct the inadequate access to business, cultural areas, and residential regions in the downtown Los Angeles area.

This new addition will be an underground light rail system that will provide a direct connection between Azusa and Long Beach and between East Los Angeles and Santa Monica. The project is forecasted to open in 2020 and has a budget of $1.427 billion. Because this project was developed after the LASIP, it is subject to all of the policies put forth. This project will be one of the first to be built with new sustainability strategies and goals in mind. Sustainability strategies must be implemented throughout the entire life of the project. Design and planning as well as construction and the continued maintenance of the project must incorporate the sustainability goals of the LASIP as well as the region. These include the incorporation of green modes, reduction of waste and pollution, and minimization of ecological impacts of transit projects.

As with any development within the state of California this project must adhere to the regulations of the California Environmental Quality Act (CEQA). This requires any project to produce an Environmental Impact Statement (EIS) to determine potential environmental impacts and whether or not an Environmental Impact Report (EIR) is needed. Particular alternatives were proposed for pieces of the project to accommodate community concerns. Repositioning the 2nd St/Central Av station to 1st and Central Av reduced property and construction impacts of the project. Cut and cover activity within Little Tokyo and on 4th and Flower streets was eliminated after alternatives were explored. The Locally Preferred Alternative (LPA) is underground alignments for the additional three stations that are to be added.

The RCT project was initiated in 2007 when 36 different potential routes were evaluated to determine the best option for this project. Ultimately, two “build” alternatives were determined; both would use Light Rail Transit (LTR) technology and two other alternatives were presented. Other alternatives were a No-Build scenario and Transportation System Management Alternatives. Two years later further study was authorized to determine the environmental impacts of these four options and additional community comments presented a fifth option for the project. Metro studied impacts and determined possible mitigation strategies. In 2010, the draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR) was released and after community comments the Metro Board of Directors designated the Fully Underground LRT as the Locally Preferred Alternative (LPA), with the addition of three new stations (The Process 2012). One year later, in 2011, Metro continued to reach out to key stakeholders for the development of the Mitigation Monitoring Program and after the Final EIS/EIR was released with the refinements to the LRT the Federal Transportation Agency authorized entry into preliminary engineering and station design. With the conclusion of the final design the project can begin construction and the Mitigation Monitoring Program will be implemented. The completion of the project is expected in 2019.

Not only does the project go through an evaluation of alternatives but also property must be acquired in order to begin work on the station. Therefore, property acquisition and use must be considered as an environmental impact of the project. Some property acquisition is permanent and some is temporary. For the purposes of this project underground easements will be needed; while this will disrupt the underground space it will prevent further damage from being done to already existing property, as underground construction does not typically interrupt above ground areas. Staging areas will also need to be acquired during construction where materials, equipment, and workers can remain for the duration of the project. Permits must be acquired to begin construction in these areas and are given only after the project has been approved through the CEQA process.

The RCT project will have three major phases of construction that are important determinants of environmental impacts. Phases include: third-party utility relocation, advanced utility relocation, and design/build construction. Each phase has impacts on the surrounding area. First, privately owned utilities will have to relocate lines that are within the build area. These will be moved to support the new underground infrastructure; therefore, existing service could be impacted, but improvements to the utility boxes can be made which would be beneficial for future service. Further, advanced utilities must be relocated; these include sewer and water lines that are within construction areas. Tunnel constructions will begin after the final design has been improved; this is the final stage of construction. For the purposes of this paper the transportation impacts and mitigations will be described to understand whether or not the construction and existence of this system is considered sustainable under the TISP criteria.

As an introduction to how impacts are determined under CEQA, the guidelines define "significant effect" or "significant impact" as a substantial, or potentially substantial, adverse change in any of the physical conditions in the area that are affected by the project. If it is determined that there will be a significant effect on the environment, then careful judgment must be made on the part of the public agency, based on factual data.

Impacts that will be outlined here will relate to emissions from both the construction and the operation of the project. Biological resources within the area will need to be accounted for in the potential impacts of the project. Bicycle and pedestrian traffic will also suffer some consequences due to the closure of some lanes and sidewalks due to construction. Focus is on the Locally Preferred Alternative because this is the project that will be built. First, impacts from construction are related to a number of temporary increases to transit disruption, traffic congestion and emissions within the area. Street closures will temporarily increase congestion on roads located within construction zones (Final EIR 2012). Travel times for existing LAMTA transit buses would be impacted along these roadways; however, the greatest impacts would occur in the evening because most construction will take place during nighttime and weekend hours. Buses would be re-routed to accommodate construction closures. Roadway capacity will be reduced, contributing to congestion within these areas and therefore transit times would also increase. Cut and cover construction may require temporary sidewalk and bike closures that will disrupt the flow of these forms of active transportation; however, once the project is completed pedestrian bridges are mitigation measures for any disruption of pedestrian flows. These construction impacts were considered to result in a considerable contribution and therefore a cumulative impact (Final EIR 2012). Waste accumulation would occur from the construction of tunnels to create the proper infrastructure for the RTA project. The waste would be transported by truck and disposed of in off-site disposal areas. These are considered to be unavoidable impacts of the project. However, transit impacts will be positive once the project has been completed. System wide linked trips are expected to increase to 1,734,500, representing a total increase of 17,400 trips over the No Build scenario. Daily boarding is expected to be 282,700 riders, which represents an increase of 24,200 in urban rail boarding (Final EIR 2012).

