Sustainable Urban Mobility Proposal for the Canton Sígsig Azuay Province

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Abstract. This research work was carried out with the purpose of evaluating and proposing a sustainable model of human mobilization for the urban center of Sígsig canton, Azuay province, Ecuador; attending to the displacements, means of transfer and reasons for travel. In the same way, the most frequent origin and destination were categorized, which later made it possible to directly conceive the circulation routes and their incidents with the central flow of circulation, both pedestrian and motorized. Based on the collection of information on the requirements that had to be obtained to shape a sustainable model, it was proposed as a starting point for the identification and study of human mobilization, the collection of primary information through direct interview with the analysis of transfer variants and reasons for circulation of a total of 792 people passing through the urban center; allowing to have an approach on the most used means of transport and percentages of circulation, as well as the reference to the reasons for the trips. In the same way, based on secondary information from the PDOT (Territorial Planning Plan) of the Sígsig canton, the connection of the road axes that unload in the urban center was evidenced. Later, in the tabulation and analysis stage, the problems and their possible solutions on mobility and transfer activities were determined, prioritizing the means of transport used. Finally, it was found that a large part of the population tends to move on foot, followed by the use of commercial and private public transport, with a maximum of five passengers. In addition, the most frequent reasons for transfer are for study and work activities; activities that fully influence mobility, therefore, a model based on public transport is recommended that provides service to the most demanding sectors, based on the existing road pattern without breaking into the urban center.

1. Introduction
As a result of the social, economic and technological changes directed to a new model of urban mobility that tends to be implemented globally, the need arises for a change that categorizes and links conflictive sectors related to 1) the increase in the average distances traveled, 2) changes in the reasons for displacement and 3) changes in the location of productive activities. [1]. The accelerated increase in the urbanization process has led to considerable evolutions in the area of infrastructure in the territories, making it necessary to assimilate the growing relationship of users. In this way, urban mobility acquires more elements related to displacements that include positive and negative effects [2]. Currently, mobility is considered as a high impact problem for social life, constituting, for its observation, a multidisciplinary, multidimensional phenomenon and a key factor for political, economic and socio-
cultural spheres [3]. Traditionally, the response to the increase in the number of users has been linked to the proposal of the urban transportation system, which is based on operational performance due to greater service in fewer units, however, it does not solve problems such as pollution or pollution. efficiency in mobility management [4]. Urban mobility has a great impact on the quality and way of life of the inhabitants, as well as on their economic development; Therefore, urban planning that sustains mobility has been an important issue in public administrations. In particular, the urban development model based on private motorized traffic presents important social and environmental impacts, allowing mobility plans to present transport alternatives with a lower polluting index and safer [5]. Introducing sustainable mobility as an urban policy implies, from planning, the notion of costs and impacts, understanding of movements not only in abstract terms of flow and efficiency, but also about time and quality of life [5], access roads, in especially on non-motorized vehicles and public transport, also, change the thinking that relates to speed as greater efficiency for one that reduces accident rates and therefore mortality and reduction of polluting effects. This would imply defining a mobility that ensures accessibility and proximity to goods and services.

Transportation systems need natural resources of all kinds: non-renewable fossil fuels, concrete and steel for the construction of infrastructure and raw materials for the manufacture of automobiles; therefore, the biggest problem is global environmental and energy sustainability, which explains current urban mobility [1]. The efficiency of a transport system has been measured only by its speed, speed becoming the evaluating parameter of the environment itself; however, the relationship between the space travelled and the time spent using the means of transport has been confused. Therefore, a transport system is effective if it is sustainable over time from environmental and social parameters. [6]. Experiencing an approach to reality, it can be observed that residents feel better in a city that provides a sense of security and friendly access, that is, that guarantees accessibility without architectural barriers [7]. Colin Buchanan in 1973, predicted that the automobile was here to stay and that it would not be easy to find substitutes for it and the problem would lie in the decision that the citizen decides, to what extent he would be willing to take his dependence on automobiles [8]. So then, we live in a society where three out of every four trips are made by motor vehicle. These data give a clear notion that human mobility is one of the activities that has the greatest impact on the environment and, therefore, should be the object of priority attention within sustainable development policies [9].

