Green transportation: Development opportunities in support of sustainable transportation

Sri Sarjana

Abstract. Green transportation is a concept developed by utilizing vehicles that are environmentally friendly in an urban environment [1]. The concept of transportation sustainability that is applied through green transportation assumes the sustainability of life in an urban environment [1]. Green transportation is expected to be able to reduce the effects of global warming and climate change which have a serious impact on life and ecosystems, although this effort is still considered less desirable [2]. Sustainability of smart life can be created through a smart environment to improve people's welfare [3]. A rapid increase in green transportation studies is being carried out in order to obtain the latest models that can be applied in various fields of human life, including various efforts that are continuously being made to improve transportation efficiency and reduce energy consumption [4], there is a threat to environmental conditions and perceived environmental discomfort [5], efforts to create smart model vehicles in the development of smart cities [6]. It is important to meet the rapidly increasing demand for energy in electric vehicles and the demand for hybrid renewable energy including wind, solar photovoltaic and battery energy storage is demanded to grow even faster [7], necessary to carry out a transition to electric vehicles that are implemented through the convergence of mobility and energy that are beneficial to society [1], the need for an electric car that has a reliable battery [8] and need to develop a comprehensive mode of public transportation based on environmentally friendly fuels [9]. Various solutions have been presented in encouraging the development of green transportation which have been published in various previous studies. However, many of the solutions given still tend to be stated partially, such as the development of green transportation carried out in China, Qatar, Singapore or in other countries. The various solutions offered from many studies are unique in the effort to develop green transportation include an efficient green transportation scheduling system to reduce transportation costs, reduce the level of environmental damage, reduce fuel consumption and greenhouse gas emissions which can be done by implementing the augmented ε-constraint method [10]. In addition, Transport Impact Assessment (TIA) process needs to develop a plan to address traffic externalities and secure resources in encouraging the use of modes that prioritize green transportation [11]. Another solution can be implemented by developing an Electronic Toll Collection (ETC) road pricing model that prioritizes the perspectives of road users, governments and agents to achieve green transportation that takes into account environmental impacts and potential accidents by implementing a comprehensive Green Safety Indicator (GSI) [12]. Green transport

1 Introduction

The growth of last five years, study for the development of green transportation around the world has become an important concern for academics and researchers to encourage the need for sustainable transportation. The concept of transportation sustainability that is applied through green transportation assumes the sustainability of life in an urban environment [1]. Green transportation is expected to be able to reduce the effects of global warming and climate change which have a serious impact on life and ecosystems, although this effort is still considered less desirable [2]. Sustainability of smart life can be created through a smart environment to improve people's welfare [3]. A rapid increase in green transportation studies is being carried out in order to obtain the latest models that can be applied in various fields of human life, including various efforts that are continuously being made to improve transportation efficiency and reduce energy consumption [4], there is a threat to environmental conditions and perceived environmental discomfort [5], efforts to create smart model vehicles in the development of smart cities [6]. It is important to meet the rapidly increasing demand for energy in electric vehicles and the demand for hybrid renewable energy including wind, solar photovoltaic and battery energy storage is demanded to grow even faster [7], necessary to carry out a transition to electric vehicles that are implemented through the convergence of mobility and energy that are beneficial to society [1], the need for an electric car that has a reliable battery [8] and need to develop a comprehensive mode of public transportation based on environmentally friendly fuels [9]. Various solutions have been presented in encouraging the development of green transportation which have been published in various previous studies. However, many of the solutions given still tend to be stated partially, such as the development of green transportation carried out in China, Qatar, Singapore or in other countries. The various solutions offered from many studies are unique in the effort to develop green transportation include an efficient green transportation scheduling system to reduce transportation costs, reduce the level of environmental damage, reduce fuel consumption and greenhouse gas emissions which can be done by implementing the augmented ε-constraint method [10]. In addition, Transport Impact Assessment (TIA) process needs to develop a plan to address traffic externalities and secure resources in encouraging the use of modes that prioritize green transportation [11]. Another solution can be implemented by developing an Electronic Toll Collection (ETC) road pricing model that prioritizes the perspectives of road users, governments and agents to achieve green transportation that takes into account environmental impacts and potential accidents by implementing a comprehensive Green Safety Indicator (GSI) [12]. Green transport
scheduling can be implemented through Evolution-Strategy-Based Memetic Pareto Optimization (ESMPO) by implementing a multi-objective search process for a faster sorting procedure in the memetic algorithm as a multi-objective sorting step [13]. Electromobility is a new form of development in the application of green transportation that prioritizes traffic safety and solves mobility problems related to environmental and social impacts on the transportation aspect [14-15], directed to become a future transportation need that shifts industry and markets to the era of electric vehicles which have a dependence on electricity generated by the energy sector which requires policies that accommodate the transportation and energy sectors simultaneously in promoting electric vehicles [16].