Further impacts have to do with the increased emissions from construction of the project. Emissions during the project are considered to be significant. The unmitigated expected emissions for the LPA is predicted to be between 376-386 lbs/day of volatile-organic compounds, three times above the 100 lbs/day threshold for the South Coast Air Quality Management District (SCAQM). Additionally, NO_x emissions are estimated to be between 2,700-2,800lbs/day far above the SCAQM threshold of 100lbs/day. These are significant impacts to air quality while construction is ongoing. Operations of the project would result in much fewer VOC and NO_x emissions of 2lbs/day of VOCs and 6lbs/day of NO_x emissions. Emissions of these contribute most heavily to the air quality within LA County as they are contributors to smog in the area. LA's air quality is an important consideration when determining alternative projects. Operation emissions do not take into account emissions that would be forgone because of the additional number of transit trips taken instead of private vehicle trips. When considering these reductions it is possible that there would be a negative contribution once the project is operational. This contributes to emission reduction goals in the region.

Biological resource impacts will occur from construction and operation of the project. Many biological impacts occur during the construction phase of the project. Because LA is already a highly dense, developed, urban area there is little wildlife within the project area. No Habitat conservation plans have been developed and no Significant Ecological Areas are located within 0.25 miles of the proposed alignments of the project. No wetlands, oak woodlands, or coastal sage scrub habitat exist in the area; these would require special attention. The Los Angeles River is located more than 0.25 miles away and is within a concrete channel, so few impacts are expected to occur. It is possible, however, that 87 mature trees within the construction area could be impacted. Permits will be required, and if these are potential nesting areas then construction will not be allowed within 300 feet of the nest. Twenty-five protected native California sycamore trees could be affected; therefore, project design will aim to minimize these impacts through the use of fencing during construction. Additionally, to improve the benefits of the project there will be increased urban design and landscaping which would incorporate additional trees, thus providing a net positive. Indirect impacts can create additional competition for habitat if trees are removed during construction and not replaced, however, existing habitat is low quality and presently only a small population of birds currently use the existing trees. Mitigation strategies will be implemented to minimize these effects, but regardless of mitigation these impacts will still be significant. In the event that tree removals must occur permits will be obtained and trees will be replaced with the planting of new trees. These are the descriptions of the project that relates most closely to determining environmental impacts, both negative and positive, and therefore will determine the sustainability of the project.

Chapter 3: TISP Criteria Analysis

Does the SRP, the LASIP , and the RCT project represent sustainable transportation?

TISP Analysis

Analysis will break down the descriptions of the SRP, LASIP, and the RCT to determine how they compare to the criteria of the environmental domain within the TISP criteria. Rather than focusing on one plan, policy, or project at a time, the analysis will break down the criteria of the environmental domain defined by the TISP and use that as a frame of reference for each piece that is studied in this paper.

Criteria One Analysis

The first environmental domain criterion that measures the sustainability of the transportation system is as follows:

"Minimize consumption of renewable & non-renewable resource for transportation."

All three plans touch on minimizing consumption of renewable and non-renewable fuels. Each piece contributes to this criterion in a different way.

The Sustainable Rail Plan

The LAMTA SRP focuses only on this criterion of minimizing consumption of renewable and non-renewable resources. A number of potential options for energy technology systems that would increase efficiency were presented. While some were used within existing systems and others were planned, the majority were recommendations for incorporation into future projects. Because of this focus on increasing energy efficiency the SRP plan does represent a fulfillment of the criteria to minimize resource consumption, both renewable and non-renewable.

Onboard storage will contribute to reductions in non-renewable energy use and work towards reducing the energy consumption element of the environmental domain. However, because rail systems use electric power, in order to truly determine if there is truly a reduction in fuel use from the implementation of this plan, fuel emissions cannot solely be displaced. This means changes from non-renewable fuels to fuels like solar, wind, and hydro for electricity. If these fuels are used in lieu of more conventional fuels, then this plan does set LAMTA on a trajectory to reduce consumption of fuels. Projects in the future are planned to use on-board storage and this will increase efficiency of the current system. The same number of riders can be served at a reduced amount of energy consumption. The SRP therefore fulfills the sustainability criteria for reducing fuel use through efficient uses of energy. However, it is unclear how the SRP will reduce consumption of renewable resources beyond using energy more efficiently. As the transportation system is far removed from influencing the choice of fuel used for their electricity, other methods of reducing the use of fuel in general need to be implemented.

The LA County Sustainable Implementation Policy

Within the LASIP there are two priorities, which relate to minimizing the consumption of renewable and non-renewable resources for transportation. Promotion of green modes of transportation reduces pollution and emissions of GHGs through encouraging commuters to transition from their own vehicles to using vanpools and/or transit services. If green modes are promoted and it takes commuters who typically use their private vehicles onto group or public transportation, then it will reduce GHG emissions. Because promotion of green modes is a priority of the LASIP it does fulfill the criteria to minimize consumption of non-renewable resources for transportation. Further support will go towards planning that incorporates cleaner modes of transportation, rather than building highways and infrastructure that encourages greater car use. Prioritizing "green modes" begins to transition current transit networks away from conventional fuels. By implementing this within the LASIP it guarantees that all future projects will have this goal in mind and contribute in reducing the use of non-renewable fuels.