In the present work, an approach to the urban movement of the Sígsig canton in the Province of Azuay is described, starting from the question of what have been the evolution processes and what would be the current challenges for an urban displacement model? This question allowed us to identify not only negative aspects, but also to propose those necessary for a sustainable mobility route.

2. Statement of the problem

Mobility, in transport terminology, is a quantitative parameter, which measures the number of trips that users make, leading to a socio-economic issue; For this reason, it is conceptualized as the negative environment that must be faced without ceasing to satisfy human needs, desires and transfer objectives [10]. In addition, it is the cause of several problems that directly and indirectly affect the city, including lack of accessibility, unfair distribution of public space, traffic congestion, road safety, pollution, and it involves high energy consumption [11].

The cantonal head of Sígsig is located in the southern part of the country, in the foothills of the South Eastern mountain range of the Andes, east of the Province of Azuay, in the Sierra Sur region of Ecuador, it is part of the regional six of the national planning units and it is one of the seven parishes of the Sígsig canton, it should be mentioned that because it is classified as an urban parish, it does not have a representative of the parish, the municipality being the representative of the same, it is part of the district 01D08 and the circuit 01D0801 together with the parishes of San Bartolomé, Güel and Cuchil, published in the Official Gazette 290 of May 28, 2012. In the cantonal center there is an approximate fluctuation
of 2655 inhabitants per km² / day [12], which is why problems related to the mobility system are experienced, the characteristic of which can be assimilated as a mode in which the vehicle has the preference and pedestrians do not use the vehicles. assets intended for your safety, added to the disproportionate increase in passenger and goods service vehicles, whose units have a limited number of users; Furthermore, the system of road intersections does not correspond to optimal distances. Finally, a commercial centralization causes prolonged parking of vehicles, preventing a rotating system that generates accessibility to services. For this reason, this work focuses on a proposal for sustainable mobility, which is operatively free of the principles of an integrated travel system and is based on legal bodies referring to a balanced form of safe, efficient, effective and harmonious mobility. the population.

3. Research Justification

The study of sustainable mobility in cities and towns has made use of applied sciences such as traffic engineering, which, with a specialized basis, has facilitated behaviour, as well as measures for its improvement [13]. On the other hand, the current transport alternatives in the urban center of the Sígsig canton, especially that of land transport, are generating certain negatives for the development and security of the inhabitants and personnel of access to the service, especially in the commercial sector in where there are daily aspects of traffic disruption, transportation and road safety. In the urban center, it is not possible to evidence practices that force a change in the way of thinking in the face of a lack of regulation and control by the agencies in charge.

The mobility of the Sígsig canton, an urban area, has certain characteristics that make the service a partial solution, in many cases due to lack of will and in others due to ignorance; On the other hand, there is no compliance with the quality standards, which, added to the causes for behaviour issues of the main actors of the system (pedestrians and drivers), arises the need for the adoption of a sustainable integrated mobility regime that considers aspects of efficiency, effectiveness and decentralization of commerce by virtue of the use of public space. The dramatic increase in mobility registered, has generally required an in-depth analysis of the dynamics that occur in this sector, the purpose of which is to monopolize both environmental and travel problems [14].

4. Methodology

This study was carried out in the Canton Sígsig, province of Azuay, regarding the collection of information from the environment, qualitative and quantitative characteristics that make up the primary sources such as interviews, origin of destination and references of use of transport and places of concurrence, which were applied to users, who were categorized by the regular adoption of the transport service or permanent activity in the urban sector.