The categorization of green transportation is related to determining the type of vehicle with clean technology such as electric buses where electric vehicles emit zero exhaust emissions which can ensure clean air and it is hoped that clean technology will be more in demand in densely populated areas which aim to have good air quality and be more liveable [17], the exploitation of green transportation is able to lighten the ecological burden to encourage the creation of a sustainable environment [18]. Transport planning plays an important role in building an integrated transportation system and evaluation of green transportation can apply the results of previous traffic planning regarding the evaluation methods and models used [19-20]. Smart city development requires the promotion of energy efficiency in urban areas with an accurate level of data reliability which is heavily influenced by the effects of global urbanization so that efficient energy management can be actualized through the utilization of green transportation [21]. Knowledge development in the development of green transportation needs to apply a strategic approach in concocting the diversity of knowledge in various sectors obtained through searching scientific articles to find knowledge concepts that have novelty values for future knowledge development. The expected goals in the study are directed to find a concept that has a novelty that is derived from green transportation in encouraging the development of a sustainable transportation system.

2 Method

The trend of urban development is experiencing rapid growth which introduces many green transportation concepts in an effort to support transportation sustainability. Mapping the concept of green transportation as an important part in developing urban governance is the main objective studied in order to explore and deepen understanding of the need for environmentally friendly transportation through scientific evolutionary exploration. Qualitative studies are applied by utilizing scientific literature through searching journal publications on the concept of green transportation in order to create sustainable cities with the support of green transportation systems that consider future transportation needs. A qualitative approach can be applied through bibliometric analysis by developing a meta-analysis of the scientific literature obtained according to the concepts studied [22].

A qualitative approach can apply meta-analysis in managing scientific journal publications based on the study topics obtained [23]. Data sources from various scientific literature can be studied through meta-analysis [24]. To generate trends in the development of scientific publications, mastery of scientific evolution is required [25]. Scientific evolution is an important part for the knowledge development of evolution in line with the concepts studied in order to encourage the strengthening of knowledge radically in line with the latest required trends. Recent issues that have relevance to the concept under study need to get attention and become findings to encourage the development of up-to-date knowledge. Analysis on a collection of scientific publications is carried out using the VOSviewer to present a visualization of the results referring to the concept being studied. VOSviewer generates in the form of network and density visualizations [26].

Journal publications as part of the main data were obtained through searches using publish or perish which were collected systematically from Google Scholar in March 2023. The databases that were successfully collected on the concept of green transportation were arranged according to 2018-2022 timeframe. To obtain a database according to the concept being studied by entering the keywords green transportation. The initial selection was obtained by scientific journals of 4920 articles according to the concept of green transportation. Five time periods were selected based on the time span of publication in order to facilitate interpretation and analyzed the feasibility of the data. Cluster analysis was carried out on the findings of each time period presented referring to concept categorization in order to facilitate the discovery of developments of concept derivatives that have the potential to have novelty.

The search for scientific journals referred to the concept of green transportation according to the sequence of stages starting from data collection to the process of bibliometric analysis aimed at obtaining concepts that have novelty values (Fig. 1.). The novelty obtained which is presented in the form of a derivative concept can be an important part that generates new knowledge for future development. The study paradigm applied refers to the preferred reporting items for systematic reviews and meta-analysis (PRISMA) [27-29].