Additionally, the LASIP recognizes that in some areas of LA the same potential for reductions of fuel use may not be accomplished with the introduction of more transit. Therefore, the use of green modes is not limited to strictly public transit. Green modes can encompass private vehicles that use cleaner fuels like hybrids or electric vehicles. In order to achieve this, these vehicles should have zero or non-zero contributions to emissions. Active modes of transportation are also encouraged in these areas. Walking and bicycling are ways in which commuters can get around the city without using any type of fuels, adhering to the minimization of renewable and non-renewable fuel uses all together.

The LASIP encourages land development that will allow people to have increasing opportunities to live and work in areas with available transit, thus reducing the necessity to travel by car. In proposing transit projects that aim to improve connections of neighborhoods within highly dense areas, the LASIP will minimize use of non-renewable and renewable fuels by providing more opportunities to utilize public transit or active transportation options. Active transportation infrastructure will allow those on foot and bicycle to make trips that they once would do with private vehicles. All priorities involving land-use, transit, and pricing strategies contribute directly to reductions in vehicle-miles-traveled, especially when used together

(Sustainable Implementation Plan 2012). Minimization of fuel use will be achieved if these plans are followed.

Regional Transit Connector Project

The RTC project will contribute to minimizing renewable and non-renewable fuel use by providing additional mobility to a number of recreational, cultural, and employment centers within downtown LA. Increased connectivity makes taking public transit more convenient since trips that before required a transfer will no longer require transfers. Trip times can be reduced and this option is now more appealing than previously. It is expected that an additional 17,400 trips daily will be taken with the addition of this new transit project. This will increase the total transit networks trips to 1,734,500 trips daily (Final EIR 2012). Increases in public transit ridership has been consistent with decreases in vehicle-miles-traveled; therefore, this contributes to minimizing the consumption of renewable and non-renewable fuels for transit. An additional effect of building these transit projects is the potential for congestion due to lane closures to cause further delays in trips taken in private vehicles. Because trips taken on this rail system will be underground the speed of the trip will remain, for the most part, unaffected by congestion. With congestion increasing on surface area streets others could find public transportation an appealing option to avoid taking their private vehicles during times with high congestion. This will further minimize use of conventional fuels through transitioning private vehicle commuters to transit.

The project itself will use electricity because it is a light-rail system. Current light-rail energy use translates into consumption of 304 billion British Thermal Units (BTUs), representing 52,337 total barrels of oil (Department of Energy 2009). This is lower than any other vehicle class including buses and automobiles. Electricity use is split between powering the rail system and the transit facilities. With an increase in transit facilities there will be a greater energy demand to power these new stations; however, transit energy consumption will be determined by considering long-term energy impacts. In the long-term, according to the Final EIR, the energy consumption impacts in the construction stage of the project will be not have substantial adverse impacts. Energy consumption after operation of the project has been determined to have beneficial long-term impacts. All alternatives to the No Build scenario result in a net decrease in VMT within the region, therefore offering a net decrease in energy consumption in the long-term (Final EIR 2012). The Locally Preferred Alternative (the three stations proposed) offers up the greatest change in VMT compared to the No Build scenario. All other alternatives also contribute to VMT reductions but the LPA represents the highest change at 102,268,800 VMT change annually. Direct evidence that the RCT would minimize consumption of annual barrels of oil is provided by the Final EIR prediction that the LPA would contribute an annual reduction of 109,551 barrels of oil (2012). Therefore, even with increases in energy use at the initial start of the project the TISP criterion that the system minimizes consumption of renewable and non-renewable fuels is met.

Criteria 1	SRP	LASIP	RTC
"Minimize consumption of renewable & non-renewable resource for transportation."	Yes – focuses on energy efficiency to minimize existing consumption	Yes – focuses on green modes and encouraging public and active transportation	Yes – results in reduced VMT and reduced barrels of oil used

Criteria Two Analysis

The second environmental domain criterion that measures the sustainability of the transportation system is as follows:

"Transportation system is designed to maximize land-use efficiency."

This is a criterion that pertains mainly to the projects built with the LASIP and RTC in mind and these projects will determine the ability of LA to meet this criterion. The LASIP does contain priorities for using land efficiently in order to make transit a more attractive option. Where the stations are located within the RTC project will determine if the project is adhering to criterion two. The SRP does not mention land-use efficiency and therefore will not be included within this section.

The LA County Sustainable Implementation Policy

Universal policy goals include adopting strategies that focus growth in areas that currently have strong transit networks, thus prioritizing land-use efficiency. Land-use efficiency is more than just minimizing land used, but rather a determination of the best use for that land depending on the use of the surrounding land (Zheng 2013). Growth should take place along main streets and downtowns to create areas that have the greater number of uses such as work, recreation, and cultural so that land-use will contribute to greater transit use (Sustainable Implementation Plan 2012). By concentrating transit within higher density areas and focusing growth where transit centers are located, public transportation options become more convenient and mobility and connectivity increase. In the case of LA this is very important because of its polycentric nature; growth needs to focus on creating activity hubs so transit becomes a more attractive alternative to traveling by private vehicle.

One of the clear strategies that the LASIP uses to make sure that land-use efficiency is kept in mind is through its use of clusters. These clusters identify each area by density of people and characterize if they are an employment, cultural, residential, and/or industrial center. Sectioning off these areas help to ensure that when transit plans and projects are put forth they focus on the areas that will benefit the most. As stated within the plan, growth focuses on building out the current transit network and using land efficiently to determine the best locations for additional stations. Through cluster identification, the best use of the land can be decided. If a specific cluster is dense in economic and residential centers, like Cluster C, then it would be a good candidate for transit projects, as stated by the LASIP. However, if a specific area were predominately industrial, like Cluster B, using land efficiently may not necessarily mean improving transit to that location since the land may be needed for additional industrial uses and therefore would not be considered a priority area for transit development.

