Transportation Research Interdisciplinary Perspectives 29 (2025) 101293

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: www.sciencedirect.com/journal/transportation-research-interdisciplinary-perspectives

Policy options for low-carbon sustainable transport systems in Kathmandu Valley, Nepal: A survey-based study

Jyoti Prajapati [a,b,*], Maheswar Rupakheti [a], Mark G. Lawrence [a,c]

[a] Research Institute for Sustainability – Helmholtz Centre Potsdam (RIFS), Potsdam, Germany
[b] Department of Environmental Systems Sciences, University of Graz, Graz, Austria
[c] Institute of Environmental Sciences and Geography, University of Potsdam, Potsdam, Germany

ARTICLE INFO

Keywords:
Low-carbon pathways
Climate change
Air pollution
Stakeholder surveys
Sustainable transport policies
Avoid-Shift-Improve approach

ABSTRACT

Mobility and transport activities have increased significantly over the past few decades in the Kathmandu Valley, a metropolitan region in Nepal and one of the fastest-growing cities in South Asia. In order to identify the low carbon sustainable transport (LCST) policy measures that fit the local context, we investigated the perceptions of stakeholders with a background and interest in the local transport system. The study is guided by the 'avoid-shift-improve (ASI)' approach and involves two rounds of consultation with key stakeholders using the Delphi method to carefully examine the local conditions and select potential policy options. We found that the stakeholders considered cost-effective planning, regulatory and technological ASI measures (e.g., integrating transport systems, vehicle inspection and maintenance, tax rebates, promoting electric vehicles and public buses) as the most preferred policies and of the highest importance. In contrast, financial (e.g., increasing tax and fuel price) and highly technological measures were considered moderately or least-preferred policies. The identified combination of policy options is expected to be suitable for developing a LCST system in the local context of the Kathmandu Valley, offering several co-benefits, including reduced emissions of harmful air pollutants and greenhouse gases, as well as improved social equity and economic development. The approach demonstrated here can be useful as a model for other developing cities in South Asia and elsewhere.

1. Introduction

1.1. Background

Transport is a major contributor to the emission of greenhouse gases (GHGs) and air pollutants worldwide due to its heavy reliance on fossil fuels. The share of global energy-related carbon dioxide (CO_2) emissions from the transport sector is 24 %, with an average annual increase of 1.9 % since 2000 (IEA, 2020). Between 2010 and 2019, emissions from the transport sector continue to grow faster than any other sector contributing to fossil fuel combustion, with the highest share of emissions from road transportation (IEA, 2020; SLOCAT, 2021). Although per capita transport demand in developing and emerging economies is lower than in OECD (Organization for Economic Co-operation and Development) countries, it is expected to increase rapidly in coming decades due to increasing incomes and infrastructure development in the developing countries (IPCC, 2014). Increased motorization of transport has resulted in traffic congestion, GHG emissions, air pollution, and other challenges in rapidly developing cities worldwide (SLOCAT, 2021). In order to slow or reverse these alarming trends, urgent action would be needed to develop sustainable mobility[1] solutions (GEF-STAP, 2010). As part of the 2015 Paris Agreement, more than three-quarters of the nationally determined contributions (NDCs) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) explicitly identify the transport sector as a mitigation priority, around two-thirds propose sectoral mitigation measures, and ca. 10 % include specific transport sector emissions reduction targets (PPMC, 2016).

Asian countries will account for over half of the global population by the middle of the 21st century and are undergoing a substantial transition in demographic profiles, urbanization, industrialization, and

* Corresponding author.
E-mail address: jyoti.prajapati@uni-graz.at (J. Prajapati).

[1] "Mobility" and "transport" are two frequently used terms in transport management. Mobility relates to the total amount of travel undertaken using all forms of transport, while transport is considered broader than mobility including the modes of transport as well as the supply of transport. However, they are closely related and most often they are considered in a synonymous way (GIZ-SUTP, 2014).

https://doi.org/10.1016/j.trip.2024.101293
Received 9 May 2023; Received in revised form 30 October 2024; Accepted 3 December 2024
Available online 30 December 2024

income (Shukla and Dhar, 2015). From 2010 to 2019, Asia experienced the highest increase in transport CO_2 emissions with a share of 41 % among world regions (SLOCAT, 2021). Within Asia, studies of low carbon transport systems are mostly focused on large developing countries like India and China, while there are limited studies related to low carbon sustainable transport system in smaller countries like Nepal (Shrestha and Rajbhandari, 2010; Shakya and Shrestha, 2011; Dhital and Shakya, 2014; Dhakal, 2003; Dhakal, 2006; Sadavarte et al., 2019), where climate change mitigation is needed across all sectors to limit GHG emissions. Most existing studies on transport in Nepal focused primarily on two aspects: (a) transport energy, such as energy policy analysis (Shukla and Dhar, 2015; Shrestha and Rajbhandari, 2010) and energy demand (Bajracharya and Bhattarai, 2016; Malla, 2014), and (b) transport emissions, including the development of emissions inventory (Sadavarte et al., 2019; Das et al., 2022) and emissions estimation (Dhakal 2006; Bhusal et al., 2024; Mool et al., 2020; Das et al., 2018). Studies on low carbon sustainable transport are limited to specific transport policies and transport modes (Dhakal, 2003; Dhital and Shakya, 2014; Pokharel and Acharya, 2015; Khanal et al., 2017; Mishra et al., 2020; Pahari et al., 2021; Khadgi et al., 2020; Regmi 2020; Prajapati et al., 2021; Mali et al., 2022). While these studies have deepened our understanding of the technical aspects of transport systems, a comprehensive analysis of low-carbon sustainable transport systems and policies that include stakeholder experience and suggestions tailored to the local context of KV, Nepal, is still lacking.

In this study, we focus on the rapidly developing transport system in Kathmandu Valley (KV), Nepal, and how the system can be transformed to reduce GHG and air pollutant emissions and to generally support regional sustainable development. Nepal already includes various targets and measures for decarbonizing the transport sector in its NDC plan (MOPE, 2016). For example, Nepal's first NDC aimed to increase the share of electric vehicles up to 20 % from the 2010 baseline by 2020 and to develop an electric rail network by 2040 (MOPE, 2016). However, by 2020, these targets were barely achieved (Mali et al., 2022). Furthermore, Nepal's second NDC aims to ensure that by 2030, 90 % of all private passenger vehicle sales, including two-wheelers, and 60 % of all four-wheeler public passenger vehicle sales will be electric. It also aims to develop a 200 km electric rail network to support public commuting and mass transportation of goods by 2030 (GON, 2020).

The transport sector in Nepal depends heavily on fossil fuel combustion. For instance, the national total diesel consumption in 2017/18 was estimated as 892,770 kL, which was 13.4 times higher than that in 1989/90 (Das et al., 2022). Given such heavy dependency on fossil fuel, meeting the ambitious targets mentioned in Nepal's NDC will be immensely challenging, but at the same time, opportunities exist for improving living conditions in regard to the transition of the current transport system into LCST systems. For example, electrification of the transport sector would not only contribute to a low carbon sustainable transport (LCST) system for the KV (and the rest of Nepal) but would also lead to a substantial decrease in air pollutant emissions, economic growth, energy independence and could also contribute to increased safety and a more regulated traffic flow (Shakya and Shrestha, 2011; Pokharel & Acharya, 2015; Mali et al, 2022, GGGI, 2018). Assertedly, Electric Vehicles (EVs) are more advanced with improvised features for traffic safety and road utilization (Mali et al, 2022, GGGI, 2018).

Further, the policies aimed at developing LCST systems need to be formulated and implemented in close consultation with stakeholders for their successful implementation (Pira et al., 2018; González and Quintana, 2016). Therefore, this study was conducted with the aim of investigating and identifying LCST policy options/innovations for KV, Nepal, guided by the 'Avoid-Shift-Improve (ASI)' approach by carefully examining the local conditions of the KV in consultation with the stakeholders. In this study, LCST policy/transport policy for KV refers to the national policies that influence the practices and local initiatives in KV. We tend to achieve this aim by addressing the following research questions- Q1: What are the existing transport policies and initiatives in KV? Q2: What are the potential LCST policies for KV? Q3: What are the most important and preferred LCST policy options by stakeholders for KV? For this, we took stock of the policy options within and outside Nepal, including existing policies in Nepal, in close consultation with stakeholders applying the Delphi method. So that the identified policy options are science-based and yet expected to be appropriate for the local conditions. The results from the case study of the Kathmandu Valley are expected to contribute to an improved understanding of issues related to urban transport and LCST policies in the local context. This study adds to the literature on sustainable mobility for developing cities like KV, where limited studies are available. The findings of the study are based on the scientific literature and are customized to the local context of KV as prioritized by the major stakeholders. We believe that our findings will assist the decision makers in choosing the appropriate LCST policies for the case of KV. This study is expected to be equally beneficial to scholars and academicians as well as to businesses and stakeholders in understanding the appropriate LCST policy measures for achieving LCST systems from the general to the local context in Nepal and elsewhere.

1.2. Low carbon sustainable transport system (LCST)

Conventional transport planning considers travel as a derived demand, but the advancement in transport technologies and digitization has made travel time more flexible (Banister, 2008). Travel is being replaced by online activities, but it could further generate spontaneous travel like online shopping and its delivery as a travel activity (Banister, 2008). Another technological advancement, like electric vehicles (EVs), tends to be much cleaner but the vehicle related problems remain the same without solving the issues of congestion, space for parking, and safety (Litman, 2013). Studies show that both cleaner vehicles and mobility management strategies are needed to achieve energy conservation and emission reduction targets (Leather, 2009; Banister, 2008; Lah, 2017; Litman, 2011; Litman, 2013; Holden et al., 2020). A low-carbon transport system refers to mobility that results in substantially lower levels of carbon consumption and emissions (Givoni and Banister, 2013). While, the low carbon sustainable transport system (LCST) is often conceived as system that serve the broader vision of sustainable development, including reducing GHGs and air pollutant emissions, and more generally, providing avenues for economically prosperous, safer, and stable societies (Leather,2009; Bhattacharya et al., 2018). The vision statement of Nepal's National Sustainable Transport Strategy (NSTS, 2015) aims to develop the sustainable transport system as a transport system that is "efficient, accessible, people-centric, affordable, reliable, safe, inclusive, environment-friendly, and climate and disaster resilient" (MOPIT/GON, 2015). Sustainable mobility scholars often argue that the emission reduction efforts should consider all options and implement those that are most beneficial on the whole, and that are based on the local context (Litman, 2011; Santos et al., 2010). In order to be effective, such efforts need to consider both "push" and "pull" approaches, i.e., pushing demand away from private motorized transport and pulling demand towards public and other forms of sustainable transport (Eriksson et al., 2008; Dalkmann and Sakamoto, 2012; Keizer et al., 2019). A further refinement of these two factors is the ASI (avoid-shift-improve) approach, which includes a wide range of key policy options (Fig. 1) and is considered to be one of the best options for framing LCST policies. Several previous publications have described the need and benefits of the ASI framework in detail (Banister, 2008; IPCC, 2014; Berger et al., 2014; Pojani and Stead, 2015; Lah, 2017; Holden et al., 2020).

The 'avoid' options promote avoiding or reducing the amount of journeys/length of trips, e.g., by creating more compact, multimodal communities, teleworking, teleshopping, and providing incentives for avoiding or reducing travel (Banister, 2008; IPCC, 2014; GIZ-SUTP, 2004; Pojani and Stead, 2015; Lah, 2017; Holden et al., 2020). The 'shift' options promote shifting to more environmentally efficient forms

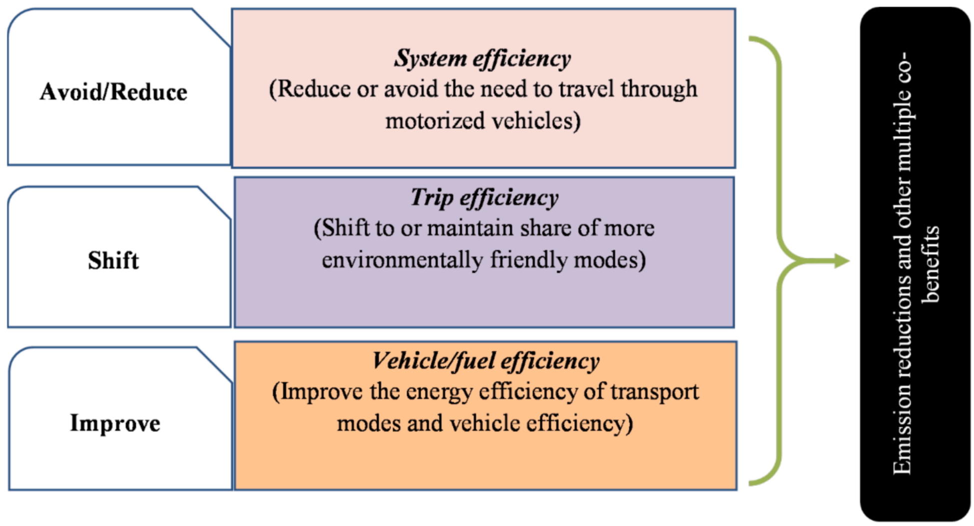

Fig.1. Key elements of the avoid, shift and improve (ASI) approach, based on GIZ-SUTP (2004).

of transport, e.g., walking, cycling, ride-sharing, and public transit, thus increasing trip efficiency (Banister, 2008; IPCC, 2014; GIZ-SUTP, 2004; Pojani and Stead, 2015; Lah, 2017; Holden et al., 2020). The 'improve' options incorporate improving vehicle and fuel technology, like promoting electric vehicles and other clean fuels, introducing higher fuel standards and higher tier vehicles, emissions controls, and low-emission zones, and developing infrastructure for low emission modes like electric vehicle's charging stations, vehicle to grid technologies, thus contributing to the overall vehicle and environmental efficiency (Banister, 2008; IPCC, 2014; GIZ-SUTP, 2004; Pojani and Stead, 2015; Lah, 2017; Holden et al., 2020).