The data collection stage presents a reference history for the years 2019-2020, which was used for interview stages, origin-destination of the inhabitants, photographic documentation of the problems encountered and capacity at the intersections of direct central circulation. Within the sample universe, the inhabitants were prioritized by their employment, commercial, educational and services relationship, which allowed us to have a population notion around daily activities; Without underestimating tourist participation, a system of criteria was stimulated that made it possible to recommend short and long-term proposals resulting from cultural adoption in the face of mobility in the environment in which individuals develop. 792 surveys were carried out in the Field Research, this study obtained data on the main existing displacements in the urban center of the canton, taking into account the intervention of the actors that constitute it. The methods applied to the development of this study were: Analytical, Synthetic and descriptive, while defining the qualitative and quantitative variables. Regarding the development of variables for the use of this research work, they were measured in the ordinal qualitative and rational quantitative fields. Synthetic Method is a process of reasoning analysis that looks for a way to contribute to an event in a summarized way, using the different fundamental elements that were present in the development of the event.
4.1. Techniques and Instruments

4.1.1. Case study
This methodological technique is a valuable research tool, since it has a skill based on recording the behaviour of the sample population involved in the phenomenon studied [15].

4.1.2. Poll
The survey can be defined as a technique that uses a set of standardized exploration operations through which data is stored and examined, which allows obtaining and processing data immediately and efficiently; aimed at users, categorized by the activity or service performed.

4.2. Instrument

4.2.1. Observation sheet
Measuring the magnitude and importance of the study, the systematic, valid and reliable observation and recording of the behaviour or conduct of the main actors of the mobility system was indispensable. Therefore, by maintaining a primary objective of registration without interference, as an observer, the inspection of behaviour played an indispensable pattern to categorize the direction towards the demanding sectors of the set of central urban displacements.

4.2.2. Questionnaire
It is carried out as a tool for the execution of the set of questions, which will include questions, providing important necessary information for a proposal based on criteria and need. This instrument will allow to standardize and integrate data. The criterion of importance of this tool is due to the operation of one or more variables to be measured.

5. Presentation of results
5.1. Reasons for displacement.
Based on data collection techniques, the identification of users demanding the service was the starting point of this study. In the same way, to be exposed as a sector of study and importance, direct observation and follow-up analysis were carried out by implementing a form derived from a specific survey, which determined the reasons for the movement of users, which is presented in the figure one.

![Figure 1. Reasons for travel.](image)

5.2. Types of means of travel based on travel reasons
For the area of mobilization, depending on the mode of transport that provides services in the urban center and the surrounding environment, the means required for reasons of travel were analysed. Therefore, the developed area is divided into fields of interest, which are usually used for the development of activities to and from the center of Sígsig.
Table 1. Reason form traveling on foot.

| Reason                       | Quantity | Percentage |
|------------------------------|----------|------------|
| Study                        | 182      | 47.52%     |
| Job                          | 91       | 23.76%     |
| Receive a service            | 26       | 6.79%      |
| Purchases                    | 25       | 6.53%      |
| Do you play any sport        | 23       | 6.01%      |
| Events and shows             | 19       | 4.96%      |
| Pay for a service            | 8        | 2.09%      |
| Tourism recreation           | 8        | 2.09%      |
| Trade                        | 1        | 0.26%      |
| TOTAL SCORE                  | 383      | 100.00%    |

From the perspective of the reason for the trip on foot, the results of the study showed that, the subjects tend to displacement due to the incidence of learning and work activities, thus relating to services and leisure, with participations lower than 6.79% of the highest of the reasons secondary.

Table 2. Reason form traveling in Intraprovincial transport.

| Reason                        | Quantity | Percentage |
|-------------------------------|----------|------------|
| Job                           | 47       | 40.87%     |
| Study                         | 30       | 26.09%     |
| Receive a service             | 16       | 13.91%     |
| Purchases                     | 12       | 10.43%     |
| Tourism recreation            | 4        | 3.48%      |
| Trade                         | 3        | 2.61%      |
| Events and shows              | 2        | 1.74%      |
| Pay for a service             | 1        | 0.87%      |
| TOTAL SCORE                   | 115      | 100.00%    |

Analysing the data by transport groups, the Intraprovincial (table 2), is one of the sectors of connection between cantons, showing that the preference in this medium categorizes, in the foreground, the work reason followed by study, with 40.87% and 26.09% respectively; the situation of the service and leisure, is again inferior to the classified reasons. Regarding the reason for traveling in mixed transport, the results show that, by virtue of access to community and parish centers, most of the respondents travel by this route, participating in an informal circulation service. Therefore, under the same analysis scheme, the fields of work and study dominate; Furthermore, derived from the interpretation, a considerable group uses a medium to acquire goods or services.