Not only does cluster identification determine how beneficial additional transit options will be but it also emphasizes where certain land-uses would prove best for certain areas. For example, rather than focusing on just transit options in Cluster A, the LASIP emphasizes the importance of encouraging active modes of transport; this supports a different land-use for that particular area to ensure that it will be used most efficiently.

Taking a close look at each region within LA can help identify the areas where new development should begin. Project plans can be designed and focused in areas where they would have the least impact to existing land-use patterns. In addition, projects will support the current uses by focusing specific developments within specific areas. Cluster A commuters suffer from long commutes to work and forms of active transit are not appealing alternatives due to the high number of auto-oriented corridors in the area. Efficient land-use here is considered to be a focus on last-mile solutions by improving active modes of transportation, focusing on creating more efficient transit options within the clusters current developed state. Carpools are extremely popular here; if 2 percent of solo drivers carpooled, then 10,000 single occupancy vehicles would be removed from the road (Sustainability Planning Policy 2012). Accomplishing this will create more efficient use of the current highway infrastructure, which would reduce congestion in the area and, therefore contribute to making active transportation more appealing. The LASIP states that development in this area should focus on creating mixed-use centers (2012). For Cluster B, land-use efficiency means integrated land-use and transportation planning since the current transit network is not as built-out as other areas. To make sure that transit will integrate well into the region, development must keep future transit goals in mind. Discouraging land-use that is inconsistent with transit sustainability goals will be important for maximizing land-use efficiency. Areas that contain employment centers with a high residential density, like Cluster C, are great candidates for transit development. With 40 percent, or 3.8 million, of the county's residents, transit development has a high potential for reducing congestion. Land-use efficiency will prioritize transit within the areas of highest employment and connect residents to these areas with transit trips that are short and convenient. As mentioned, Cluster D provides the greatest opportunity for current transit-oriented development; land-use efficiency here means developing and designing projects that fit well within the current land-use. Horizontal and vertical development is attractive in these areas to maintain the clusters characterization as an economic, entertainment, and cultural center.

Regional Connector Transit Project

The RCT project contributes to maximizing land-efficiency in various ways. Since LA is plagued with high congestion on current roadways it important for further development to reduce congestion and prevent additional congestion in the region. Prioritizing transit projects above additional highway projects illustrates the knowledge that increases in highway infrastructure is not the answer for using land most efficiently in LA. The RCT project contributes to regional project goals of creating an integrated, dynamic, and livable area with projected growth in mind. Goals further aim to create transit supportive land use that supports current land-use patterns, i.e., focusing on transit growth in centers of employment, recreation, and residential areas. The three stations planned for the RCT project are in areas of high traffic and in downtown hotspots. Station one will be built next to Little Tokyo/Arts District; this is a cultural and recreational center with many visitors. This area will now be made more accessible to a number of people through transit development that supports the current land-use pattern and connects a number of high traffic areas. The second station is set to be in the civic center, an area of high employment, providing commuters an alternative to taking their vehicles to work each day. Lastly, the third station will be built in a recreational hotspot that is located next to a number of museums, concert halls, and theaters. Station locations illustrate an effort to connect already bustling areas of the city with alternative transit options to reduce congestion and support current land-use patterns.

One particular characteristic of the project that contributes to land-use efficiency is the fact that the project is underground. Underground projects allow for the land above to be used for other purposes, thus increasing the value of the land and reducing the impact that the project will have on usability and efficiency. In designing the RCT, plans revolved around creating transit links that worked well with current land-use. For example, as discussed above, the three stations planned will link together the areas that are currently in highest use, making sure the project will support current land-use. Additionally, any project that was determined to have a significant impact on the environment in which it was built must produce an EIR. Within the EIR different alternatives to the project are evaluated on their ability to provide the same benefits to the community. In the evaluation of the alternatives, land-use trade-offs between options are apparent. It is clear that this underground alternative prioritizes land efficiency in the way that it minimizes impacts to existing infrastructure.

There were three different project options analyzed within the EIR. Two options were at-grade projects and the third was an underground option, the one chosen after comparing alternatives. The underground option prioritizes land-use efficiency in a number of different areas compared to the at-grade alternatives. Rather than crossing through residential areas like the at-grade options, the underground option goes through the busiest downtown areas, and therefore better accomplishes connectivity to high-use centers. The RCT project corridor plans also consider where future development is planned. The underground route is more closely located to projects planned in the future (22 projects are planned), thus considering the direction of future land-use patterns. Future land-use designs plan to incorporate a cohesive street network in the region of the RCT; if at-grade options were prioritized, then these future plans would be at risk, compromising the ability of the region to improve the use of active transit. In contrast, the underground option does not compromise these design plans and will allow for more complete streets that support both rail transit and active transit options. Therefore, the underground option is one that works to ensure that land is used most efficiently to accomplish sustainable development in both the present and the future. Integration of new developments in the same area is high with the underground option as is the ability of the project to integrate into current land-use patterns, known as urban-fit potential.