Among the three ASI strategies, studies suggest that Avoid and Shift strategies can account for 40–60 % of transport emission reductions, at lower costs than improve strategies (SLOCAT, 2021). Although ASI is considered one of the best approaches, each ASI approach is an essential but not sufficient condition for obtaining sustainable mobility (Holden et al., 2020). Sustainable mobility scholars have stressed that emissions reduction could be achieved through each approach, but the combination of all three approaches is vital for maximizing the synergies and reducing the rebound effect (Lah, 2017; Holden et al., 2020). The different policy instruments under each strategy (avoid, shift, improve) can be categorized into five groups, namely: planning, regulatory, economic, information and technological (Dalkmann and Sakamoto, 2012).

Previous studies have contributed in improving our understanding of urban mobility in developed countries, while there are limited studies on low carbon sustainable transport system (Shukla and Dhar, 2015; Regmi, 2020; Jones et al., 2013; Ahmad and de Oliveira, 2016; Pojani and Stead, 2015; ADB, 2010; Muzzini and Aparicio, 2013; Pokharel and Acharya, 2015; Khanal et al., 2017; Das et al., 2018; Sadavarte et al., 2019; Mool et al., 2020; Khadgi et al., 2020; Regmi, 2020; Prajapati et al., 2021; Das et al., 2022: Bhusal et al., 2024) in urban areas of developing countries, hindering their capacity to formulate sustainable transport policies that fit to the specific conditions of those countries (Ahmad and de Oliveira, 2016). Nevertheless, developing cities can learn from developed cities about the roles of new technologies, forms of institutional management, and the long-term consequences of different de facto policies on the transport sector, but with careful consideration and adaptation of the knowledge to the specific local and national context (Santos et al., 2010; Gakenheimer, 1999; Das et al., 2018).

1.3. *Study area*

The focal region of this study: the Kathmandu Valley (KV) of Nepal, is one of the fastest urbanizing regions in South Asia (Muzzini and Aparicio, 2013). KV, including the capital city of Kathmandu, is more advanced and significantly differs from the rest of the country in energy-use patterns and emissions of greenhouse gases (GHGs) and air pollutants (Sadavarte et al., 2019; Bhattarai et al., 2019; Mool et al., 2020; Aryal et al., 2022; Das et al., 2022). It is estimated that ca. 3.5 million people live in the KV now (a 3-fold increase from ca. 1.1 million in 1991), i.e., ca. 10 % of the country's population reside in the KV with an area less than 0.5 % of the country's total land surface area (CBS, 2012). KV has an annual population growth rate of 4.63 % and an urban growth rate of 6.6 % (CBS, 2014; KSUTP, 2016). With this growth, the transport sector has also grown rapidly with a ca. 30-fold increase in the vehicle fleet size from ca. 46,000 between 1990 and 2018 in the Bagmati Zone (where the KV is located), and ca. 50 % of the country's current vehicle fleet is concentrated in the KV (Dhital and Shakya, 2014; KSUTP, 2016; DOTM, 2018).

The transport sector in the KV accounts for ca. 50 % and 27 % of national gasoline and diesel use, respectively, and ca. 38 % of the national energy consumption in the transport sector (Sadavarte et al., 2019). It is also responsible for 35 % of the country's total technology-related carbon dioxide (CO_2) emissions, and 30–55 % of various air pollutants (Malla, 2014; Sadavarte et al., 2019). In terms of trip distribution by purpose, work trips and education trips together have a share of about 73 % in KV, which has increased significantly over time (CEN/CANN, 2012). Walking is still the preferred mode of travel (Table 1), but it has declined from 53.1 % in 1991 to 40.7 % in 2012 and is forecasted to go down up to 38.8 % in 2022(JICA, 2012,). This decline is mainly due to an increase in motorization, especially two wheelers, whereas not many changes have been seen in the share of public transportation (JICA, 2012).

With ever expanding urbanization, the travel and energy demands on the transport sector of KV, Nepal are projected to increase by several folds over the coming decades, exacerbating the already problematic situation (Shrestha and Rajbhandari, 2010; Shakya and Shrestha, 2011; Malla, 2014; Shukla and Dhar, 2015; KSUTP, 2016; Bajracharya and Bhattarai, 2016; Shakya et al., 2023). Besides emissions of GHGs and air pollutants (Malla 2014; Das et al., 2018; Sadavarte et al., 2019;

Table 1
Trip distribution by mode (JICA , 2012).

	Walk	Bicycle	Motor cycle	Car	Bus
1991	53.10 %	6.60 %	9.30 %	3.80 %	27.20 %
2011	40.70 %	1.50 %	26 %	4.20 %	27.60 %
2022(forecasted)	38.80 %	1.60 %	29.30 %	6.80 %	23.50 %

Bhattarai et al., 2019; Mool et al., 2020; Das et al., 2022; Aryal et al., 2022; Bhusal et al., 2024), the transport sector is also associated with a number of other repercussions inherent to the current situation, such as heavy dependence on imported fossil fuels (risking the energy security of the country), growing chronic traffic congestions, road accidents, and impacts on public health. These major predicaments are strong incentives to transform towards a low-carbon sustainable transport (LCST) system in the KV and the rest of Nepal.

2. Materials and methods

The current study comprises of three phases (Fig. 2): Literature review including analysis of existing policies and initiatives in KV and ASI related policies published in literature; identification of potential LCST policy measures that fit the local specifics of the KV; and identification of most preferred/suitable LCST policies through two rounds of a major stakeholders' preference survey following the Delphi method.

2.1. Literature review

We reviewed several 'could be possible' LCST policies for the KV from a list of policy measures collated from the literature (e.g., peer reviewed journal articles, book chapters, empirical case studies, and policy documents from Nepal and elsewhere), currently in use or proposed or planned to be used in different parts of the world. We also considered publications such as conference papers, fact sheets, and policy briefs as they often contribute on revealing innovative information while reducing the time between research and practice (Paez, 2017; Pappas and Williams, 2011). However, we tried to minimize the use of such non-peer reviewed literature as much as possible. The selection of the final literature used here was based on mainly three inclusion criteria: First, the time period between 1990 and 2018; second, the study content focuses on at least one of the policy instruments related to the urban transport and sustainable mobility paradigm which are either in use, implemented or proposed for various cities around the world; and third, there is a policy match with the local context of KV (based on literature and expert validation).

Online databases (Google Scholar, Scopus), and relevant websites (Ministry and departments of Government of Nepal, the Word Bank, JICA, ADB, IEA) were used. Search terms related to sustainable mobility, LCST, ASI, and KV were used for the inclusion of the eligible studies (Pullin and Stewart, 2006). Google Scholar yielded results for various full-text keywords, for example, 'Sustainable mobility or sustainable transport' (11,500), 'sustainable transport policies or sustainable mobility policies' (115), 'Sustainable mobility in Kathmandu valley, Nepal or sustainable transport in Kathmandu Valley, Nepal' (9,390). The documents related to national level policies and acts were searched on the relevant websites of various agencies of the Government of Nepal (GON), including the Ministry of Physical Infrastructure and Transport (MOPIT), Department of Transport Management (DOTM), Department of Environment (DOE), Department of Roads (DOR), Kathmandu Valley Development Authority (KVDA). For each search, the initial 200 results were viewed, and 'best match' literatures were selected (71) based on the screening of titles and abstracts.

2.2. Existing transport policies and initiatives in Nepal

With regard to the evolution of transport systems and the development of related policies, initiatives, and events in the KV, Fig. 3 shows more details on the chronology of the development of the transport system and related policies in Nepal. The chronology of centrally planned transport services in Nepal can be traced back to 1959, when a local bus service was initiated in the KV by the *Nepal Yatayat Sewa* (Nepal Transport Service, NTS). Additionally, big public transport services like *Nepal Yatayat Sewa, Sajha Yatayat* (1961), and the Trolleybuses (1975) effectively serviced the KV for many years. These were unfortunately shut down in the 1990 s due to financial problems, bad management, and political interference, resulting in the massive privatization of public transport (Pradhan et al., 2006). However, the introduction of the Kathmandu Valley Development Authority Act (1988) and the Motor Vehicle and Transport Management Act (1993), the initiation of vehicle emission testing, and the introduction of battery-operated three-

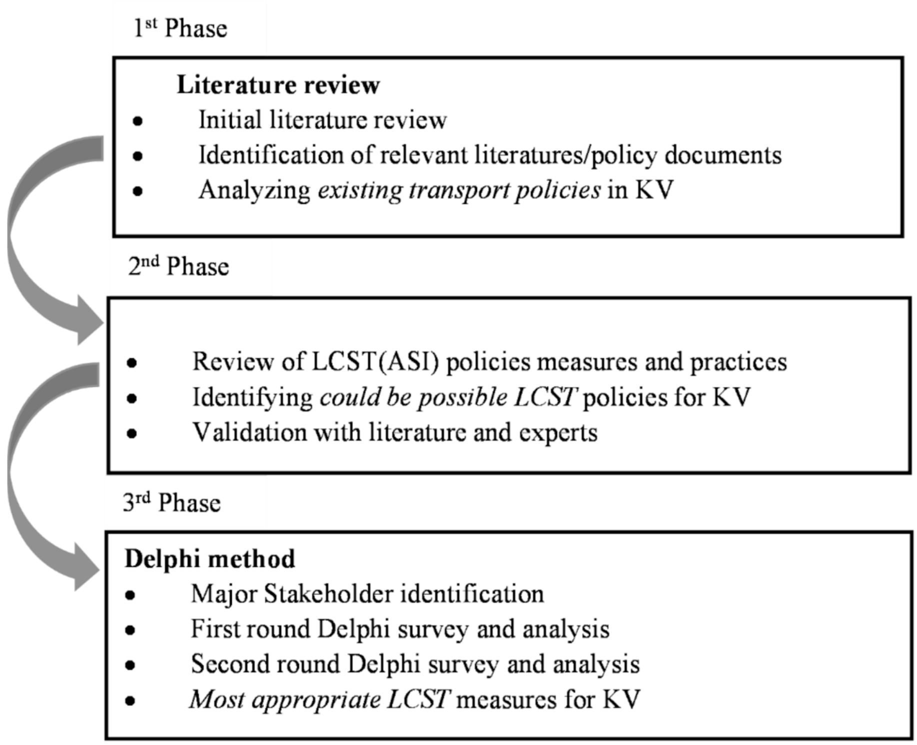

Fig. 2. Methodological framework of the study.

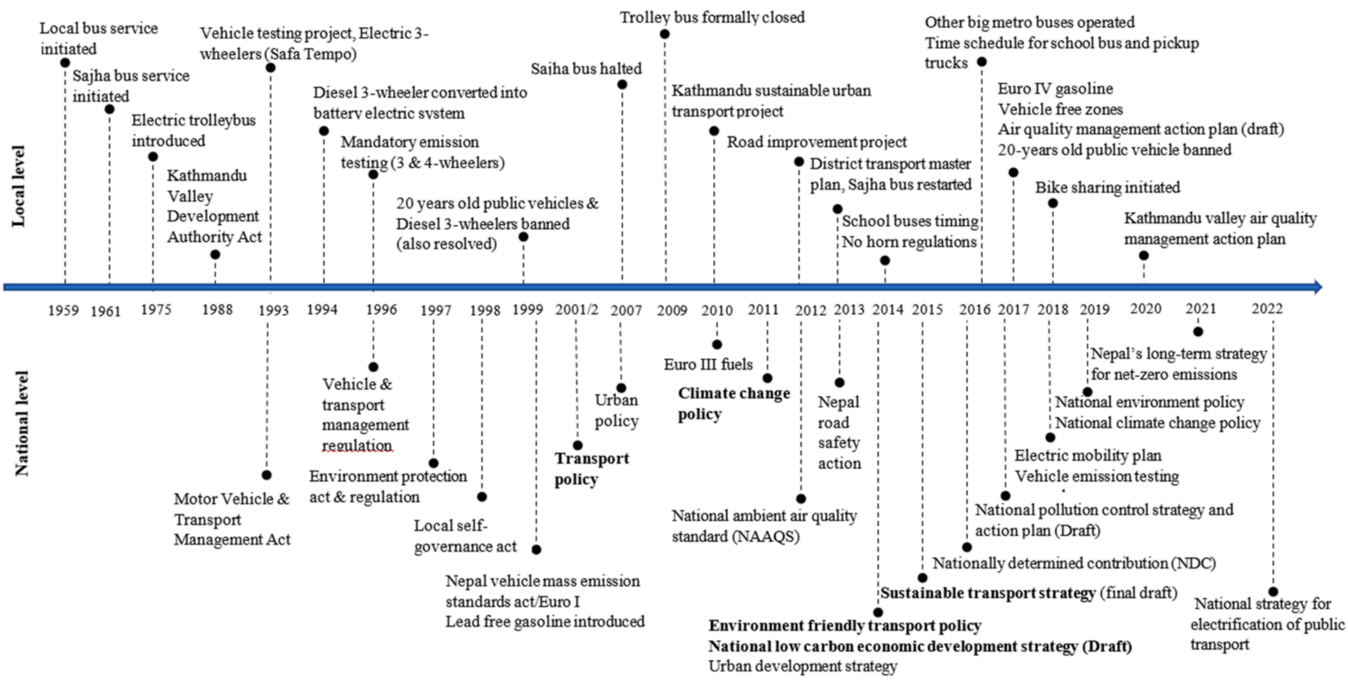

Fig. 3. Chronologies of transport milestones at local (Kathmandu Valley) and national level (based on Pokharel and Acharya, 2015; Das et al, 2018; Websites and reports of: MOPIT; MOPE; DOE; DOTM, GON; JICA; ADB, UNESCAP). Last updated on 15/05/2024).

wheelers named *Safa Tempo* (Clean Tempo), along with the phasing out of diesel 3-wheelers from the KV were several significant transition steps towards better transport management and improved vehicles in the KV in the late 1990 s (Pokharel and Acharya, 2015; GON, 1993). With the introduction of the Transport Policy (2001) and the Urban Policy (2007), infrastructure development in the transport sector gradually received priority in the first decade of this century, resulting in rapid motorization to cope with expanding urbanization in the KV (Pokharel and Acharya, 2015; MOPIT/GON, 2001).