3 Result and Discussion

The results of meta-analysis in the bibliometric pattern are shown to be interactive and interesting related to the concept of green transportation which can be recognized easily through network and density visualization. The data obtained from 4920 scientific journals was then processed following the steps in the preferred reporting items for systematic reviews and meta-analysis. In addition, the calculation of citation values and indexes is also carried out every year to find out the ongoing publication trends. Furthermore, VOSviewer is implemented as a tool in analyzing green transportation
in order to obtain derivative concepts that are expected
to have novelty values that can be useful for knowledge
development. The use of this application program is
currently experiencing quite rapid development in an
effort to find various novelties related to concepts,
theories or knowledge that have the potential to have an
important role, especially in the development of green
transportation that supports sustainable transportation.

The classification of green transportation derivatives
is presented in six clusters during the publication period
of the last five years, referring to Table 2. In the latest
year's publication, it can be seen that there are several
new concept derivatives that have not appeared and have
not been studied in the previous year. Several derivative
concepts can be found in clustering including green bond, green open space, green hydrogen, hole transport
layer, narrative transportation, green gentrification and
green port. The development for the concept of green
transportation has seen remarkable progress in the last
five years of publication review where several new
concept derivatives were found (Table 3). Knowledge
development through further studies in developing the
novelty found as an effort to develop knowledge for
improving the quality of knowledge in the future as well
as supporting the development of sustainable
transportation system.

Refer to Table 1 which shows that even though the
number of papers obtained each year is not the same,
with a slight difference, it does not reduce the quality of
the results obtained. Even though there has been a
downward trend in publications from 2018 to 2022 due
to the relatively shorter publication time in the newer
year. However, with the exception of the author per
paper category, which has an increasing trend, it means
that journal publications in recent years have a greater
number of authors.

<table>
<thead>
<tr>
<th>Citation Metric</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Papers</td>
<td>990</td>
<td>989</td>
<td>983</td>
<td>971</td>
<td>989</td>
</tr>
<tr>
<td>Citation</td>
<td>52830</td>
<td>44977</td>
<td>32044</td>
<td>20824</td>
<td>6389</td>
</tr>
<tr>
<td>Cites/year</td>
<td>10566</td>
<td>11244</td>
<td>10681</td>
<td>10412</td>
<td>6389</td>
</tr>
<tr>
<td>Cites/paper</td>
<td>.00</td>
<td>.25</td>
<td>.33</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Authors/paper</td>
<td>53.36</td>
<td>45.48</td>
<td>32.60</td>
<td>21.45</td>
<td>6.46</td>
</tr>
<tr>
<td>h-index</td>
<td>3.41</td>
<td>3.41</td>
<td>3.55</td>
<td>3.59</td>
<td>3.67</td>
</tr>
<tr>
<td>g-index</td>
<td>115</td>
<td>104</td>
<td>83</td>
<td>67</td>
<td>30</td>
</tr>
<tr>
<td>hA-index</td>
<td>39</td>
<td>41</td>
<td>39</td>
<td>42</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 1. Characteristics of journal publications on the
Table 2. Clustering in classifying the concept of green transportation.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Concept Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2022</td>
</tr>
<tr>
<td>1</td>
<td>Active transportation, air pollution, energy conservation, green bond, green area, green economy, green infrastructure, green space, green travel, high speed rail, public transport, sustainable transportation, urban area, transport infrastructure</td>
</tr>
<tr>
<td>2</td>
<td>Environmental performance, environmental sustainability, green credit policy, green distribution, green innovation, green job, green logistic, green manufacturing, green packaging, green technology, green warehousing, green transportation, heat transport</td>
</tr>
<tr>
<td>3</td>
<td>Circular economy, electric vehicle, electrification, green energy, green hydrogen, green open space, green vehicle, hydrogen economy, hydrogen production, transportation industry, maritime transportation, sustainable development</td>
</tr>
<tr>
<td>4</td>
<td>Climate change, electron transport, environmental pollution, freight transport, hole transport layer, mass transport, narrative transportation, transport behaviour, transport property</td>
</tr>
<tr>
<td>5</td>
<td>Carbon emission, energy consumption, renewable energy, transportation cost, transportation time, transportation activity</td>
</tr>
</tbody>
</table>
### Table 2 (continued). Clustering in classifying the concept of green transportation.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Concept Classification</th>
<th>2022</th>
<th>2021</th>
<th>2020</th>
<th>2019</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Green building, green finance, green port, maritime transport</td>
<td>Green space, green gentrification, transport infrastructure, internet of think</td>
<td>Blockchain technology, energy consumption, intelligent transportation, smart city, transportation industry, urban transport</td>
<td>Narrative transportation, green time</td>
<td>Environmental sustainability, green building, green maintenance, methodology</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3. Publications based on the top ten rankings and the largest number of citations on the concept of green transportation.