Another component important for determining whether or not the RCT project maximizes land-use efficiency is considering impacts to current highway infrastructure and congestion. If the project worsens congestion then it wouldn't be considered a maximization of land-use. At-grade options would cause disturbances and further congestion to intersections and street lanes along these option alignments. At-grade Option A would impact 24 lanes within the corridor and Option B would impact 27 lanes, increasing congestion and traffic in an already highly congested area (Final EIR 2008). However, the RCT project's underground option will impact an intersection where a pedestrian walkway will need to be built to accommodate the project; this could increase congestion at this particular intersection. However, the underground option still proves to be the best, even with this impact in mind. This is because the at-grade alternatives will impact a higher number of intersections. Option A will impact 12 intersections, and Option B will impact 13 intersections, further supporting the underground option as the one that works best within current land-use patterns. Project goals include reducing congestion, not adding to it, which is what the other alternatives would do. While the underground option does contribute a bit to congestion at one intersection, the project will reduce congestion overall, supporting sustainable transit-oriented development and maximizing land-use efficiency.

Criteria 2	SRP	LASIP	RTC
"Transportation system is designed to maximize land-use efficiency."	No – does not discuss land-use efficiency	Yes – focuses on cluster identification to determine the most efficient land-use for each region	Yes – prioritizes land-use efficiency between potential projects, choosing the project that has the least impact to current land-use

Criteria Three Analysis

The third environmental domain criterion that measures the sustainability of the transportation system is as follows:

"Minimize transportation system's impact on ecological systems."

This criterion is the only one that relates solely to environmental impacts to the specific ecological environment of LA. Transit development will have impacts on the existing ecological systems. Sustainability under TISP requires that impacts be minimized when transit networks are in-use, planned, designed, and built. All three plans contribute to these four areas of transit network development. The SRP determines design elements, the LASIP focuses on planning, and the RCT project will have impacts both during and after build.

The Sustainable Rail Plan

The SRP will contribute to reducing ecological impacts because it aims to achieve greater energy efficiency. Energy efficiency will address the ecological impacts caused through the consumption of fossil fuels used from the electricity production for operation of the light-rail system and other transit projects. Increasing energy efficiency means that the same operation capacity can be achieved with a reduced amount of energy use. Within the SRP, the quoted reduction in electricity use with an increase in energy efficiency is 15 percent, using an on-board system (Sustainable Rail Plan 2015). On-board systems prove to have the smallest impact on the surrounding ecosystem since installation would take place within the vehicle and not require further stress on land. This will result in a number of minimizations to impacts on ecological systems. Land disturbances are minimized, especially in comparison to the development of a wayside station, which would require additional land and create disturbances to the ecosystem in the area.

Impacts from energy use, in the case of light-rail systems, are felt on the power plant end rather than the transit end. Emissions of electricity related energy use are dependent on the type of fuel used when the energy is created. Emissions at this end will determine how much of an ecological impact is created by the particular fuel used on the power plant end. As energy efficiency improvements are implemented into existing and future transit projects, energy emission reductions will be achieved. These achievements translate into a minimization of emission impacts to surrounding air quality and surrounding ecosystems within the region of the power plant. The SRP identifies the Gold Line and Red Line alignments as existing transit corridors that will benefit from energy efficiency improvements. These improvements will minimize the impacts these current transit networks have on ecosystems within the area of the power plant they receive energy from. Quantitative data will provide a clearer picture of actual achievements related to impacts. This data can only be collected after the system has been in use for some time; thus, numbers are unavailable for analysis at this point. However, once energy efficiency improvements are made, different transit projects can use various technologies to determine which options truly result in the most energy efficient solution, along with the greatest reduction in impacts to ecological systems. If this is realized and the best options are chosen, then the SRP would be considered to be sustainable under criterion 3 of TISP analysis.

The LA County Sustainable Implementation Policy

Within the LASIP there are set environmental benefits that are to be achieved through the implementation of the plan. A few of these benefits will help to minimize impacts to the ecological systems in the region. These benefits are as follow:

1. Reduced emissions of criteria pollutants
2. Reduced greenhouse gas emissions (GHGs)
3. Reduced infrastructure costs and associated environmental benefits accrued from energy, waste, water reduction, and land preservation.

If projects built under the plan are able to achieve these benefits then impacts to ecological systems would be minimized. These benefits would occur on a long-term scale since the areas of ecological impact are quite large. One of these benefits relate to reducing the impact that current and future transportation has on air quality, a huge concern within the LA region due to smog and pollution from vehicles. Criteria pollutants (ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead) can cause health problems for those who continually breathe these in each day (EPA 2014). Health issues in humans include increased respiratory symptoms, hospitalization for heart or lung disease, and even premature death. Additionally, this produces air of lesser quality for all species living within the area; plants and animals also suffer from the reduced quality of air, creating a domino effect within many areas of the surrounding ecological system. Criteria air pollutants currently cause a number of ecological impacts throughout the region. Current transportation within the region creates ecological impacts. Thus, reducing emissions of criteria pollutants will contribute to minimizing ecological impacts.

Greenhouse gas emissions contribute to the even greater ecological impact of global climate change. Global climate change encompasses a multitude of different impacts to the entire ecological system and will require major changes in current human behavior. The LASIP sets LA metro up for providing reductions of GHG emissions to minimize the impacts transportation contributes to overall global climate change. Whether or not the transit projects that LA metro plans and builds contribute to decreasing impacts of global climate change, this will be very difficult to measure since impacts of climate change take place on a large scale, both in time and space. However, transportation does produce GHG emissions through fossil fuel use. Twenty pounds of CO_2 is emitted per gallon of fossil fuel used per vehicle, which can translate into 6 tons of CO_2 per vehicle per year (EPA 2015). As stated within the criterion one analysis of this section, there are expected to be reductions in fuel use, vehicle use, and emissions with the implementation of transit projects under the LASIP. Greater transit use has proven to reduce emissions of GHGs and has often been prioritized as an option for reducing GHG emissions. Thus, with these projected decreases in emissions of GHGs from transportation use within the LA region, ecological impacts are to be minimized in line with the TISP criteria for sustainability.