The road improvement project in 2012 initiated the road expansion drive throughout the KV to reduce the ever-increasing traffic congestion (Khanal et al., 2017). However, by mid-2015, it became evident that the vehicle-centric "predict and provide" approach had worsened the situation by increasing the traffic demand (Khanal et al., 2017). The road capacity expansion and development of new road infrastructure further increased the additional traffic volume, continuing the problem of congestion (van Der Loop et al., 2016; Lee, 2018). Besides, increased air pollution and associated health problems, and the destruction of public spaces and traditional settlements were among the negative consequences of the road expansion project (Khanal et al., 2017). The share of non-motorized transportation, e.g., walking and cycling, is also declining rapidly with increased motorization, vanishing old infrastructures, and lack of new dedicated infrastructures in the KV, making pedestrians and cyclists the most vulnerable amongst the road users, representing almost 50 % of all traffic fatalities (JICA., 2012).

Eventually, the formulation of the Environment Friendly Vehicle and Transport Policy (2014), comprising of the well-established ASI strategic approach, the final draft of the National Sustainable Transport Strategy (MOPIT/GON, 2015), and the draft of the National Low Carbon Economic Development Strategy (2014), along with the National Action Plan for Electric Mobility (GGGI, 2018), are some significant policy and strategic steps undertaken by the government, paving the way towards the development of a LCST system in the KV. Supported by these policies and guided by the ASI approach, a number of initiatives have been introduced recently by the local and federal governments: locally restricting the vehicles in the core city areas (in 2018), school timing differentiation, and specific time allocation for freight vehicles to enter the busy residential area (in 2014 and 2016), the revival of big bus services such as the *Sajha Yatayat* (2013), *Mahanagar Yatayat* (2016), private bike ride sharing initiatives, e.g., *Tootle and Pathao* (2017), and phasing out of private vehicles older than 20 years in 2017. The Kathmandu Sustainable Urban Transport Project (KSUTP), which was supported by the Asian Development Bank (ADB) was completed (MOPIT, ADB, 2010), but it was limited to only certain project areas.

Nevertheless, with the gradual development of drafts and planning of environmental policies, the government has endorsed the Climate Change Policy (2011), which was updated as the National Climate Change Policy (2019), the Vehicle Emission Testing Manual (2018), the National Environmental Policy (2019), and the Kathmandu Valley Air Quality Management Action Plan (DOE, 2020). Recently, Nepal's Long-term Strategy for Net-zero Emission has been introduced in order to achieve sustainable net zero CO_2 emission by 2045 (GON, 2021). The net-zero emission initiatives are expected to enhance electricity consumption per capita and improve the energy equity issue (Shakya et al., 2023). Besides, the National Strategy for Electrification of Public Transport (2022) has been introduced for transitioning current public transport into electric public transport in Nepal (UNESCAP, 2023).

2.3. LCST in the local context of Kathmandu Valley, Nepal

Amidst the existing policies, developing sustainable city transport, i.e., improving accessibility, minimizing travel times, and providing equal mobility options to all while reducing environmental impacts has become a key challenge and priority in urban transport planning in rapidly urbanizing cities like KV (Hickman et al., 2013). The policy instruments related to LCST-ASI approach is based on the experiences of many cities (e.g., Bogota, Hong Kong, Singapore, London) with the positive outcomes from incorporating sustainable practices in their transport management (Leather, 2009; Santos et al., 2010; Dalkmann and Sakamoto, 2012; IPCC, 2014; GIZ-SUTP, 2004; Hickman et al., 2013; Haque et al., 2013; Han, 2010; Uteng, 2007; Faiz et al., 2006; Bener et al., 2003; GIZ-SUTP, 2014; IEA, 2012; IEA, 2013; Persia et al., 2016; ADB, 2010; Wang, 2014; Ye et al., 2017; Taylor, 2017; Jones et al., 2013). In particular, developing countries offer a unique local context with regard to urban transport and the integration of transport modes (Jones et al., 2013). Dalkman and Sakamoto (2012) have justified the applicability of the ASI approach in both developed and developing countries by highlighting some important differences in their contexts (Dalkmann and Sakamoto, 2012). In the context of Asia, CO_2 mitigation in a transport system while it is in transition, is achieved more effectively by aligning mitigation policies with sustainable development policies and measures such as mandates for mode share and choices (e.g., urban design, information, and communication systems and behavioral measures) guided by the ASI approach (Shukla and Dhar, 2015). Based on the literature on sustainable mobility and existing policy measures, fifty-three LCST measures that were potentially applicable in the context of the Kathmandu Valley were identified. Forty-three measures were classified into three groups following the ASI approach (Table 2), along with a fourth group of ten cross-cutting measures. The comprehensive list was further validated through consultation with relevant experts and literature as described in the section below:

When certain strategies are planned or applied without a broader consultation, there could be conflict among the stakeholders in the applicability and adoption of such policies. Transport systems are complex systems that include multiple agents making decisions and where some characteristics emerge from the aggregation of individual behaviors (Furtado et al., 2015; Berger et al., 2014). In the case of LCST policies also, if the stakeholders are not properly involved since the early stages of the decision-making process, then this may cause protests and even the failure of plans, wasting money and time (Pira et al., 2018; González and Quintana, 2016). Existing studies in Nepal have identified certain strategies for development of the transport sector along with the analysis of scenarios and implications. For instance, considering interventions such as increasing public buses, improving fuel economy, electrifying the transport sector on a mass scale (including introduction of electric microbuses and electric two-wheelers), hybrid electric cars, along with a combination of various other measures (Shrestha and Rajbhandari, 2010; Shakya and Shrestha, 2011; Dhital and Shakya, 2014; Dhakal, 2003; Dhakal, 2006). In these studies, limited policies are analyzed as potential measures to improve or transform the current transport system in the KV. Involvement and close consultation of stakeholders are imperative for the successful implementation of integrated ASI related policies in the local context. Addressing this gap, we have conducted our study in close consultation with stakeholders following the Delphi method as elaborated in the method section for the specific conditions of the KV.

2.4. Evaluation of most appropriate LCST policies through Delphi method

The Delphi method is a structured process utilized to arrive at a group opinion or decision through surveying a panel of experts (Yousuf, 2007; Skulmoski et al., 2007). The process employs several rounds of questionnaires, and the responses are aggregated and shared with the group after each round (Yousuf, 2007; Skulmoski et al., 2007). It is considered to be applicable for interdisciplinary issues that incorporate physical, social, policy, and economic perspectives (Rees et al., 2017). It has been used in a wide variety of research areas to develop, identify, forecast and validate a list of options, including analysis of the transport sector (Cafiso et al., 2013; Rees et al., 2017; Stephenson et al., 2018; Hirschhorn, 2019). The Delphi method relies on a series of questionnaires in two or more rounds, distributed to selected experts in a process with interspersing questionnaires and controlled opinion feedback, until a desired level of consensus is reached among respondents or until opinions are stable across survey rounds (von der Gracht, 2012; Hirschhorn, 2019). For example, a two-stage Delphi process was carried out by Shiftan et al. (2003) to develop two scenarios for the future

Table 2
List of 'could be possible' ASI policies for KV.

Policies (**[References]**)	
Avoid/Reduce	1. Integrated land use and traffic management system (**[a], [b], [c], [d]**)
	Parking and riding system (**[e], [d], [f]**)
	Low emission zones (**[d], [g]**)
	Vehicle free zones (**[e], [b], [d]**)
	Regulating timing period for freight transport (**[h]**)
	Carpooling (**[e], [d]**)
	Traffic calming measures (**[e], [d]**)
	Vehicle registration tax (**[i], [b], [d]**)
	Parking charges(**[b], [e], [d]**)
	Road pricing /congesting charging (**[b], [e], [d], [j]**)
	Limiting vehicle registration for private vehicles (**[d], [j]**)
	Increasing fuel price for private vehicles (**[b], [e]**)
	Promoting vehicle sharing (**[e], [i]**)
	Regulating odd even system for private vehicles (**[h], [j]**)
	Telework and flexible time (**[e], [d], [f]**)
Shift/Maintain	2. Non-motorized transport (NMT) accessibility (**[a], [d], [h], [f]**)
	New technology big public buses (**[h], [l], [m]**)
	Allocating dedicated lanes for buses (BRT) (**[a], [d], [h]**)
	Promoting electric vehicles (**[d], [h], [l], [n]**)
	Installing electric charging stations (**[l], [g]**)
	Late night service of public transport (**[k], [j)**
	Transit signal priority system (**[d], [h], [j]**)
	Bike sharing schemes (**[e], [d], [f]**)
	Taxi fare meter system and accessibility (**[k], [i]**)
	Dial-a- ride system (**[k]**)Freight (goods and cargo) railway system (**[d], [f], [m]**)
	Passenger railway system (**[d], h], [m]**)
	Rope way system (**[m]**)
Improve	3. Regular vehicles inspection and maintenance system (**[n], [o], [p]**)
	On-road vehicle emission test (**[n], [o], [p]**)
	Increasing vehicle fuel standard (**[b], [e], [d]**)
	Clean technology vehicles (**[e], [h], [n]**)
	Promoting alternative fuels (**[e], [h]**)Prohibiting the use of duplicate or counterfeit parts in vehicles (expert suggestion)
	Integrating public transport system (**[d],[h],[f], [j]**)
	Enhancing transport service information system (**[k], [j]**)
	Integrating fare, ticketing, and tariff system (**[h], [m]**)
	Subsidy and tax leave on parts of electric vehicles (**[k], [j]**)
	Improving existing bus networks and service (**[h], [i]**)
	Introducing intelligent transport system (**[h],[m]**)
	Rebates/financial rewards in clean transports (**[e], [i]**)
	Increasing fossil fuel tax (**[b], [c], [e], [m]**)
	Improving transit through dedicated lanes (**[a], [d], [h]**)
Cross-Cutting measures*	4. Managing existing urban green islands and parks (**[a]**)
	Planting trees, plants and developing more green parks and open space (**[a)**
	Installing CC cameras on public buses and bus stops (**[i]**)
	Prioritizing road safety in all the transport projects (**[e], [j], [q]**)
	Introducing innovative travel health insurance policy (**[q]**)
	Disable friendly transport infrastructure development (**[k], [j]**)
	Promoting research and studies on transport issues (**[f], [j]**)
	Conducting capacity building and sensitization programs to the stakeholders (**[c], [m]**)
	Including public consultation for formulating the plans and policies (**[c], [f]**)
	Conducting public awareness programs (**[c], [h],[i]**)

[References][1] The references are not limited to the citation given here: ([a]-Khanal et al., 2017; [b]-Lah,2017; [c]-Banister, 2008; [d]-Dalkmann and Sakamoto, 2012; [e]-Litman,2011; [f]-Santos et al., 2010; [g]-Nakamura and Hayashi, 2013; [h]-Pojani and Stead, 2015; [i]- Han, 2010; [j]- Haque et al., 2013; [k]- Uteng, 2007; [l]-Taylor, 2017; [m]-Pokharel and Acharya, 2015; [n]-IPCC, 2014; [o]-Faiz et al., 2006; [p]- Jha, 2001; [q]-Bener et al., 2003).

development of the Tel-Aviv Metropolitan Area in Israel based on experts' views on the probability and desirability of a menu of policy measures (Shiftan et al., 2003). Similarly, Stephenson et al. (2018) used a more elaborated four-stage Delphi study to collect experts' views on interventions for sustainable transport for better outcomes than were being achieved by the existing policy environment in New Zealand (Stephenson et al., 2018). In our case, we adopted two rounds of structured questionnaire survey through which the desired level of consensus (i.e., indicated by consistent results) was achieved. The main purpose of the second survey was to judge the results of the first survey, in particular the consistency of the responses, irrespective of who replied, which helped us to assess consistent results in the preferences. The results from both rounds of the survey were found consistent in terms of agreements in preferences of measures by the respondents (to be discussed later in the result section below).

For the survey, the major stakeholders identified for our study comprised government organizations, international/non-governmental organizations (INGOs/NGOs), transport associations, scientists, experts, academicians, media personnel, and university students in relevant fields. They were selected based on their responsibility, influence, proximity, interdependences, and representativeness, following the stakeholder engagement guidelines as described in a previous study (Partridge et al., 2005). For instance, we have selected four groups of respondents following the classification defined by Partridge et al. (2015): policymakers and government officials (by responsibility and influence), urban planners and engineers and experts (by proximity), transport organizations, NGOs and INGOs, research institution and individuals (by representations and responsibility), and media and academicians (by influence). The list and contact details of the participants of the annual flagship event called the "Kathmandu Sustainable Urban Mobility Forum (KSUMF)" and other similar events were considered to prepare a shortlist of the key stakeholders to be surveyed as per our purposive sampling strategy. The purposive sampling technique, also called judgment sampling, is a non-random technique of selecting the participant based on the qualities the participant possesses (Etikan et al., 2016). It does not require a set number of participants, and the information is gathered from relevant people (stakeholders) based on their virtue of knowledge or experience (Bernard, 2002; Etikan et al., 2016). Our selected list of stakeholders was the relevant respondents to provide a better response based on their background knowledge and experience (Partridge et al., 2005; Etikan et al., 2016). The list was further updated by exploring the websites of relevant ministries and research institutions. A questionnaire with a list of 53 identified relevant policies based on the ASI approach (Table 1) was prepared for the case of KV, Nepal. For the convenient ranking of preferences and to increase the response rate, we used a Likert scale of 1–3 to rate the least preferred, moderately preferred, and highly preferred policies (Willits et al., 2016; Drolet and Morrison, 2001).