<table>
<thead>
<tr>
<th>Rank</th>
<th>TC</th>
<th>APY</th>
<th>Title</th>
<th>Source</th>
<th>Authors</th>
<th>Cite</th>
<th>SJR</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>250</td>
<td>50.00</td>
<td>A review on air emissions assessment: Transportation</td>
<td>Journal of cleaner production</td>
<td>Y Van Fan, S Perry, JJ Klemeš, CT Lee</td>
<td>[32]</td>
<td>15.8</td>
</tr>
<tr>
<td>3</td>
<td>244</td>
<td>48.80</td>
<td>Green supply chain management, economic growth and environment: A GMM based evidence</td>
<td>Journal of cleaner production</td>
<td>SAR Khan, Y Zhang, M Anees, H Golpîra</td>
<td>[33]</td>
<td>15.8</td>
</tr>
<tr>
<td>4</td>
<td>241</td>
<td>48.20</td>
<td>A new holistic conceptual framework for green supply chain management performance assessment based on circular economy</td>
<td>Journal of cleaner production</td>
<td>Y Kazancoglu, I Kazancoglu, M Sagnak</td>
<td>[34]</td>
<td>15.8</td>
</tr>
<tr>
<td>5</td>
<td>190</td>
<td>47.50</td>
<td>Defending blue sky in China: Effectiveness of the “Air Pollution Prevention and Control Action Plan” on air quality improvements from 2013 to 2017</td>
<td>Journal of Environmental Management</td>
<td>Y Feng, M Ning, Y Lei, Y Sun, W Liu, J Wang</td>
<td>[35]</td>
<td>11.4</td>
</tr>
<tr>
<td>6</td>
<td>176</td>
<td>44.00</td>
<td>Spatiotemporal traffic flow prediction with KNN and LSTM</td>
<td>Journal of Advanced Transportation</td>
<td>X Luo, D Li, Y Yang, S Zhang</td>
<td>[36]</td>
<td>3.7</td>
</tr>
<tr>
<td>7</td>
<td>159</td>
<td>31.80</td>
<td>Lean and green combine to impact environmental and operational performance</td>
<td>International Journal of Production Research</td>
<td>RA Inman, KW Green</td>
<td>[37]</td>
<td>14.6</td>
</tr>
<tr>
<td>8</td>
<td>159</td>
<td>31.80</td>
<td>Optimal scheduling of plug-in electric vehicles and renewable microgrid in energy and reserve markets considering demand response program</td>
<td>Journal of cleaner production</td>
<td>P Aliasghari, B Mohammadi-Ivatloo, M Alipour</td>
<td>[38]</td>
<td>15.8</td>
</tr>
<tr>
<td>9</td>
<td>154</td>
<td>38.50</td>
<td>Environmental, social and economic growth indicators spur logistics performance: from the perspective of South Asian Association for Regional Cooperation countries</td>
<td>Journal of cleaner production</td>
<td>SAR Khan, C Jian, Y Zhang, H Golpîra, A Kumar</td>
<td>[39]</td>
<td>15.8</td>
</tr>
<tr>
<td>10</td>
<td>153</td>
<td>30.60</td>
<td>Corporate environmental sustainability in the retail sector: Drivers, strategies and performance measurement</td>
<td>Journal of cleaner production</td>
<td>M Naidoo, A Gasparatos</td>
<td>[40]</td>
<td>15.8</td>
</tr>
</tbody>
</table>