The third benefit in the LASIP that contributes to minimizing ecological impacts of the transit network within LA is a reduction in infrastructure costs and the resulting environmental benefits that come with reductions in these costs. As development of transit networks begin to become developed within existing infrastructure and land-use costs will decrease along with decreased energy, water, and land use, resource use consumption will decrease and the ecological systems that require these resources will benefit because resources will now be more abundant. This will reduce current stresses and prevent additional stresses from occurring, and by doing so minimize ecological impacts on the surrounding area. Therefore the LASIP meets the TISP criterion 3 requirement to be considered a sustainable transportation plan.

Regional Connector Transit Project

While the SRP and the LASIP provide the framework for reducing ecological impacts, none of these reductions can come to fruition without the proper execution on the project end. First, the RCT project must reduce criteria air pollutants through a reduction in pollution emissions from operation. Second, GHG emissions must also be reduced, and lastly, infrastructure costs must be minimized in order to reduce impacts to resources within the area. This would ensure two things: that the RCT project adheres to the guidelines of the LASIP and that the RTC project is sustainable under the TISP analysis.

There are two time periods in which the RCT project could potentially create the greatest number of ecological impacts. These times are during the construction of the project and the operation of the project. Most notable impacts will occur from the construction of the project, since previous sections have already determined that the project will reduce emissions from vehicles after it begins to operate. Any project that is built within the state of California and has a significant environmental impact is required to go through the CEQA process of review and ecological impacts are determined through this review. CEQA reviews are a resource for the public and key stakeholders to determine the extent of the project's impact, and, in this paper's case, it allows the appropriate evaluation under the TISP analysis.

In evaluation of the biological resource impacts, which include ecosystem impacts, it was noted that a number of tree species would need to be removed to accommodate the project. Ecological impacts due to the removal of the trees will occur to the tree species itself, as its population will decline, but any species that uses the trees for habitat will also be impacted.

If the trees provide an integral service to the surrounding ecosystem, then impacts will be felt throughout the ecosystem in the area. Waste accumulation during construction was also noted as a significant impact. Waste piles will have impacts on the surrounding ecosystem as well, depending on where the waste will be located and its volume is what will determine the severity of the impacts. These are unavoidable impacts of the project, but just because it has impacts does not mean the project does not adhere to criterion 3 of the TISP analysis. Rather, the goal is that impacts are minimized as much as possible, since construction is a naturally impactful process. Impact minimization measures are being taken during construction to deal with the potential impacts to surrounding ecosystems. Tree impacts will be minimized through additional barriers added to protect the tree species near the construction zones. Additionally, new trees will be added to mitigate for the ones that will have been lost. However, they won't be able to provide any ecosystem services comparable to the trees that were removed until they have grown to the same size of the previous trees.

As for impacts more generally related to the ecosystem of the area, a distinguishing factor here is the highly urbanized environment that is downtown LA, the site of the RCT. For this reason alone there are not any critical habitat areas or areas of concern that would require additional mitigation. Additionally, any impacts endured are occurring in an already deeply impacted region. Species in the region are already adapted to urbanized surroundings; therefore, the operation of the project, by nature of the area, does not represent the need for significant minimization of ecological impacts. As mitigation plans are followed and the reduction in emissions expected to result from the operation of the project are realized, then the ecological impacts of the project will be minimized. Therefore, the RCT project can be considered sustainable under criterion 3 of the TISP.

Criteria 3	SRP	LASIP	RTC
"Minimize transportation system's impact on ecological systems."	Yes – focuses on improving energy efficiency and in turn reducing ecological impacts from emissions produced from fossil fuel use	Yes – focuses on reducing criteria pollutants, GHG emissions, and resource use to reduce impacts from these areas	Yes – mitigates ecological impacts from the construction of project and reduces vehicle emissions during operation of transit addition

<u>Criteria Four Analysis</u>

The fourth environmental domain criterion that measures the sustainability of the transportation system is as follows:

"Limit transportation related wastes & pollution."

This criterion of the TISP determines the ability of the new transportation system to reduce waste and pollution as a whole. This relates not only to the transit network being built but also existing forms of transportation along with private forms as well. Analysis focuses on overall limitations to waste and pollution within the transportation sector due to the policies, plans, and projects developed for LAMTA.

<u>Sustainable Rail Plan</u>

With improvements in energy use will come a reduction in transportation related wastes and pollution. Thus, while none of the proposed energy system plans directly contribute to reducing pollution; by reducing consumption, they will contribute to reductions to pollution from these systems through decreased energy use. Since there are a number of possible technologies that can be used to implement greater energy efficiency, the ability of the SRP to meet this criterion of the TISP will also depend on which particular technology is used.