In the first survey, the questionnaire was sent to around 300 shortlisted stakeholders, and an online survey was carried out over a period of months from June-July 2018. Ninety-five (ca. 32 %) completed responses were received. The second round of questionnaire survey was conducted by directly participating in a workshop during the 7th KSUMF held on 11 August 2018 in Kathmandu. This forum was attended by almost 50 % of the participants of the first survey and other stakeholders interested in or engaged with the development of clean and sustainable transportation. The purpose of the second round was to evaluate the results of the first round of the survey, which was done after the brief presentation of results from the first survey, followed by a discussion on the need for sustainable mobility policies in KV. For this, the second questionnaire incorporating the results of the first survey was distributed to the participants, who were asked to judge the results of the first round of the survey. The discussion during the presentation further helped the participants to evaluate and refine the 'highly preferred policies' (identified in the first survey) and categorize them into 'most important' and 'important' measures. Out of forty-five participants from various governmental agencies, non-governmental agencies, academia, transport entrepreneurs, urban/transport planners, research institutions, and media personnel.[2] Nineteen participants completed the questionnaire, while others provided their feedback and recommendations orally in the second round of the Delphi survey.

3. Results

3.1. Results for Delphi round i

The ninety-five respondents who completed the questionnaire were composed of a fair mixture of stakeholders (Table 3) including the NGOs, the INGOs, college/university students (environment science or similar disciplines), transport companies, private vehicle owners, consultancies, experts including transport engineers and researchers, and government officials. We categorized them into 6 main groups: Group I (INGOs/NGOs), Group II (Academician/students), Group III (Freelancers and other companies), Group IV (transport engineers and planners), Group V(GOs), and Group VI (media). Nearly 60 % of the respondents were from the first three groups. In the first round of the Delphi survey, we also inquired about the modal share/trip distribution by mode of the stakeholders and their perception on the need of improvement of the transport system in KV. Regarding the use of transport modes in the KV informed by the survey participants (Fig. 4), walking accounts for the highest share, at 52 % for short distances (< 1 km). For medium distances (1–5 km), two-wheelers were used widely (19 %) and for long distances (>5 km), buses (27 %) represent the largest share. The results show that walking is still the prioritized mode of travel for short and medium distances with an average value of 32.5 % for both short and medium distances together. This result is consistent with the JICA forecast for 2022 (Table 1) for trip distribution by mode, although the travel distance is not distinguished in their study. Based on our study findings, buses are the preferred means of transport for distances greater than 15 km. However, motorcycles could also be used for such distances, particularly in areas with inefficient public transport options, such as commuting between Bhaktapur and Kathmandu. Nonetheless, these findings should be interpreted with caution, given the limitations of our sample size, the residence of stakeholders in the survey, and the study's timeframe. Regarding the question on the need for improvements in the current transport systems, the response was overwhelmingly 100 % 'Yes', which is not a surprise given the manifold challenges noted above for the current transport systems. Furthermore, a clear majority of the respondents (85 %) expressed that they are willing to use the public transport service instead of their private vehicles, in case of a better public transport service in terms of regulated, demand-oriented transport options, with a fixed schedule and accessible to all, which is currently lacking in KV (Prajapati et al., 2019). This perception among stakeholders highlights the poor state and unattractive conditions of the current transport systems and the urgent need for transitioning to improved LCST transport systems. This is also a good sign in the sense that the stakeholders are likely to accept new measures if they are implemented with the aim of improving the current transport situation.

The results related to the preferences of LCST policies of the first round of the Delphi survey are exhibited in Figs. 5 to 8 where the number values indicate the number of participants, and Table 3, where the importance of policy measures are ranked. More than 60 % of the participants considered 5 out of 15 avoid-related, 6 out of 13 shift-related, and 11 out of 15 improve-related policies as highly preferred

[2] https://www.spotlightnepal.com/2018/08/11/7th-kathmandu-sustainable-urban-mobility-forum-conducted/.

Table 3
Preferences of various groups of stakeholders on the selection of different policy measures (H = High preference, M = moderate preference, L = Low preference). The number in the table represents the number of responses.

	Policies	Group I INGOs/NGOs(n = 40)				Group II Academicians/ students(n = 26)				Group III Freelancers/other companies (n = 15)				Group IV Transport engineers/ transport companies(n = 6)				Group V GOs(n = 6)				Group VI Media(n = 2)				Total (n = 95)
S. N	**Rankings (→)**	**H**	**M**	**L**	**NA**	**H**	**M**	**L**	**NA**	**H**	**M**	**L**	**NA**	**H**	**M**	**L**	**NA**	**H**	**M**	**L**	**NA**	**H**	**M**	**L**	**NA**	
	Avoid policies																									
1	**Integrating land use and traffic management**	**30**	7	3		**20**	6	0		8	7	0		3	2	0	1	**5**	1	0		**2**	0	0		95
2	**Traffic calming measures**	**30**	6	**3**	**1**	**20**	4	1	1	8	7	0		**4**	1	0	1	**5**	0	1		**2**	0	0		95
3	**Parking and riding system**	25	11	4		16	8	2		**11**	2	2		3	1	1	1	3	1	2		**2**	0	0		95
4	**Vehicle free zones**	23	10	6	**1**	17	7	2		**12**	3	0		**5**	0	0	1	5	0	1		1	0	1		95
5	**Freight transport time regulations**	26	11	3		15	9	2		8	7	0		3	2	0	1	**4**	1	1		**2**	0	0		95
6	Low emission zones	22	14	4		18	8	0		7	6	2		3	2	0	1	**4**	1	1		0	1	1		95
7	Carpooling	18	14	8		13	11	2		7	6	2		1	3	1	1	2	2	2		**2**	0	0		95
8	Promoting vehicle sharing	16	16	8		8	14	4		4	9	2		1	1	3	1	3	2	1		0	1	1		95
9	Road pricing	5	22	**11**	**2**	6	15	5		3	6	6		1	1	3	1	1	2	3		1	0	1		95
10	Setting vehicle registration tax	10	18	12		8	15	3		2	10	3		1	1	3	1	3	2	1		0	2	0		95
11	Increasing parking charges	6	15	19		4	17	5		4	6	5		2	2	1	1	1	3	2		1	0	1		95
12	Tele work and flexible time	15	19	6		10	12	4		7	4	3	1	1	3	1	1	1	4	1		**2**	0	0		95
13	Limiting private vehicles registration	14	11	15		8	13	5		4	8	3		1	1	3	1	1	2	3		**2**	0	0		95
14	Odd even system for private vehicles	5	10	25		8	9	9		2	3	10		0	3	2	1	2	2	2		1	1	0		95
15	Increasing fuel price for private vehicles	10	9	20	**1**	6	13	7		1	10	4		1	2	2	1	2	1	3		1	0	1		95
	Shift policies																									
16	**Non-motorized transport accessibility**	27	10	3		**21**	5			**15**	0	0		**4**	1	0	1	**5**	1	0		**2**	0	0		95
17	**Promoting electric vehicles**	**31**	7	2		20	5	0	1	11	3	1		2	2	1	1	**6**	0	0		**2**	0	0		95
18	**Introducing new technology big public buses**	**30**	8	2		16	10	0		**12**	3	0		**4**	0	1	1	**6**	0	0		1	1	0		95
19	**Developing dedicated bus lanes**	26	11	3		15	8	3		11	4	0		**4**	1	0	1	**6**	0	0		**2**	0	0		95
20	**Late night public transport service**	25	11	4		**22**	3		1	7	6	**1**	**1**	**3**	2	0	1	4	1	1		1	1	0		95
21	**Installing electric charging stations**	25	11	3	1	19	7			7	7	1		1	3	1	1	**6**	0	0		**2**	0	0		95
22	Enforcing fare taxi meter system	25	10	5		15	8	3		7	7	1		2	2	1	1	4	2	0		**2**	0	0		95
23	Developing passenger railway system	18	11	10	1	9	13	3	1	5	4	6		1	2	2	1	4	1	1		1	0	1		95
24	Introducing transit signal priority	14	18	8		13	12	1		6	7	2		2	2	1	1	4	2	0		1	1	0		95
25	Developing freight railway system	12	15	13		6	16	4		2	9	4		2	1	2	1	3	2	1		1	0	1		95
26	Introducing bike sharing schemes	13	17	10		8	11	7		4	10	1		0	3	2	1	2	1	3		0	1	1		95
27	Promoting dial-a-ride system	13	13	14		9	12	5		2	10	3		2	0	3	1	1	4	1		1	1	0		95
28	Developing rope way system	11	11	17	1	10	9	6	1	5	4	6		1	0	4	1	3	2	1		0	0	2		95
	Improve policies																									
29	**Regular vehicles inspection and maintenance**	**31**	6	3		20	3	1	2	**12**	3	0		**6**	0	0		5	0	1		**2**	0	0		95
30	**Promoting clean technology vehicles**	**30**	7	3		**22**	2	0	2	**13**	2	0		4	1	1		**6**	0	0		**2**	0	0		95
31	**Improving existing bus networks and service**	**30**	7	3		18	6	1	1	**12**	1	2		**6**	0	0		**6**	0	0		1	1	0		95
32	**Integrating public transport system**	29	9	2		**21**	3	0	2	11	4	0		**6**	0	0		5	1	0		1	1	0		95
33	**Integrating fare, ticketing and tariff system**	28	9	3		18	5	1	2	10	3	0	2	5	1	0		5	1	0		1	1	0		95
34	**On-road vehicle emission test**	26	10	4		17	8	0	1	10	5	0		**6**	0	0		4	2	0		1	1	0		95
35	**Subsidy/tax leave on electric vehicle parts**	23	13	3	1	20	3	0	3	10	5	0		3	3	0		4	1	0	1	0	1	1		95
36	**Increasing vehicle fuel standard**	25	8	7		19	5	1	1	8	7	0		4	2	0		**6**	0	0		1	1	0		95
37	Improving transit through dedicated lanes	25	10	5		16	7	2	1	10	5	0		5	1	0		**6**	0	0		0	2	0		95
38	Enhancing transport service information system	25	12	3		15	6	3	2	8	7	0		**6**	0	0		5	1	0		1	1	0		95
39	Enhancing intelligent transport system	21	17	2		15	10	0	1	9	4	2		4	2	0		4	2	0		2	0	0		95
40	Rebates/rewards on clean transports	18	18	4		16	8	0	2	9	6	0		3	3	0		**6**	0	0		0	1	1		95
41	Prohibiting duplicate/counterfeit vehicle parts	20	12	7	1	17	7	1	1	6	6	3		3	2	1		2	4	0		1	0	1		95
42	Promoting alternative fuels	18	12	10		15	8	1	2	3	9	3		3	2	1		4	1	1		1	1	0		95
43	Increasing fossil fuel tax	10	16	13		6	14	4	2	0	11	4	1	1	3	1	1	5	1	0		1	0	0	1	95

(*continued on next page*)

Table 3 (*continued*)

S. N	Policies	Group I INGOs/NGOs(n = 40)				Group II Academicians/ students(n = 26)				Group III Freelancers/other companies (n = 15)				Group IV Transport engineers/ transport companies(n = 6)				Group V GOs(n = 6)				Group VI Media(n = 2)				Total (n = 95)
	Rankings (→) Avoid policies	H	M	L	NA	H	M	L	NA	H	M	L	NA	H	M	L	NA	H	M	L	NA	H	M	L	NA	
	Cross cutting																									
44	**Managing existing urban green islands and parks**	30	8	2		**21**	4	0	1	**14**	1			**4**	1	1		**6**	0	0		**2**	0	0		95
45	**Planting trees, plants and developing more green parks and open space**	**33**	5	2		**24**	1	0	1	**13**	2			**4**	1	1		**6**	0	0		**2**	0	0		95
46	**Installing closed-circuit (CC) cameras on public buses and bus stops**	22	15	3		18	6	1	1	7	5	3		3	3	0		**5**	1	0		**2**	0	0		95
47	**Prioritising road safety in all the transport projects**	**32**	6	2		**21**	4	0	1	**13**	2			**5**	1	0		**5**	1	0		**2**	0	0		95
48	**Introducing innovative travel health insurance policy**	17	22	1		17	5	3	1	3	9	0	3	3	2	1		4	1	1		**2**	0	0		95
49	**Disabled-accessible transport infrastructure development**	30	8	2		17	5	2	2	12	2	1		3	3	0		4	2	0		**2**	0	0		95
50	**Promoting research and studies on related issues**	25	11	4		**21**	4	0	1	8	7			**4**	2	0		5	1	0		0	1	1		95
51	**Conducting capacity building and sensitization programs to the stakeholders**	24	12	4		15	7	3	1	8	7			3	3	0		4	2	0		0	**2**	0		95
52	**Including public consultation for formulating the plans and policies**	26	12	2		18	4	3	1	10	3	2		4	2	0		**5**	1			1	0	1		95
53	**Conducting public awareness programs**	21	16	3		16	7	3		12	2	1		5	1	0		**6**	0			1	1	0		95

policies represented in bold text in Table 3. In the case of the cross-cutting policies, all 10 policies (Fig. 8, Table 3) are considered as highly preferred policies by more than 60 % of the participants. Most of the stakeholders considered in the study belong to some specific groups with some (prior) knowledge of the current transport systems and policies. However, the preference levels of all groups are almost similar in all high, moderate, and low preferred policies (Table 3), except for slight differences in rankings of these policies. For instance, the top ranked avoid-related policies by Group I and Group II are 'integrated land use and traffic management' and 'traffic calming measures' while Group III and Group IV ranked 'vehicle free zones' at the top rank. Likewise, Group V and Group VI rated more than two policies as the top high preferred policies. The common preferences for avoid-related policies when all groups combined are shown in Fig. 5. In the case of shift-related policies (Table 3), the top ranked policy for Group I is 'promoting electric vehicles' while it is 'non-motorized transport accessibility' for Group II and III. For Groups IV to VI, there are more than one top ranking of policies. The common preferences of all the groups about shift-related policies are given in Fig. 6. In the case of improve-related policies (Table 3), the top ranked policies for Group I, Group II, and Group III are, respectively, 'regular vehicles inspection and maintenance', and 'promoting clean technology vehicles', while for Groups IV to VI, there are more than one top ranking policies. The overall combined groups' preferences for highly preferred improve-related policies are given in Fig. 7. In the case of the cross-cutting issues (Table 3), the top ranked high preferred policy for Group I and II is 'planting trees and developing more green parks and open space, for Group III, it is 'managing existing urban green islands and parks' while there are many top rankings in case of group IV to VI. The overall preferences for all groups for cross-cutting issues combined are presented in Fig. 8. Since there is not much change in preferences among stakeholders between round one and round two of the Delphi survey, the detailed analysis of policies is presented in the result section of Delphi II.