Table 3. Reason for travel in mixed commercial transport.

| Reason                        | Quantity | Percentage |
|-------------------------------|----------|------------|
| Job                           | 70       | 36.46%     |
| Study                         | 52       | 27.08%     |
| Purchases                     | 36       | 18.75%     |
| Receive a service             | 25       | 13.02%     |
| Trade                         | 3        | 1.56%      |
| Events and shows              | 3        | 1.56%      |
| Pay for a service             | 2        | 1.04%      |
| Tourism recreation            | 1        | 0.52%      |
| TOTAL SCORE                   | 192      | 100.00%    |
Table 4. Reason for travel in private motorized transport.

| Reason                | Quantity | Percentage |
|-----------------------|----------|------------|
| Job                   | 45       | 44.12%     |
| Study                 | 23       | 22.55%     |
| Purchases             | 12       | 11.76%     |
| receive a service     | 12       | 11.76%     |
| events and shows      | 5        | 4.90%      |
| Trade                 | 4        | 3.92%      |
| Tourism recreation    | 1        | 0.98%      |
| **TOTAL SCORE**       | **102**  | **100.00%**|

In the private automotive sector, work and study activities dominate and it is a sector that in relation to the survey universe represents 12.79%, also, purchasing and service reception activities are added, both with 11.76%. Regarding the causes of relocation, this study highlights two important reasons that respond to the common objective of displacement in the population. In addition, it has a binding criterion for centric mobility; Whether it deals with direct or indirect transport, the use of them inevitably causes urban central circulation.

Table 5. Pedestrian mobility for work reasons.

| Route                        | Quantity | Percentage |
|------------------------------|----------|------------|
| Sígsig center - Sígsig center| 53       | 58.24%     |
| Güeł - Güeł                  | 12       | 13.19%     |
| Sígsig center - Sígsig periphery | 10   | 10.99%     |
| Güeł - Sígsig periphery      | 5        | 5.49%      |
| Sígsig periphery - Sígsig periphery | 4  | 4.40%      |
| Güeł- Sígsig center          | 2        | 2.20%      |
| Cuchil-Cuchil                | 2        | 2.20%      |
| Sígsig center - Cuchil       | 1        | 1.10%      |
| Sígsig periphery - Sígsig center | 1  | 1.10%      |
| Güeł-Chordeleg               | 1        | 1.10%      |
| **TOTAL SCORE**              | **91**   | **100.00%**|

In the same way that the study of the ratio between the reasons for transfer and means of transport has been carried out, the incidence of displacement by route of origin to destination is characterized. Therefore, table 5 shows that 98.9% have an intracantonal displacement (within cantonal limits) for work reasons. However, the content of table 6, concerning the study, responds to a mobility distributed in 58.79% urban and 41.21% inter-parish; for this reason, it responds to a peripheral displacement that circulates through the cantonal center.

Table 6. Pedestrian mobility for study reasons.

| Route                        | Quantity | Percentage |
|------------------------------|----------|------------|
| Sígsig center - Sígsig center| 107      | 58.79%     |
| Güeł - Güeł                  | 36       | 19.78%     |
| Sígsig center - Sígsig periphery | 12   | 6.59%      |
| Güeł - Sígsig center         | 9        | 4.95%      |
| San Bartolomé- San Bartolomé | 8        | 4.40%      |
| Sígsig periphery - Sígsig periphery | 6  | 3.30%      |
| Sígsig -center Cuchil        | 3        | 1.65%      |
| Sígsig - center Güeł         | 1        | 0.55%      |
| **TOTAL SCORE**              | **182**  | **100.00%**|

Although the previous results are based on intracantonal analysis, focused on work and educational reasons; However, the intercantonal scope (between cantons) was also considered as an appropriate question, directed by the connectivity of displacement. From the analysis presented in table 7, it shows
that the route that connects the urban center to Cuenca and San Bartolomé-Cuenca, constitutes 29.79% and 19.15% respectively, ratifying the demand for service. Regarding the educational motive, referring to table 8 indicates that 63.33% use this means of transport for an urban intracantonal circulation.