Technology used will determine how much pollution and how much waste can be limited. For example, technologies that produce greater energy efficiency will limit pollution even more than those that produce a bit less efficiency. Determining which technology limits pollution the most will require testing on planned projects. Much like pollution limitation, waste limitation will work in much the same way. Different technologies used will produce different amounts of wastes. If the particular energy efficiency technology used requires additional land for building a substation, then much more waste will be created than for an on-board system, which does not require additional infrastructure to be built. However, the option that prevents the most waste may not be the same one that prevents, or limits, pollution the most. The purpose of the SRP is to assist in evaluating the technology that will limit both pollution and waste the most for each particular transit system. The most sustainable transit system will be the one that uses the technology that is the best fit for that particular system; this will not be the same for each transit project as each one is unique in design and location. Because of variations in projects, whether or not the SRP meets criterion four under the TISP analysis will need to be evaluated on a case-by-case basis. As a whole, the SRP does lead the way for creating rail projects that limit both pollution and waste and can, therefore, be considered sustainable under this criterion, as long as rails built with energy efficiency technology are prioritized.

The LA County Sustainable Implementation Policy

Analysis of the LASIP's ability to limit transportation wastes and pollution will really be determined after many years of implementation of the policy to evaluate if the related plans were carried out. Also, it will be important for evaluation to clearly define what is meant by waste and pollution in terms of transit plans in order to measure the success appropriately. Since the plan has not been in effect long enough, the evaluation here focuses on limiting waste and pollution in terms of goals of the plan.

One of the benefits illustrated within the LASIP is that of:

> *"Reducing infrastructure costs and associated environmental benefits accrued from energy,waste, and water reduction and land preservation."*

This is the only particular benefit that explicitly states goals for waste. Reducing criteria pollutants, as mentioned in previous sections, is another benefit expected from implementation of the LASIP. This relates specifically to pollution from transit. Limiting wastes and pollution from the transportation system can mean a number of things and apply to a number of different stages of the transit project. Within the LASIP, limiting waste and pollution applies most directly to limiting waste of resources from the building of transit projects and limiting pollution once the project is in operation. In order to be sure that this is being achieved, monitoring must take place to determine how much waste reduction was achieved based on comparisons from other projects built previous to the implementation of the LASIP. This will determine how much of a reduction has been achieved and therefore inform a decision on whether or not the LASIP fulfills the fourth criterion of the TISP. It was mentioned in previous sections the contribution that the LASIP will have on limiting pollution once built. For this reason, it is not necessary to restate it here.

However, it is important to note that the LASIP, if similar results are found to what is expected, will limit pollution of the transportation network.

Another way in which the LASIP works to limit waste is through the priority to:

"Plan and support transportation improvements that minimize material and resource use through conservation, re-use, re-cycling, and re-purposing."

By making this a priority within the LASIP, any projects or plans following will encourage a conscious effort to re-use and re-purpose any waste from transit projects that could potentially increase the specific impact. This will contribute to limiting the solid waste resulting from the project. Since solid waste most often results from the construction of the project, it will need to be during this time in which waste is re-purposed that it can be considered as meeting the criteria of the TISP as it relates to limiting waste and pollution. The LASIP does not stipulate a particular plan for when and how the waste must be re-purposed and re-cycled; therefore, in order to fulfill the criteria of the TISP, a plan to recycle the solid waste will be necessary.

The LASIP sets forth plans for transit projects but it also works to encourage an increase in the use of active modes of transportation. With a focus on active modes the policy works towards creating greater connectivity of roads and sidewalks for making active modes more appealing and practical. As people begin to increasingly use active transportation as a viable option for transportation, a shift from building more transit projects to building more active transportation infrastructure can take place. Following with a focus on a new type of infrastructure will come a reduction in waste because the projects built and designed will require less disturbance to existing structures. Waste accumulation will be limited since smaller forms of infrastructure will begin to be more common. Therefore, with the correct measurement and enforcement of these priorities within the LASIP, this policy can be said to be sustainable and adhere to criterion four under the TISP.

Regional Connector Transit Project

The RCT project will create pollution and waste from build to operation. Building the RCT project will create the most pollution and the most waste since this is the portion of the project that creates the most disturbances. Pollution will occur from a number of build operations: construction of the underground tunnel, increase of vehicles due to construction, dust pollution, etc. The goal of adhering to the TISP criteria is to limit the pollution coming from these particular operations. It was not mentioned within the evaluation of the project if any techniques were being used in order to reduce the amount of solid waste that will accumulate from the digging of the underground tunnel. The Final EIR did mention that the waste would be transported to a different location and deposited in an area not in the vicinity of the project. However, it was not specified as to what will be done with the waste. Limiting the amount of waste at this particular portion of the project would mean that the waste could be recycled and potentially used for future projects within the region. Additionally, to determine if this transit project was able to limit the waste in comparison to other projects, another analysis would be needed. This wouldn't be possible until after the project was built and in full operation. This would also be the time in which waste from the construction of the project could be recycled for re-use.

During operation of the project, pollution and waste would need to be limited as well. Pollution will be very minimal at the origin of the project since the rail will be operated using electricity. However, pollution will occur at the power plant end, and limiting pollution here will be dependent on the particular fuel that is used. The renewable types of fuels used for the electricity generation will limit pollution more effectively than power plants that use non-renewable fuels like natural gas or fossil fuels. Solid waste generation is not typical at the operation end of the project since the infrastructure is permanent and the rail lasts for many years. Waste that could be generated would be from the riders of the RCT; this could be limited easily with the proper bins available for waste items. Because the waste of the RCT project is a concern and it is not certain whether or not waste is going to be limited compared to other projects, it is difficult to illustrate that the RCT project would limit waste. Additionally, limitation of pollution during the construction of the project is difficult to determine since it would be dependent on the particular fuel used at the power plant end. For these reasons of uncertainty it is not clear whether or not the RCT project will limit waste and pollution during the times of greatest disturbance. Thus, it cannot be determined to be sustainable under criteria four of the TISP.