3.2. *Results for Delphi round II*

In the second round of the Delphi survey, slight changes in the rankings of preference level compared to the first round are found; for example, policies like 'increasing fuel prices for private vehicles' shifted from 'moderately preferred' to 'least preferred', while 'developing ropeways (cable car)' shifted from 'least preferred' to 'moderately preferred'. For 'improve' policies, most of the moderately preferred policies - such as 'introducing intelligent transport systems', 'regular vehicle inspection and maintenance systems', and 'provision of rebates in clean transport' - were chosen to be 'highly preferred' in the second survey. However, the overall selection and interpretation of the policies does not change due to these minor shifts in the second survey. We tend to reduce the potential biases in the Delphi process by applying countermeasures like maintaining expert anonymity, randomizing question order in each round, including participants from diverse backgrounds, and iterating the survey until the desired consensus is achieved (Skinner et al., 2015; Paré et al., 2013). Although we tried to minimize the potential biases due to the judgment of experts in our study, there could be non-response bias.

Further, the 'highly preferred' policies indicated by the respondents in the first round of the survey are further grouped in the second round of the survey into 'the most important' and 'important' measures (Table 3). In the case of 'avoid' policy options, the most highly preferred policies (Table 3) are cost effective regulatory tools such as the provision of low emission zones, vehicle free zones, carpooling, mobile office (e.g., home office and flexible timing), and planning policies such as integrated land-use and traffic management and the traffic calming measures. These were also considered to be the 'most important' policies to avoid or reduce overall travel requirements. The pricing and economic policies such as vehicle registration tax, parking charges, and road pricing/congestion pricing are moderately preferred policies while

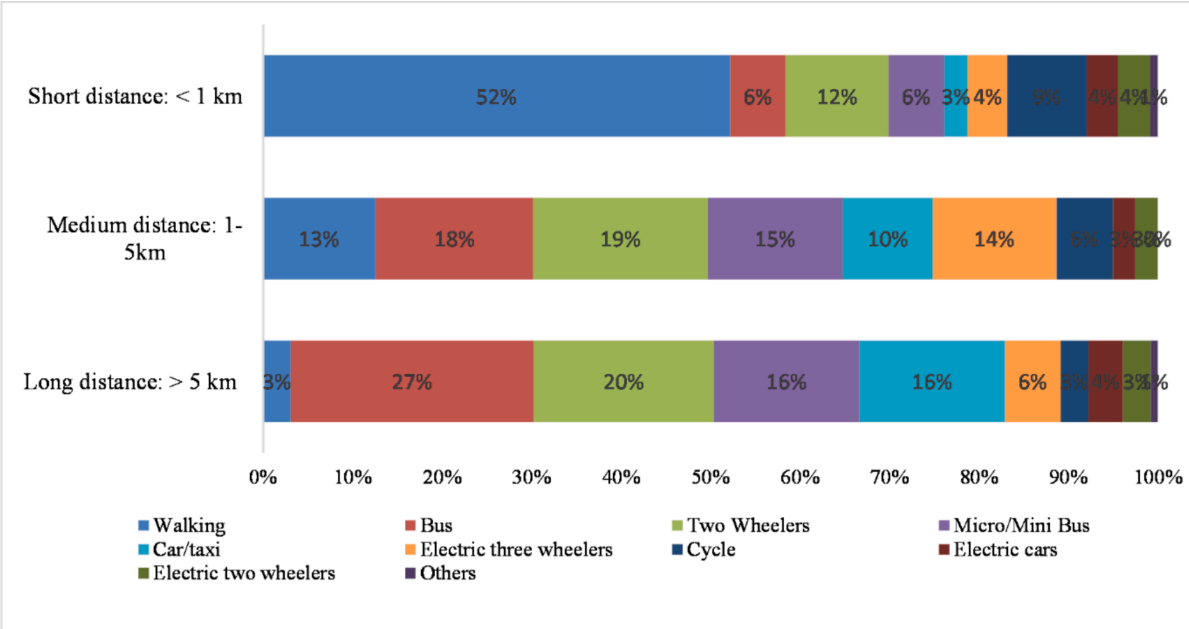

Fig. 4. Trip distribution by mode of the stakeholders.

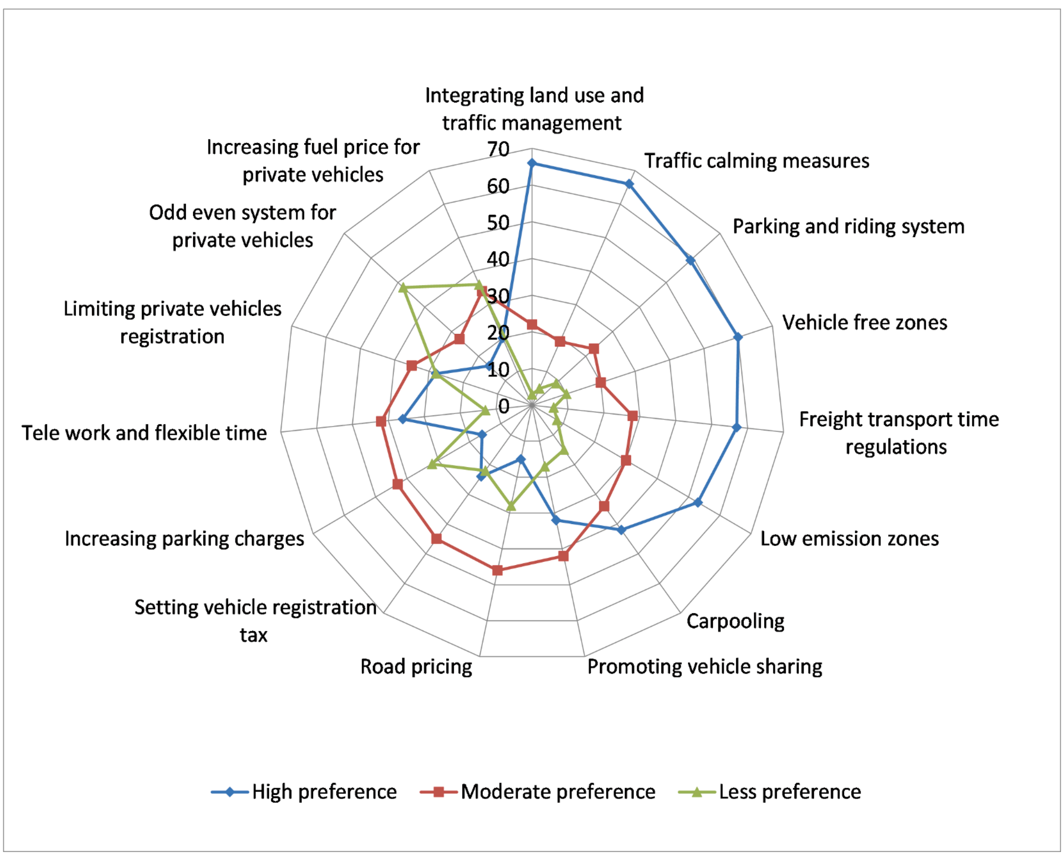

Fig. 5. Stakeholder's preference on various avoid/reduce policies. The number (0–70) in figure indicates the number of respondents.

increasing fuel prices and odd–even systems are the least preferred 'avoid' policies. Similarly, in the case of the 'shift' policy options (Table 3), prioritizing new technology public vehicles, BRT (bus rapid transit) systems, accessible NMT systems, promoting electric vehicles and their infrastructures, availability of late-night public transport are considered to be the most important and highly preferred policies. Studies also suggested the need of dedicated lanes for public transport like bus rapid transit system in comparison to high budget mass transport options like metro rails and monorails (Bhattarai and Shahi, 2021, Ojha, 2021, Acharya et al., 2021). In contrast, transit signal priority, bike-sharing schemes, dial-a-ride systems, and railways systems are moderately prioritized and the ropeway is the least preferred option.

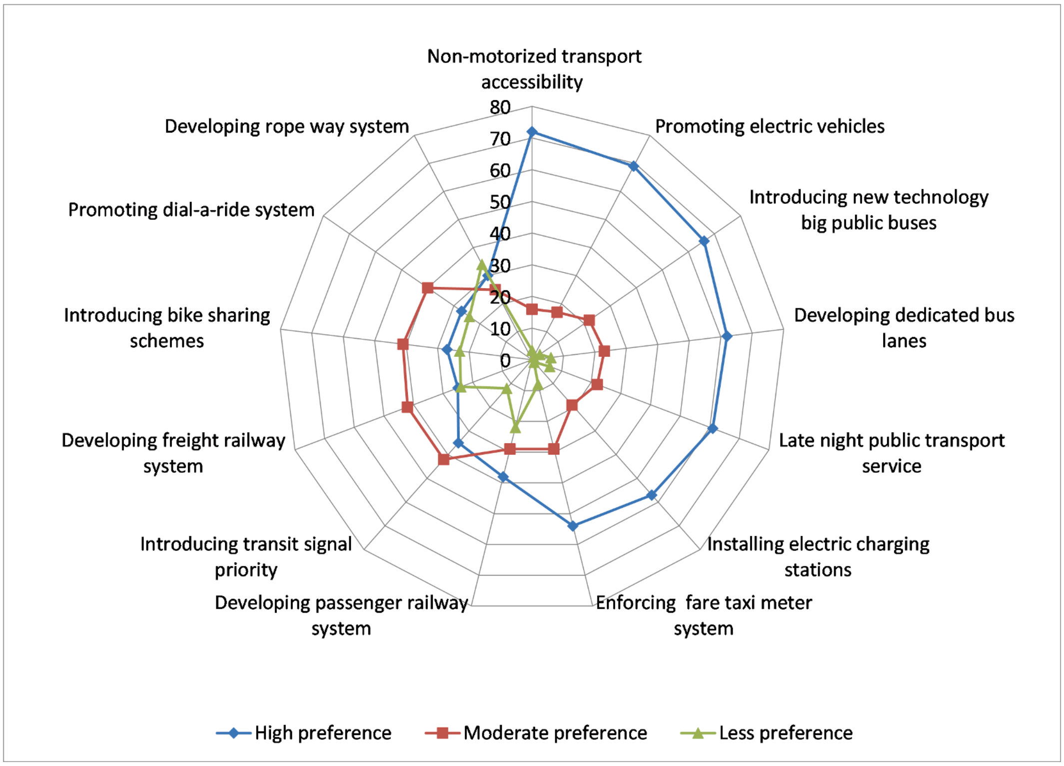

Fig.6. Stakeholder's preference on various shift/maintain policies. The number (0–80) in figure indicates the number of respondents.

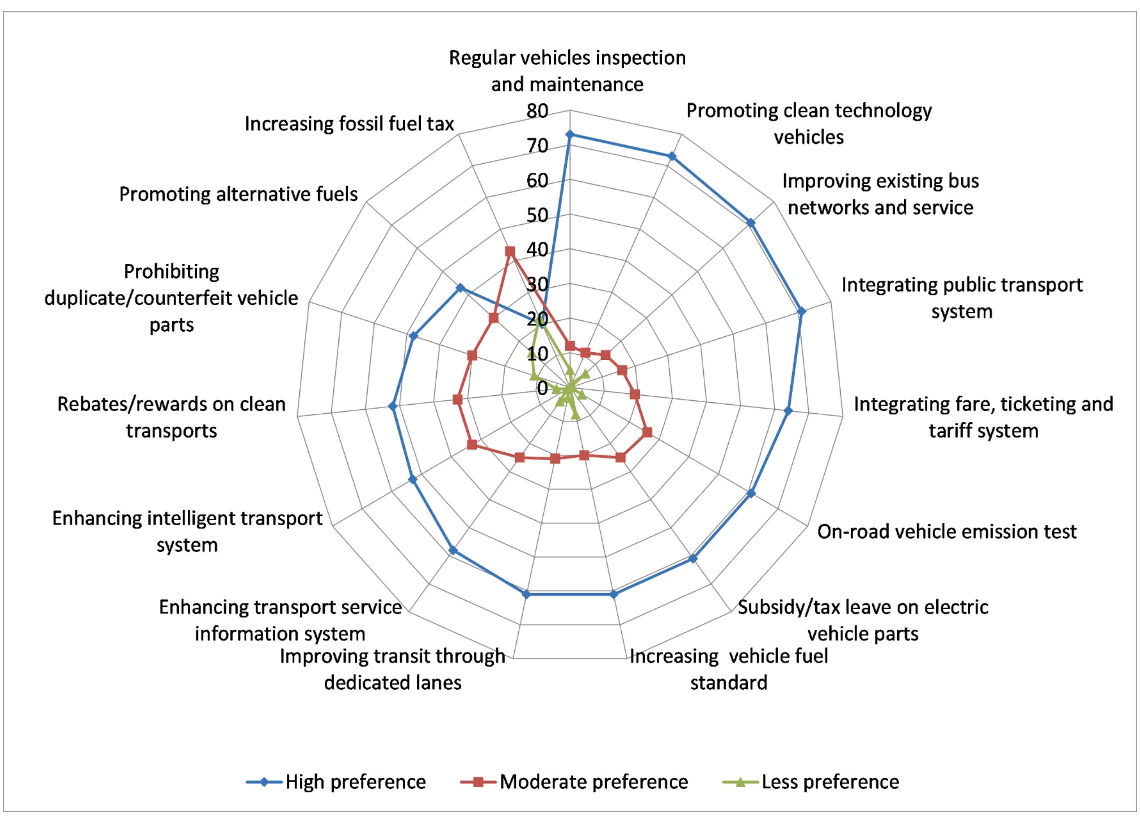

Fig. 7. Stakeholder's preference on various improve policies. The number (0–70) in figure indicates the number of respondents.