**Table 7. Mobility in intraprovincial transport for work reasons.**

| Route                        | Quantity | Percentage |
|------------------------------|----------|------------|
| San Bartolomé - Cuenca       | 14       | 29.79%     |
| Sígsig center-Cuenca         | 9        | 19.15%     |
| Sígsig periphery - Gualaceo  | 4        | 8.51%      |
| Sígsig periphery - Cuenca    | 3        | 6.38%      |
| Sígsig periphery - Sígsig center | 3  | 6.38%      |
| Sígsig center - Gualaceo     | 2        | 4.26%      |
| Sígsig center - Sígsig periphery | 2  | 4.26%      |
| San Bartolomé - Gualaceo     | 2        | 4.26%      |
| San Bartolomé - Sígsig center| 2        | 4.26%      |
| Sígsig center - Chordeleg    | 2        | 4.26%      |
| Sígsig periphery - Chordeleg | 1        | 2.13%      |
| Cuenca - Sígsig center       | 1        | 3.33%      |
| Sígsig center - San Bartolomé| 1        | 2.13%      |
| Sígsig center - Sígsig center| 1        | 2.13%      |
| **TOTAL SCORE**              | 47       | 100.00%    |

**Table 8. Mobility in intraprovincial transport for educational reasons.**

| Route                        | Quantity | Percentage |
|------------------------------|----------|------------|
| Sígsig center-Cuenca         | 7        | 23.33%     |
| Sígsig periphery - Sígsig center | 19   | 63.33%     |
| Sígsig periphery - Cuenca    | 2        | 6.67%      |
| Cuenca - Sígsig center       | 1        | 3.33%      |
| Sígsig center - Sígsig center| 1        | 3.33%      |
| **TOTAL SCORE**              | 30       | 100.00%    |

Although from analyses previously described where displacements and their territorial modalities are appreciated, it is worth emphasizing the mixed commercial public sphere, which has become one of the means with the greatest supply in view of existing demand in the inter-parish and urban centric sphere; for this reason, their displacement in the work and educational reasons, responds to a local mobility.

**Table 9. Mobility in mixed transport for work reasons.**

| Route                        | Quantity | Percentage |
|------------------------------|----------|------------|
| Sígsig periphery - Sígsig center | 30    | 42.86%     |
| Sígsig center - Sígsig periphery | 10   | 14.29%     |
| Güel - Sígsig center         | 8        | 11.43%     |
| Cuchil - Sígsig center       | 8        | 11.43%     |
| Sígsig center - Sígsig center| 5        | 7.14%      |
| Sígsig center - Cuchil       | 3        | 4.29%      |
| Cuchil - Sígsig periphery    | 3        | 4.29%      |
| Sígsig center - cuenca       | 2        | 2.86%      |
| Sígsig center - Güel         | 1        | 1.43%      |
| **TOTAL SCORE**              | 70       | 100.00%    |
Table 10. Mobility in mixed transport for study reasons.

| Route                                      | Quantity | Percentage |
|--------------------------------------------|----------|------------|
| Sígsig periphery - Sígsig center           | 30       | 57.69%     |
| Güel - Sígsig center                       | 11       | 21.15%     |
| Cuchil- Sígsig center                      | 6        | 11.54%     |
| Sígsig center- Sígsig center               | 4        | 7.69%      |
| San Bartolomé -Sígsig center               | 1        | 1.92%      |
| **TOTAL SCORE**                            | **52**   | **100.00%**|

In the case of transportation by private vehicle, the displacements respond to intracantonal and intercantonal circulations, being 64.44% and 35.56% respectively; for work reasons. In the field of study, 47.82% present an urban circulation, 26.09% intercantonal and 26.09% from parishes to the cantonal center.