Criteria 4	SRP	LASIP	RTC
"Limit transportation related wastes & pollution."	Yes – focuses on energy efficiency and limiting pollution by decreasing energy consumption	Yes – focuses on recycling and re-using to limit waste accumulation	No – strategies for limiting waste and pollution during construction are not clear, difficult to determine if limits

			will be achieved

Chapter 4: Conclusions and Recommendations

Conclusions and Recommendations for Further Research

Conclusions

In conclusion, the LAMTA has successfully adhered to the TISP criteria in the majority of the goals set forth in the pieces analyzed in this paper. The LASIP adheres to all four criteria for making a transportation system that is sustainable. It reduces the use of both renewable and non-renewable fuels through increased transit use and takes into account land efficiency by using cluster identification. The ecological impacts of the system are reduced through the use of mitigation measures and pollution and waste will be limited through changes in infrastructure. The SRP does not adhere to every criterion; while energy efficiency provides reduction in the use of fossil fuels and by doing so reduces ecological impacts and limits waste and pollution, it does not consider land-use efficiency. Therefore, in order to be completely sustainable under the TISP environmental domain, the SRP needs to incorporate a discussion and consideration of land-use changes that would occur from the implementation of the technologies recommended within the plan. Considering this as part of a determination of which appropriate technology is best to use would allow the SRP to be considered sustainable under criterion two of the TISP. Lastly, the RCT project is another that only meets three of the criterion of the TISP. The RCT project contributes to a minimization of fossil fuel consumption by providing alternatives to private vehicles. The project is built underground, thereby minimizing disturbances to land-use efficiency. Additionally, the ecological impacts of the RCT project are minimal as the area the project is built in is highly urban and any impacts are to be mitigated. However, limiting the amount of pollution and waste during the construction stage of the project is where the RCT project fails to adhere to the TISP criteria. In order to adhere to this criterion, measures to limit waste and pollution during construction would need to be clearly outlined within the project plans. For example, the waste that is created by the construction of the project should be clearly allocated for re-use of some kind. Furthermore, the waste and pollution of this project would need to be compared to that of previous projects to ensure that it was limited in relation to similar projects in the past. When measures like these are outlined and followed only then can it be determined that the project is sustainable under the fourth criterion of the TISP.

Although there were two instances in which a criterion was not met by a particular piece the analysis has proved that, cumulatively, LAMTA has provided policies, plans, and projects that are sustainable when compared to the environmental domain of the TISP. Of the twelve evaluations included within this paper, ten were identified as adhering to the TISP under the environmental domain, creating an 83 percent adherence. Thus, LAMTA can be confident in these plans, policies, and projects in building a sustainable transit system in LA.

Recommendations

There are a number of ways to continue research for determining the sustainability of these plans. Criteria analysis could be improved through the addition of quantitative data analysis. Acquiring quantitative data can inform the claims of sustainability made within this paper and further support the reductions, limitations, and minimizations that are required of each TISP criterion. Quantitative data will also help to pinpoint the areas in which improvements can be made and create a baseline for evaluation of future improvements.

LAMTA plans and projects should continually be evaluated because these plans are extremely recent. As these are implemented they should be tested for effectiveness under the TISP criteria. Much of the analysis of the LASIP and the RCT is based on the promise that they will achieve what is required to be sustainable under the criteria; therefore, they must continue to be evaluated to determine if the priorities and goals of the project are realized. Updates on the achievements mentioned in this paper would provide further support for the claims of sustainability. As these projects continue to be analyzed it is possible that they will need to be adjusted if certain goals or priorities are not being met; therefore, as plans are adjusted a continuous analysis of adherence to the TISP criteria will need to be done.

The analysis of the LAMTA plans, policies and projects focused on the environmental domain alone. Recommendations for further research would be to include the social and economic domains of the TISP as well. Criteria analysis on these domains could highlight more opportunities for LAMTA to improve plans to be even more sustainable and result in not just environmental benefits but also social and economic benefits as well. Further, environmental domain analysis could be more specific by looking at particular aspects of pollution. For example, rather than just determining that the project will reduce pollution it can be more specific, i.e., which pollutant will be reduced and by how much. Defining goals and specific pollutants will give greater support for claims of sustainability under all domains.

Because this analysis focused on one policy, plan, and project there are many additional plans, policies, and projects that should also be evaluated. LAMTA has many other projects planned and additional policies that focus on specific goals in relation to energy, pollution, GHGs, and more. Analysis of these would provide an even greater picture of LAMTA's efforts and could further support their move towards a sustainable transit network within the county and also highlight areas where improvements are needed.

One last recommendation for further research is to include an analysis of how LAMTA will reduce private vehicle use and evaluate these methods using TISP. Because the majority of LA commuters use private vehicles, plans for encouraging transit use instead of private vehicle use can be important tools for creating a sustainable transit network. These plans must be made sustainable since they can prove to be fundamental in transitioning LA away from a car commute city into a public transit commute city. This additional research can supplement the research done in this paper to provide a more comprehensive look at all methods planned by LAMTA to increase transit use.

As further research and analysis is conducted these plans will be guaranteed to contribute to creating a sustainable transit network. These methods of evaluation can be applied to other counties and be used as a universal tool for evaluation of transportation. Once these are made to be sustainable forms of transit, only then can it be sure that transportation GHGs, pollution, ecological impacts, and overall environmental degradation will begin to be minimized.

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