Furthermore, almost all policies related to the 'improve' options (Table 3), i.e., increasing the fuel standard, enforcing strict vehicle inspection and maintenance, promoting clean technology vehicles and fuels, and providing better subsidies and tax breaks on electric vehicles are considered highly preferred and 'most important' policies for the KV, whereas increasing fossil fuel taxes considered as a 'moderately

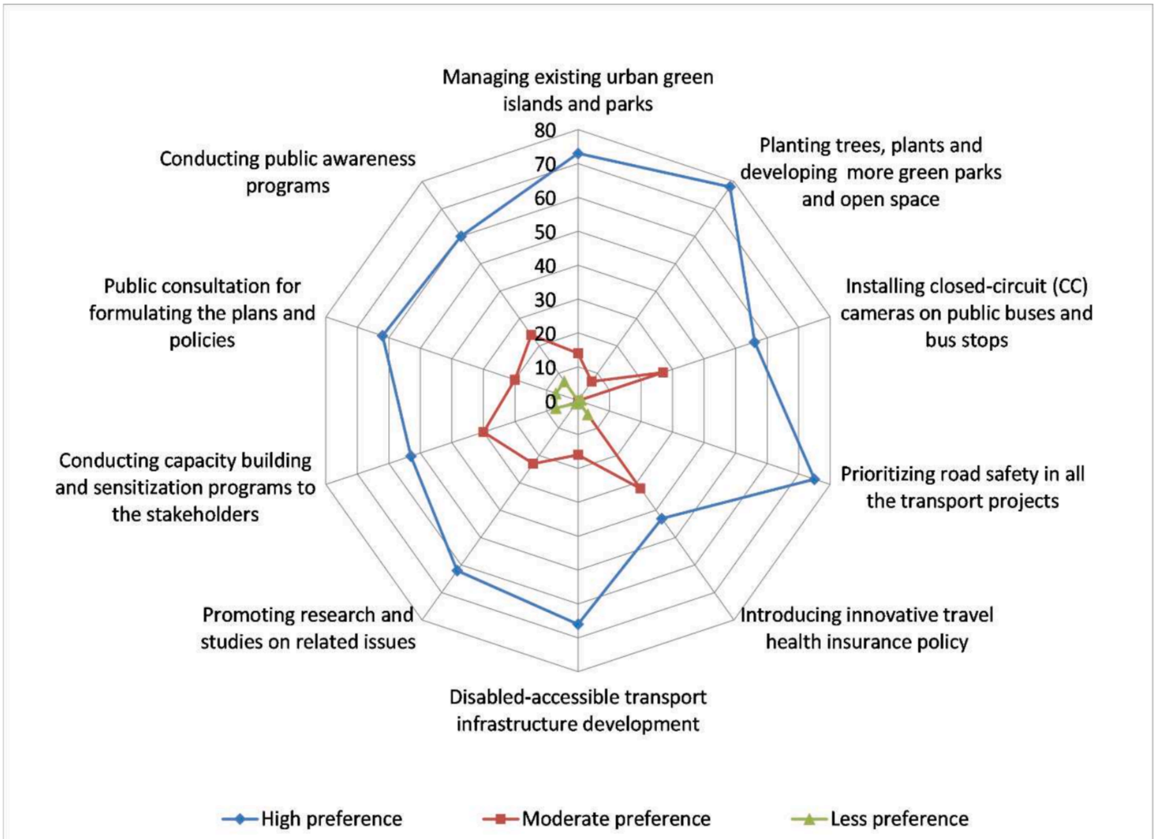

Fig. 8. Stakeholder's preference on various cross-cutting policies. The value (0–70) in figure indicates the number of respondents.

preferred' policy option.

3.3. Additional policy measures

Beyond the policy measures identified and used in the questionnaire survey for our study, some stakeholders also provided additional valuable recommendations such as retrofitting the existing vehicles with pollution control devices, provision of mandatory emission control measures in new vehicles, strict implementation of traffic rules and regulations, implementation of a new master plan for transport sector development, improved coordination among various government agencies and policymakers, and adoption of sustainable transportation actions by the government officials themselves as role models. We also surveyed participants' perceptions on the challenges of current transport systems for achieving LCST in the KV. They perceived the 'political aspect' as the most challenging because the major decisions for formulation and implementation of any such policy heavily rely on strong political will and vision.

4. Discussion

The results regarding the preferences and perceived importance of the various LCST policy options indicate that the stakeholders of transport systems in Kathmandu Valley prioritize elements of the ASI approach, especially the cost-effective ones. They doubt on the success of technological alternatives with high budgets and economic policies in the KV. This could be due to the existence of various challenges for the implementation of such policy measures in existing and planned transport systems (Lah, 2017; Lah, 2015). From the societal and economic point of view, the acceptability of policies by the local residents is the main challenge to the successful implementation of identified policy measures in our study. However, engagement of stakeholders early on and throughout the policy making process could increase the local residents' acceptance and ownership. From an environmental standpoint, policy priorities should consider the geographical context of KV. For instance, the bowl-shaped landscape of KV hinders the dispersal of vehicular emissions in the urban atmosphere (Bhattarai et al., 2019). In addition, factors such as inadequate road length, poor traffic management, congested roads, a mix of both old and new vehicles, and a multimodal public transport system have led to unprecedented levels of traffic congestion, increasing vehicular emissions, frequent accidents, and an unregulated and unreliable public transit system (Bhattarai et al., 2019; Aryal et al., 2022). The policy practices outlined in our study aim to address these issues through ASI strategies.

The policies identified in our study also require efficient, timely, swift, and broad (national scale) implementation. Past low carbon transport policies have failed primarily due to inefficient enforcement of existing policies in KV (e.g., Mali et al., 2022). For instance, as per the NDC of Nepal, the government had planned to increase the share of EVs to 20 % by 2020 but unfortunately failed to meet the target (Mali et al., 2022). This is due to the lack of clear and stable policies (Mali et al., 2022) accompanied by action plans on how to meet those targets in the given timeframe to import and operate EVs within Nepal. Policies promoting clean technology vehicles, a heavy subsidy and tax leave on EVs and their parts could ease the operation of EVs in KV. Another problem that hinders the development of the EV system in Nepal is the lack of a standard tariff structure in practice for charging EVs (Mali et al., 2022; Das et al., 2018). Policies on lowering the electricity tariff for EVs charging and installing electric charging stations in Nepal should be developed for the overall development of EVs in Nepal. A potential component of such system is to reduce the price of electricity used to charge EVs during the electricity off peak hours, such as in the nighttime. Further, charging infrastructure developers should pay special attention to the universal/global standards and designs of charging infrastructure. This could help in the universal accessibility of EVs and prevent future local lock-ins in overall EVs development (Bakker et al., 2015). Within the fleet of fossil fuel-based vehicles, the vehicular inspection and maintenance (I/M) program is confined only to three and four-wheelers while there is a dominance of two-wheelers in KV (ca. 80 % of the total vehicle fleet) and their regular maintenance has been found to reduce emissions significantly (Faiz et al., 2006; Das et al., 2018). The existing I/M programs are also neither strict nor real time based (Faiz et al., 2006; Das et al., 2018). For this, regular vehicle I/M and on-road vehicle emission tests are necessary for all types of vehicles including two-wheelers. Nepal introduced the Euro VI standard petrol and diesel in 2020 to reduce emissions. However, Nepal has yet to introduce Euro VI or Euro VI equivalent BS VI (Bharat Standard VI) standard vehicles. In order to reduce vehicular emissions, improve engine performance, and improve fuel economy, Nepal should shift to higher standard vehicles, preferably Euro VII, and build capacities of technicians and mechanics, as soon as possible.

The number of private vehicles, especially two-wheelers are rapidly increasing in KV and other regions in Nepal (DOTM, 2018). One of the main reasons for this growth is the lack of adequate and efficient public transportation (Bajracharya and Bhattarai, 2016; Mishra et al., 2020). This increased number of two-wheelers has also contributed to air pollution as well as increased road traffic accidents (Huang et al., 2016; Bajracharya and Bhattarai, 2016). Hence, policies encouraging the use of public transport, like introducing big public buses with new technologies and tools (such as GPS tracking, and mobile applications), late night public transport service, and improving existing bus networks and services, are necessary in KV. In a similar vein, a previous study highlights the need for initiatives to enhance existing public transport in KV, including its schedules, such as replacing low-occupancy vehicles with multi-occupancy buses within a Bus Rapid Transit (BRT) system on major roads, supported by fixed schedules and strict traffic regulations (Bhattarai et al., 2019). More specifically, electric big public buses should be prioritized. The pre-feasibility study of big electric public buses (BYD's K7) by GGGI has shown that the cumulative lifetime costs of electric buses are 39 % lower than that of diesel vehicles (GGGI, 2018). Studies have suggested that the dedicated lanes for public transport/Bus Rapid transit (BRT) system as another cost-effective mass transport options for enhancing the public transport quality and service in KV (Bhattarai and Shahi, 2021; Ojha, 2021; Acharya et al., 2021).

Moreover, policy options that discourage the use of fossil fuel based private vehicles should be prioritized in KV. Some of such policies, as identified in our study are increasing fossil fuel tax, limiting private vehicle registration, and increasing the vehicle registration tax. The increased number of vehicles and lack of parking spaces for both two-wheelers and four-wheelers are other pertinent and chronic problems in KV. The increased on-street parking in the major streets of KV has posed the risk of accidents due to the narrowing of streets (Pahari et al., 2021). For such issues, along with the efficient management of parking places, it is necessary to introduce policies like parking and riding, increasing parking charges, promoting non-motorized transport, and improvement of mass transport. In regard to the walkability and access of non-motorized transport, policies on vehicle restriction zones have not been effectively implemented in KV (Das et al., 2018). Thus, vehicle congestion and high emissions still exist around the densely located main market centers, deteriorating the air quality, traffic safety and health of locals (Das et al., 2018). Strict implementation of vehicle free zones and low emission zones is necessary to improve walkability and access to non-motorized transport. Research on the effectiveness of vehicle-free zones has shown a substantial improvement in air quality following their implementation in certain areas of KV (Khadgi et al., 2020). Transport policymakers in Nepal should reevaluate their vehicle-centric urban transport approach and embrace low-carbon sustainable transport policies that prioritize mobility for people. Similarly, Khanal et al., 2017 emphasized the necessity of creating a more equitable and inclusive city while addressing the issues of accessibility, safety, and environmental health risks associated with the growing urban population in KV.

Thus, in order to systematically address a number of issues in the current unsustainable transport situation in KV, like rapid urbanization, increased motorization, and heavy fuel dependency of the transport system, the low carbon sustainable transport measures need to be identified in consultation with stakeholders that are appropriate and feasible for implementation in the local context. Most of the available studies on the transport system in Nepal investigated several issues, mostly individually, and have identified policies measures to improve transport system in Nepal similar to or the same as our findings (Shrestha and Rajbhandari, 2010; Shakya and Shrestha, 2011; Dhital and Shakya, 2014; Dhakal, 2003; Dhakal, 2006; Shukla and Dhar, 2015; KSUTP, 2016; Bajracharya and Bhattarai, 2016; Shakya et al., 2023; Das et al., 2018; Sadavarte et al., 2019; Mool et al., 2020; Das et al., 2022; Bhusal et al., 2024). However, our study considered all issues together holistically and presented a list of important and priority measures as identified by the stakeholders. Hence, the proper balance of ASI policies and the coordination from the enablers of key sustainable transport aspects such as the economic, social, political, technological, infrastructural (including institutional, regulatory and human resource) and environmental aspects play a vital role in the successful implementation of such policies (IEA, 2013; ADB, 2010; Lah, 2015).

5. Conclusions

In order to develop low carbon sustainable transport (LCST) systems in the Kathmandu Valley, Nepal, our study clearly shows the strong recognition from interested and key stakeholders for the substantial and specific improvements in the current transport systems. An integrated avoid-shift-improve (ASI) approach is vital for identifying policy measures suitable in the local context and preferred by the key stakeholders, as identified in our case study for the Kathmandu Valley. As indicated by the stakeholder preferences received through a comprehensive survey of the ASI policy options using the Delphi approach, cost-effective planning, and the regulatory ASI measures (e.g., integrated land use planning, non-motorized (NMT) infrastructures, regular vehicle inspection and maintenance system) are essential to be prioritized in the context of the KV. A combination of both technical and non-technical measures related to economic, environmental, and social dimensions of LCST customized to the carefully examined local specifics is likely to deliver optimal air quality, climate, and social-equity co-benefits.