Table 11. Mobility in private transport for work reasons.

| Route                  | Quantity | Percentage |
|------------------------|----------|------------|
| Sígsig center-Sígsig center | 9        | 20.00%     |
| Sígsig center-cuenca   | 6        | 13.33%     |
| Sígsig periphery -Sígsig center | 5        | 11.11%     |
| Sígsig center-Sígsig periphery | 5        | 11.11%     |
| Sígsig center-Gualaceco | 4        | 8.89%      |
| Güel -Sígsig center     | 3        | 6.67%      |
| Sígsig center- Ludo     | 2        | 4.44%      |
| Güel -Güel              | 2        | 4.44%      |
| Sígsig periphery -Cuenca | 2        | 4.44%      |
| Sígsig center-Chigunda  | 1        | 2.22%      |
| Sígsig center-Cuchil    | 1        | 2.22%      |
| Sígsig center-Chordeleg | 1        | 2.22%      |
| Güel-Cuenca             | 1        | 2.22%      |
| Cuchil- Sígsig center   | 1        | 2.22%      |
| Sígsig center-San Bartolomé | 1        | 2.22%      |
| Sígsig center- Guayaquil | 1        | 2.22%      |
| **TOTAL SCORE**         | **45**   | **100.00%**|

Table 12. Mobility in private transport for study reasons.

| Route                  | Quantity | Percentage |
|------------------------|----------|------------|
| Sígsig center-Sígsig center | 7        | 30.43%     |
| Güel -Sígsig center     | 6        | 26.09%     |
| Sígsig center - Cuenca  | 5        | 21.74%     |
| Sígsig periphery -Sígsig center | 3        | 13.04%     |
| Sígsig center-Chordeleg | 1        | 4.35%      |
| Sígsig periphery -Sígsig periphery | 1        | 4.35%      |
| **TOTAL**               | **23**   | **100.00%**|

Regarding the results of the joint survey, it is observed that foot traffic is the most used method, representing 48.36% of the total, followed by mixed commercial transport. In addition, the rate of use of private vehicles occupies the fourth place with 13.51% differentiated from 1.01% of intraprovincial traffic.
### Table 13. Means of transport for the urban population of Sígsig and its area of influence.

| Type of transport                  | Quantity | Percentage |
|-----------------------------------|----------|------------|
| 0. walk                           | 383      | 48.36%     |
| 1. Urban bus                      | 0        | 0.00%      |
| 2. Intracantonal bus              | 0        | 0.00%      |
| 3. Intraprovincial bus            | 115      | 14.52%     |
| 4. Interprovincial bus            | 0        | 0.00%      |
| 5. School and institutional bus    | 0        | 0.00%      |
| 6. Conventional taxis             | 0        | 0.00%      |
| 7. Executive taxi                 | 0        | 0.00%      |
| 8. Mixed transport                | 192      | 24.24%     |
| 9. Light load                     | 0        | 0.00%      |
| 10. Heavy load                    | 0        | 0.00%      |
| 11. Bicycle                       | 0        | 0.00%      |
| 12. Motorcycle                    | 0        | 0.00%      |
| 13. Automobile                    | 53       | 6.69%      |
| 14. Jeep                          | 15       | 1.89%      |
| 15. Pickup                        | 32       | 4.04%      |
| 16. Van                           | 2        | 0.26%      |
| **TOTAL SCORE**                   | 792      | 100.00%    |

### 6. Conclusions

Based on the survey results, it can be concluded that urban circulation in Sígsig is directly related to the causes of displacement and the means of transport used to carry out this action. In the case of transport by pedestrian means, it represents 48.36% of the total, thus being the model that dominates downtown urban circulation.

The flow of study and work activities accounted for 36.24% and 31.94%, representing 68.18% of all surveys. On the other hand, when comparing services and acquisitions, similar values are obtained, corresponding to the purchase rate of 10.73% and the rate of reception of services of 9.97%; Furthermore, the activity with the lowest incidence in the canton turned out to be commerce, obtaining a value equivalent to 1.39% of the population studied. Given that this is the basis for solving the problem, it is concluded that the urban population presents particularities of displacement rather than commercial ones, which affirms the flow of origin and destination in different modes of transport, confirming the importance of adopting a sustainable model of transport. public passenger service.

The new model of sustainable mobility must show characteristics of effective, efficient and orderly services, which will be based on uncongested and non-monopolistic circulation, referring to mixed transport used by 24.24% of the population. On the other hand, being a demanding service, it will be based on good practices and strategic circulation, covering priority areas and grouping essential frequency services.

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