Visualization of the network and density is shown in an interactive and attractive display referring to Fig. 2-3. The linkages between concepts illustrated through the links between nodes indicate that there is a relationship between concepts that connect each other. The large number of journal publications on a particular topic is represented by the size of nodes formed. Greater the number of journal publications, larger the node size.
While the color of nodes classifies groups or clusters that have the suitability of the concept being studied. The same node color shows that the concept under study has clusters that have similarities. In addition to node size, the color brightness generated in the density visualization also indicates the number of publications produced. The brighter color, greater the number of publications found. Opportunities for new concepts exist in areas that have low color brightness, but still need to be filtered and considered with previously published concepts.

Fig. 2. Network visualization on green transportation.

Fig. 3. Density visualization on green transportation.

The large size of nodes indicates that the concept has been studied in many previous publications. Meanwhile, the small size of the node means that the number of publications is still low and even has the possibility of finding new concepts. Vehicle emission, environmental protection, green initiative, green economy, green supply chain, green distribution, and green warehousing. It is still rare for studies on concepts that have small node sizes expected for researchers and academics to be able to follow up to be researched in the
future to increase studies especially those that are relevant to sustainable transportation.

The linkages between green transportation and several derivative concepts generated through bibliometric analysis refer to Fig. 4. Several derived concepts that have an important role in the development of green transportation can be shown by their linkages through links connected to green transportation including green supply chain, green manufacturing, green packaging, green logistics, green production, carbon emission, air pollution, environmental impact, technology challenge, smart city, electric vehicle, bicycle and sustainable development. Derivative concepts obtained from the existence of links shown through links that connect with green transportation have the opportunity to be followed up for the development of further studies that support efforts to optimize sustainable transportation.

Clustering of authors based on network visualization (Fig. 5) shows that the same colour group addresses research concepts that have good fit. The dominance of discussion on the concept of green transportation can be seen in each cluster which is interrelated to one another. Several top authors are the main references for each cluster, for example those controlled by Wang Y, Zhang Y, Liu Y, Zhang X, Wang J, Li Y, Wang Z and Xu L. The names of authors displayed are very easy to identify from the country where the authors come from, China. In addition, this presentation is able to answer which country is the most dominant in journal publications and conduct studies on the concept of green transportation. For this reason, it is important to develop green transportation and its derivative concepts through knowledge development, such as the various developments that have been carried out by authors in China who have contributed a lot to the development of transportation systems and sustainable urban development, as has happened recently.

### 4 Conclusion

Green transportation studies in various urban areas require references and benchmarks for designing environmentally friendly cities. Results of the study state that there has been an increase in the discussion of the concept of green transportation published in scientific journals which has a positive trend based on data published in the last five years. The concept of green transportation contributes to developing sustainable transportation for the development of urban areas through the use of various resources and infrastructure to be integrated with each other by adopting environmentally friendly technologies to create sustainable cities. The characteristics of sustainable city are characterized by a physically active population that supports the creation of a sustainable environment [41].

Green transportation studies need to be encouraged to strengthen the depth of the discussion and need to be studied further through knowledge development. Several findings derived from the concept of green transportation found in the process of scientific evolution and potential to have important novelty values to be followed up in the future include green supply chain, green warehousing, green distribution, green logistics, green manufacturing, green production, green packaging, green infrastructure, green economy, green marketing, green initiatives, clean energy, emission reduction, new energy vehicles and green cities. These findings were obtained referring to network and density visualization as analytical material for this it is felt important for academics and researchers to be able to
study more deeply in order to improve quality in urban development through the development of green transportation that is in harmony with sustainable development. In addition, the government needs to make policies in the development of transportation infrastructure by participating actively in promoting environmental sustainability programs by introducing a green transportation system which is an important requirement at this time to ensure the country's sustainable development [42], need to be encouraged to develop renewable energy and create green energy [43]. In addition, it is necessary to use green transportation applications to help increase the efficient use of transportation [44].

Fig. 5. The connectedness of authors in studying green transportation.

References


Knowledge development of spiritual resilience concepts faced during the Covid-19 pandemic in meta-analysis.