One limitation of our study was that the resources were only available to conduct two rounds of the Delphi survey, with a limited set of stakeholders. However, the results were found to be consistent across the two rounds. Although we tried to minimize the potential bias due to the judgment of experts in our study, to some extent, there could be both response bias and non-response bias. However, since the responses are consistent across two rounds of the Delphi survey with the current transport situation in the Kathmandu Valley, and in line with the findings of the previous studies, such biases are expected to be minimal. The existing policies analyzed in our study are based on available documents of the relevant government agencies, scientific journals, and other reports published by national and international agencies such as the World Bank and UNEP. The adoption of the new constitution in 2015 has established Nepal as a federal republic with three tiers of governance: federal, provincial, and local. Local governments play a pivotal role in implementing the policies formulated at all three levels of government. This study broadly categorized the governing bodies (Fig. 3) into national and local levels. While the findings of our study hold true with respect to policies, future research on the transport system of KV could explore these three tiers of government in more depth as some roles of transport system governance have recently been transferred to the provincial government. Likewise, we have selected the stakeholders based on their responsibility, influence, proximity, interdependences, and representativeness, following the stakeholder engagement guidelines as described in Partridge et al., 2005. Future studies could map the stakeholders into further governmental structures like central, provincial, and local, which are not included in this study. Considering these limitations, future studies could include a higher number of stakeholders, and interactions of the policies are highly recommended for further advancing our understanding of LCST systems at multiple levels (from individual to systemic). Scenario studies based on carefully identified policies are also equally important to optimize the future implications of LCST measures and utilization of limited financial resources.

CRediT authorship contribution statement

Jyoti Prajapati: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Maheswar Rupakheti:** Writing – review & editing, Supervision. **Mark G. Lawrence:** Writing – review & editing, Supervision, Resources.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

JP was a recipient of the International Climate Protection (IPC) Fellowship provided by the Alexander von Humboldt Foundation, Bonn, Germany. The authors acknowledge financial support by the Alexander Von Humboldt Foundation, the Research Institute for Sustainability – Helmholtz Centre Potsdam (RIFS), formerly the Institute for Advanced Sustainability Studies (IASS), which is funded by the German Federal Ministry for Education and Research (BMBF) and the Brandenburg Ministry for Science, Research and Culture (MWFK), and the University of Graz. The authors also sincerely acknowledge all the stakeholders for their participation and recommendations for the successful completion of this study. They are grateful to the reviewers for their constructive feedback and comments during the review process.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trip.2024.101293.

Data availability

The data that has been used is confidential.

References

Acharya, S., Upreti, S., Jha, S., Marasani, A., Kattel, S., Tiwari, H., 2021. Public Transportation Optimization on Godawari to Budanilkantha Route Via Introduction of Bus Rapid Transit. *Journal of Advanced College of Engineering and Management* 6, 131–135. https://doi.org/10.3126/jacem.v6i0.38346.

ADB, 2010. Sustainable transport initiative: Operational plan, Asian Development Bank (ADB). The Philippines, Manila.

Ahmad, S., de Oliveira, J.A.P., 2016. Determinants of urban mobility in India: Lessons for promoting sustainable and inclusive urban transportation in developing countries. *Transp Policy* 50, 106–114. https://doi.org/10.1016/j.tranpol.2016.04.014.

Aryal, T.R., Ichihashi, M., Kaneko, S., 2022. How strong is demand for public transport service in Nepal? A case study of Kathmandu using a choice-based conjoint experiment. *Journal of Economic Structures* 11 (1), 29. https://doi.org/10.1186/s40008-022-00287-3.

Bajracharya, I., Bhattarai, N., 2016. Road transportation energy demand and environmental emission: A case of Kathmandu valley. *Hydro Nepal: Journal of Water, Energy and Environment* 18, 30–40. https://doi.org/10.3126/hn.v18i0.14641.

Bakker, S., Leguijt, P., Van Lente, H., 2015. Niche accumulation and standardization–the case of electric vehicle recharging plugs. *J Clean Prod* 94, 155–164. https://doi.org/10.1016/j.jclepro.2015.01.069.

Banister, D., 2008. The sustainable mobility paradigm. *Transp Policy* 15 (2), 73–80. https://doi:10.1016/j.tranpol.2007.10.005.

Bener, A., Abu-Zidan, F.M., Bensiali, A.K., Al-Mulla, A.A., Jadaan, K.S., 2003. Strategy to improve road safety in developing countries. *Saudi Med J* 24 (6), 603–608.

Berger, G., Feindt, P.H., Holden, E., Rubik, F., 2014. Sustainable mobility—challenges for a complex transition. *J Environ Plann Policy Manage* 16 (3), 303–320. https://doi.org/10.1080/1523908X.2014.954077.

Bernard, H.R., 2002. *Research methods in anthropology: Qualitative and quantitative approaches*, 3rd ed. Alta Mira Press, Walnut Creek, CA.

Bhattacharya, A., Ghosh, J., Tezuka, T., Bhattacharya, T., 2018. Assessment of low carbon transport for sustainable development in Bhutan: a general equilibrium approach. *International Journal of Public Policy* 14 (1/2), 64–103. https://doi:10.1504/ijpp.2018.10011844.

Bhattarai, D.K., Shahi, P.B., 2021. Integrated Multi-Modal Transportation System: A Sustainable Approach for Urban Transport in Kathmandu. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN* 18 (6), 47–59.

Bhattarai, K., Yousef, M., Greife, A., Lama, S., 2019. Decision-aiding transit-tracker methodology for bus scheduling using real time information to ameliorate traffic congestion in the Kathmandu Valley of Nepal. *J Geogr Inf Syst* 11 (2), 239–291. https://doi.org/10.4236/jgis.2019.112016.

Bhusal, P., Shrestha, S.M., Dhital, N.B., Bhandari, G.S., Das, B., Pandit, R., 2024. Analysis of in-vehicle air quality and load factor as environmental and social dimensions of sustainable urban mobility: A case study from Kathmandu valleyNepal. *Journal of Air Pollution and Health* 9 (1), 41–58. https://doi.org/10.18502/japh.v9i1.15078.

Cafiso, S., Di Graziano, A., Pappalardo, G., 2013. Using the Delphi method to evaluate opinions of public transport managers on bus safety. *Saf Sci* 57, 254–263. https://doi.org/10.1016/j.ssci.2013.03.001.

CBS, 2012. National population and housing census 2011: National Report, Central Bureau of Statistics (CBS), Government of Nepal.

CBS, 2014. Population atlas of Nepal. Central Bureau of Statistics (CBS), Government of Nepal.

CEN/CANN 2012. "Public Transport Quality Survey," Clean Air Network Nepal (CANN) and Clean Energy Nepal (CEN), 2012.

Dalkmann, H., and Sakamoto, K., 2012. Urban Transport: Policy Recommendations for the development of eco-efficient infrastructure. Low carbon green growth roadmap for Asia and the Pacific, 101. Retrieved from: https://hdl.handle.net/20.500.12870/4038.

Das, B., Bhave, P.V., Puppala, S.P., Byanju, R.M., 2018. A global perspective of vehicular emission control policy and practices: An Interface with Kathmandu Valley case Nepal. *Journal of Institute of Science and Technology* 23 (1), 76–80. https://doi.org/10.3126/jist.v23i1.22199.

Das, B., Bhave, P.V., Puppala, S.P., Adhikari, S., Sainju, S., Mool, E., Byanju, R.M., 2022. Emission factors and emission inventory of diesel vehicles in Nepal. *Sci Total Environ* 812, 152539. https://doi.org/10.1016/j.scitotenv.2021.152539.

Dhakal, S., 2003. Implications of transportation policies on energy and environment in Kathmandu Valley Nepal. *Energy Policy* 31 (14), 1493–1507. https://doi.org/10.1016/S0301-4215(02)00205-7.

Dhakal, S., 2006. Urban Transportation and the Environment in Kathmandu Valley, Nepal: Integrating global carbon concerns into local air pollution management, Institute for Global Environmental Strategies (IGES). Japan.

Dhital, H.C. and Shakya, S.R., 2014. Implication of Sustainable Low Carbon Transportation Development Strategy in Emerging City: A case of Kathmandu Valley. In *Proceedings of IOE Graduate Conference* (Vol. 2, pp. 215-224).

DOE, 2020. Air quality management action plan for Kathmandu Valley. Department of Environment (DOE), Government of Nepal (GON).

DOTM, 2018. Number of vehicles registered in Nepal by 2016-17. Department of Transport Management (DOTM), Government of Nepal.

Drolet, A.L., Morrison, D.G., 2001. Do We Really Need Multiple-Item Measures in Service Research? *J Serv Res* 3 (3), 196–204. https://doi.org/10.1177/109467050133001.

Eriksson, L., Garvill, J., Nordlund, A.M., 2008. Acceptability of single and combined transport policy measures: The importance of environmental and policy specific beliefs. *Transp Res A Policy Pract* 42 (8), 1117–1128. https://doi.org/10.1016/j.tra.2008.03.006.

Etikan, I., Musa, S.A., Alkassim, R.S., 2016. Comparison of Convenience Sampling and Purposive Sampling. *Am J Theor Appl Stat* 5 (1).

Faiz, A., Bahadur Ale, B., Nagarkoti, R.K., 2006. The role of inspection and maintenance in controlling vehicular emissions in Kathmandu valley Nepal. *Atmospheric Environment* 40 (31), 5967–5975. https://doi.org/10.1016/j.atmosenv.2005.11.064.

Furtado, B.A., Sakowski, P.A.M., Tovolli, M.H., 2015. Modeling Complex Systems for public policy. Ipea. https://doi.org/10.1007/978-1-4419-6562-2.

Gakenheimer, R., 1999. Urban mobility in the developing world. *Transp Res A Policy Pract* 33 (7–8), 671–689. https://doi.org/10.1016/S0965-8564(99)00005-1.

GEF-STAP, 2010. Advancing Sustainable Low-Carbon. Transport Through the GEF, A STAP advisory document prepared by Holger Dalkmann and Cornie Huizenga. Global Environment Facility. Washington, D.C.

GGGI, 2018. National action plan for electric mobility: Accelerating implementation of Nepal's nationally determined contribution. Global Green Growth Institute, Seoul, Korea.

Givoni, M., Banister, D., 2013. *Moving towards low carbon mobility*. Edward Elgar, Cheltenham, UK.

GIZ-SUTP, 2014. Urban transport and climate change: module 5e sustainable transport: a sourcebook for policy-makers in developing cities (www.sutp.org/en-sourcebook, last accessed 04/11/2020).

GIZ-SUTP, 2004. Sustainable urban transport: avoid-shift-improve. (URL: SUTP_GIZ_FS_Avoid-Shift-Improve_EN.pdf) last accessed 04/11/2020.

GON, 1993. Vehicle and Transport Management Act, 1993, Government of Nepal (GON).

GON, 2020. Second Nationally Determined Contribution (NDC) of Nepal, Government of Nepal (GON).
GON, 2021. Nepal's long-term strategy for net-zero emissions, Government of Nepal (GON). https://unfccc.int/sites/default/files/resource/NepalLTLEDS.pdf.
González, Y.H., Quintana, S.C., 2016. An integrated assessment of alternative land-based passenger transport policies: A case study in Tenerife. *Transp Res A Policy Pract* 89, 201–214. https://doi.org/10.1016/j.tra.2016.05.016.
Han, S.S., 2010. Managing motorization in sustainable transport planning: the Singapore experience. *J Transp Geogr* 18 (2), 314–321. https://doi.org/10.1016/j.jtrangeo.2009.06.010.
Haque, M.M., Chin, H.C., Debnath, A.K., 2013. Sustainable, safe, smart-three key elements of Singapore's evolving transport policies. *Transp Policy* 27, 20–31. https://doi.org/10.1016/j.tranpol.2012.11.017.
Hickman, R., Hall, P., Banister, D., 2013. Planning more for sustainable mobility. *J Transp Geogr* 33, 210–219. https://doi:10.1016/j.jtrangeo.2013.07.004.
Hirschhorn, F., 2019. Reflections on the application of the Delphi method:lessons from a case in public transport research. *Int J Soc Res Methodol* 22 (3), 309–322. https://. https://doi.org/10.1080/13645579.2018.1543841.
Holden, E., Banister, D., Gössling, S., Gilpin, G., Linnerud, K., 2020. Grand Narratives for sustainable mobility: A conceptual review. *Energy Res Soc Sci* 65 (January), 101454. https://doi.org/10.1016/j.erss.2020.101454.
Huang, L., Adhikary, K.P., Choulagai, B.P., Wang, N., Poudyal, A.K., Onta, S.R., 2016. Road traffic accident and its characteristics in Kathmandu valley. *Journal of the Nepal Medical Association* 55 (203), 1–6. https://doi.org/10.31729/jnma.2829.
IEA, 2012. Policy pathways brief: Improving the fuel economy of road vehicles: a policy package. International Energy Agency (IEA).
IEA, 2020. Tracking progress: Transport. Retrieved from, International Energy Agency (IEA) https://www.iea.org/reports/tracking-transport-2020.
IEA, 2013. A tale of renewed cities: a policy guide on how to transform cities by improving energy efficiency in urban transport system. International Energy Agency 201375739 Paris Cedex 15, France.
IPCC, 2014. Transport. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge,University Press, Cambridge,United Kingdom and New York, NY, USA.
Jha, P.K., 2001. Transport Sector Technical Inspection System in Nepal. Retrieved from. https://www.researchgate.net/publication/228465337_Transport_sector_technical_inspection_system_in_Nepal.
JICA. 2012. Final Report, Data Collection Survey on Traffic Improvement In Kathmandu Valley. Ministry of Physical Planning, Works and Transport Management. 2012. Retrieved from https://openjicareport.jica.go.jp/pdf/12345484_01.pdf.
Jones, S., Tefe, M., Appiah-Opoku, S., 2013. Proposed framework for sustainability screening of urban transport projects in developing countries: A case study of Accra, Ghana. *Transp Res A Policy Pract* 49, 21–34. https://doi.org/10.1016/j.tra.2013.01.003.
Keizer, M., Sargisson, R.J., van Zomeren, M., Steg, L., 2019. When personal norms predict the acceptability of push and pull car-reduction policies: Testing the ABC model and low-cost hypothesis. *Transport Res F: Traffic Psychol Behav* 64, 413–423. https://doi.org/10.1016/j.trf.2019.06.005.
Khadgi, J., Thapa, R., Prasai Joshi, T., Maskey Byanju, R., 2020. Effectiveness of vehicle-free zone in reducing air pollution. *Int J Environ Sci Technol* 1–12. https://doi.org/10.1007/s13762-020-02977-6.
Khanal, P., Gurung, A., Chand, P.B., 2017. Road expansion and urban highways: consequences outweigh benefits in Kathmandu. Retrieved from HIMALAYA, *the Journal of the Association for Nepal and Himalayan Studies* 37 (1), 15. https://digitalcommons.macalester.edu/himalaya/vol37/iss1/15.
KSUTP, 2016. Kathmandu sustainable urban transport project (KSUTP) A Sustainable Transport Project Status and Progress. Kathmandu Sustainable Urban Transport Project, Nepal.
Lah, O., 2015. The barriers to low-carbon land-transport and policies to overcome them. *Eur Transp Res Rev* 7 (1). https://doi.org/10.1007/s12544-014-0151-3.
Lah, O., 2017. Sustainable development synergies and their ability to create coalitions for low-carbon transport measures. *Transp Res Procedia* 25, 5083–5093. https://doi.org/10.1016/j.trpro.2017.05.495.
Leather, J., 2009. Rethinking transport and climate change. ADB Sustainable Development Working Paper Series, Asian Development Bank, Manila, The Philippines.
Lee, S., 2018. Transport policies, induced traffic and their influence on vehicle emissions in developed and developing countries. *Energy Policy* 121 (February), 264–274. https://doi.org/10.1016/j.enpol.2018.06.035.
Litman, T., 2013. Comprehensive evaluation of energy conservation and emission reduction policies. *Transp Res A Policy Pract* 47, 153–166. https://doi.org/10.1016/j.tra.2012.10.022.
Litman, T., 2011. Smart transportation emission reduction strategies, identifying truly optimal ways to conserve energy and reduce emissions. Victoria Transport Policy Institute, 47(January 2013), 153–166.
Mali, B., Shrestha, A., Chapagain, A., Bishwokarma, R., Kumar, P., Gonzalez-Longatt, F., 2022. Challenges in the penetration of electric vehicles in developing countries with a focus on Nepal. *Renewable Energy Focus* 40 (March), 1–12. https://doi.org/10.1016/j.ref.2021.11.003.
Malla, S., 2014. Assessment of mobility and its impact on energy use and air pollution in Nepal. *Energy* 69, 485–496. https://doi:10.1016/j.energy.2014.03.041.
Mishra, K., Sah, R.C., Aithal, P.S., 2020. Operational Assessment of Public Transport; A Case of Kathmandu. Nepal. *International Journal of Case Studies in Business, IT, and Education (IJCSBE)* 4 (2), 132–152. https://ssrn.com/abstract=3694383.
Mool, E., Bhave, P.V., Khanal, N., Byanju, R.M., Adhikari, S., Das, B. and Puppala, S.P., 2020. Traffic condition and emission factor from diesel vehicles within the Kathmandu valley. *Aerosol and Air Quality Research*, *20*(3), pp.395-409. https://doi:10.4209/aaqr.2019.03.0159.
MOPE, 2016. Nationally Determined Contributions. Ministry of Population and Environment (MOPE). Government of Nepal.
MOPIT/ADB, 2010. Kathmandu sustainable urban transport project (Main Report). Ministry of Physical Infrastructure and Transport (MOPIT), Government of Nepal (GON) and Asian Development Bank (ADB).
MOPIT/GON, 2015. National Sustainable Transport Strategy (NSTS) for Nepal (2015~2040) (Final Draft). Ministry of Physical Infrastructure and Transport (MOPIT), Ministry of the Environment (MOE), Government of Nepal (GON), Japan United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP).
MOPIT/GON, 2001. National Transport Policy 2001. Ministry of Physical Infrastructure and Transport (MOPIT). Government of Nepal (GON).
Muzzini, E., Aparicio, G., 2013. *Urban growth and spatial transition in Nepal: an initial assessment.* Directions in Development: Countries and Regions. The World Bank, Washington DC, USA.
Nakamura, K., Hayashi, Y., 2013. Strategies and instruments for low-carbon urban transport: An international review on trends and effects. *Transp Policy* 29, 264–274. https://doi.org/10.1016/j.tranpol.2012.07.003.
Ojha, K., 2021. Road safety status and some initiatives in Nepal. *ITEGAM-JETIA* 7 (27), 20–40. https://doi.org/10.5935/jetia.v7i27.713.
Paez, A., 2017. Gray literature: An important resource in systematic reviews. *J Evid Based Med* 10 (3), 233–240. https://doi.org/10.1111/jebm.12266.
Pahari, S., Khanal, S., and Khanal, U., 2021. On-street Parking In Inner Kathmandu: Determining On-street Parking Load And Parking Efficiency Of Motorcycles In The Streets Of New Road In Kathmandu Metropolitan City. *International Journal of Innovations in Engineering Research and Technology, 7*(08), pp.7-15. https://Repo.Ijiert.Org/Index.Php/Ijiert/Article/View/157.
Pappas, C., Williams, I., 2011. Grey literature: its emerging importance. *J Hosp Librariansh* 11 (3), 228–234. https://doi:10.1080/15323269.2011.587100.
Paré, G., Cameron, A.F., Poba-Nzaou, P., Templier, M., 2013. A systematic assessment of rigor in information systems ranking-type Delphi studies. *Inf Manag* 50 (5), 207–217. https://doi.org/10.1016/j.im.2013.03.003.
Partridge, K., Jackson, C., Wheeler, D., Zohar, A., Krick, T., Forstater, M., Monaghan, P., Sillanpää, M., Machhiwala, S., Forde, C., 2005. From Words to Action: The Stakeholder Engagement Manual-Volume 1 The Guide to Practioners' Perspectives on Stakeholder Engagement. AccountAbility, UNEP and Stakeholder Research Associates, Cobourg.
Persia, L., Cipriani, E., Sgarra, V., Meta, E., 2016. Strategies and measures for sustainable urban transport systems. *Transp Res Procedia* 14, 955–964. https://doi:10.1016/j.trpro.2016.05.075.
Le Pira et, al., 2018. Dealing with the complexity of stakeholder interaction in participatory transport planning. *Advances in Intelligent Systems and Computing. 572*. https://doi:10.1007/978-3-319-57105-8_3.
Pojani, D., Stead, D., 2015. Sustainable urban transport in the developing world: Beyond megacities. *Sustainability (switzerland)* 7 (6), 7784–7805. https://doi.org/10.3390/su7067784.
Pokharel, R., Acharya, S.R., 2015. Sustainable transport development in Nepal: challenges, opportunities and strategies. *J East Asia Soc Transp Stud* 11, 209–226. https://doi.org/10.11175/easts.11.209.
PPMC, 2016. Paris process on mobility and transport, (http://www.ppmc transport.org/transport-day-2016).
Pradhan, S., Ale, B.B., Amatya, V.B., 2006. Mitigation potential of greenhouse gas emission and implications on fuel consumption due to clean energy vehicles as public passenger transport in Kathmandu Valley of Nepal: a case study of trolleybuses in Ring Road. *Energy* 31 (12), 1748–1760. https://doi.org/10.1016/j.energy.2005.10.013.
Prajapati, A., Bajracharya, T.R., Bhattarai, N., Froyen, Y.K., 2019. Public Bus Accessibility and its Implications in Energy and Environment: A Case Study of Kathmandu Valley. *J Inst Eng* 15 (3).
Prajapati, A., Bhattarai, N., Bajracharya, T.R., 2021. Passenger Transport Modal Mix by Incorporating Travel Behaviour: A Case Study of Kathmandu Valley Nepal. *Strategic Planning for Energy and the Environment* 231–254. https://doi.org/10.13052/spee1048-4236.4032.
Pullin, A.S., Stewart, G.B., 2006. Guidelines for systematic review in conservation and environmental management. *Conserv Biol* 20 (6), 1647–1656.
Rees, D., Stephenson, J., Hopkins, D., Doering, A., 2017. Exploring stability and change in transport systems: combining Delphi and system dynamics approaches. *Transportation* 44, 789–805. https://doi.org/10.1007/s11116-016-9677-7.
Regmi, M.B., 2020. Measuring sustainability of urban mobility: A pilot study of Asian cities. *Case Studies on Transport Policy* 8 (4), 1224–1232. https://doi.org/10.1016/j.cstp.2020.08.003.
Sadavarte, P., Rupakheti, M., Bhave, P.V., Shakya, K., and Lawrence M.G., 2019. Nepal emission inventory – part I: technologies and combustion sources (NEEMI-Tech) for Nepal 2001-2016., *Atmospheric Chemistry and Physics, 19*(20), 12953–12973. https://doi: 10.5194/acp-2019-113.
Santos, G., Behrendt, H., Teytelboym, A., 2010. Part II: Policy instruments for sustainable road transport. *Res Transp Econ* 28 (1), 46–91. https://doi.org/10.1016/j.retrec.2010.03.002.
Shakya, S.R., Shrestha, R.M., 2011. Transport sector electrification in a hydropower resource rich developing country: energy security, environmental and climate change co-benefits. *Energy Sustain Dev* 15, 147–159. https://doi.org/10.1016/j.esd.2011.04.003.

Shakya, S.R., Nakarmi, A.M., Prajapati, A., Pradhan, B.B., Rajbhandari, U.S., Rupakheti, M., Lawrence, M.G., 2023. Environmental, energy security, and energy equity (3E) benefits of net-zero emission strategy in a developing country: A case study of Nepal. *Energy Rep* 9, 2359–2371. https://doi.org/10.1016/j.egyr.2023.01.055.

Shiftan, Y., Kaplan, S., Hakkert, S., 2003. Scenario building as a tool for planning a sustainable transportation system. *Transp Res Part D: Transp Environ* 8 (5), 323–342. https://doi.org/10.1016/S1361-9209(03)00020-8.

Shrestha, R.M., and Rajbhandari, S., 2010. Energy and environmental implications of carbon emission reduction targets: case of Kathmandu Valley, Nepal. *Energy Policy, 38*, 8818-4827. https://doi:10.1016/j.enpol.2009.11.088.

Shukla, P.R., Dhar, S., 2015. Energy policies for low carbon sustainable transport in Asia. *Energy Policy* 81, 170–175. https://doi.org/10.1016/j.enpol.2015.02.021.

Skinner, R., Nelson, R.R., Chin, W.W., Land, L., 2015. The Delphi method research strategy in studies of information systems. *Commun Assoc Inf Syst* 37, 31–63. https://doi.org/10.17705/1cais.03702.

Skulmoski, G.J., Hartman, F.T., Krahn, J., 2007. The Delphi method for graduate research. *J Inf Technol Educ* 6, pp-pp. https://doi:10.1007/3-540-47847-7_10.

SLOCAT., 2021. Tracking Trends in a Time of Change: The Need for Radical Action Towards Sustainable Transport Decarbonization, Transport and Climate Change Global Status Report – 2nd edition.

Stephenson, J., Spector, S., Hopkins, D., McCarthy, A., 2018. Deep interventions for a sustainable transport future. *Transp Res Part D: Transp Environ* 61, 356–372. https://doi.org/10.1016/j.trd.2017.06.031.

Taylor, M.A., 2017. Special issue on low carbon mobility. *Int J Sustain Transp* 11 (1), 1–2. https://doi.org/10.1080/15568318.2015.1106263.

UNESCAP, 2023. National Strategy for Electrification of Public Transport in Nepal. United Nations, Economic and Social Commission for Asia and the Pacific. Retrieved from https://www.unescap.org/kp/2023/national-strategy-electrification-public-transport-nepal.

Uteng, T.P., 2007. Social sustainability in the transport sector: An essential requisite for sustainable mobility. *International Journal of Environment and Sustainable Development* 6 (2), 113–135. https://doi.org/10.1504/IJESD.2007.014198.

van der Loop, H., Haaijer, R., Willigers, J., 2016. New findings in the Netherlands about induced demand and the benefits of new road infrastructure. *Transp Res Procedia* 13, 72–80. https://doi.org/10.1016/j.trpro.2016.05.008.

von der Gracht, H.A., 2012. Consensus measurement in Delphi studies. *Technol Forecast Soc Chang* 79 (8), 1525–1536. https://doi:10.1016/j.techfore.2012.04.013.

Wang, L., 2014. Framework for evaluating sustainability of transport system in megalopolis. *IERI Procedia, 9*, 110-116, https://doi: 10.1016/j.ieri.2014.09.049.

Willits, F.K., Theodori, G.L., Luloff, A.E., 2016. Another look at Likert scales. Available At: *Journal of Rural Social Sciences* 31 (3), 6 https://egrove.olemiss.edu/jrss/vol31/iss3/6.

Ye, Y., Wang, C., Zhang, Y., Wu, K., Wu, Q., Su, Y., 2017. Low-carbon transportation oriented urban spatial structure: Theory, model and case study. *Sustainability* 10 (1), 19. https://doi.org/10.3390/su10010019.

Yousuf, M.I., 2007. Using experts' opinions through Delphi technique. Pract Assess Res Eval 12, Article 4. https://doi.org/10.7275/rrph-t210.