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Social Learning and the Mitigation of Transport CO_2 Emissions

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Abstract: Social learning, a key factor in fostering behavioural change and improving decision making, is considered necessary for achieving substantial CO_2 emission reductions. However, no empirical evidence exists on how it contributes to mitigation of transport CO_2 emissions, or the extent of its influence on decision making. This paper presents evidence addressing these knowledge gaps. Social learning-oriented workshops were conducted to gather the views and preferences of participants from the general public in Bahrain on selected transport CO_2 mitigation measures. Social preferences were inputted into a deliberative decision-making model and then compared to a previously prepared participative model. An analysis of the results revealed that social learning could contribute to changes in views, preferences and acceptance regarding mitigation measures, and these changes were statistically significant at an alpha level of 0.1. Thus, while social learning evidently plays an important role in the decision-making process, the impacts of using other participatory techniques should also be explored.

Keywords: Bahrain; climate change mitigation; deliberative decision making; social learning; transport CO_2 emissions

1. Introduction

The twenty-first session of the Conference of Parties (COP21) achieved consensus among the 196 participating countries to limit the rise in the global average temperature to below 2 °C above pre-industrial levels, with efforts focusing on a target of 1.5 °C above those levels. Unlike the Kyoto protocol, developing countries will commit to reducing emissions by 2020, as indicated in their Intended Nationally Determined Contributions. A total of 186 parties submitted these intended contributions to emission reductions from different energy consuming sectors prior to the COP21. The road transport sector appears to be a priority among these sectors for developing countries. This is because emissions from the transport sector in developing countries are expected to increase rapidly over the coming years [1,2]. Reductions in transport CO_2 emissions can be achieved through technological advances. However, achieving substantial reductions requires also a change in the public's behaviour [3]. Targeting behavioural change is necessary, especially in the Gulf Cooperation Council (GCC) countries, where the per capita CO_2 emissions rank among the highest globally [4].

Social learning has been identified as a key factor for fostering behavioural changes relating to climate change mitigation. It has been variously defined, and several publications have explored its theoretical aspects (e.g., [5–10]). Two main perspectives have been observed with respect to the concept of social learning. The first perspective focuses on learning process to build a joint framework, whereas the second perspective devotes more attention to reaching convergence among different stakeholders to solve a given problem [11]. In this paper, taking into account the different concepts and applications of social learning in the different research areas, I applied the following definition, developed in the context of natural resource management, which is close to the climate change mitigation field:

"a process of social change in which people learn from each other in ways that can benefit wider social-ecological systems" [7]. Within the literature, social learning has been applied at two levels. The first entails learning at an individual level [12], while the second extends to the wider group or even to the societal level [7,11,13]. Recent researches have either adopted the group level (e.g., [11]) or combined both levels (e.g., [14]), and the later approach is applied here.

Outcomes of social learning vary within empirical literature; however, the outcomes can be classified into four main dimensions: the cognitive dimension, the moral dimension, the relational dimension and the agreement dimension (see Table 1). Types of process dynamics can also vary. Literature on social learning categorises these into three loops: single-loop learning, double-loop learning and triple-loop learning. In the first type of process dynamics, single-loop learning, participants express their views and preferences. At the double-loop learning level, the participants discuss their views, question them and change them as appropriate. Finally, when participants prioritise their preferences and reach consensus about decisions, this indicates the triple-loop learning level [13,15–17].

Table 1. Classification of potential outcomes for social learning as identified in relevant literature. (Adapted from: [12,14,18–21])

Main Dimensions	Cognitive Dimension	Moral Dimension	Relational Dimension	Agreement Dimension
Sub-dimensions	- Acquisition of new knowledge - Knowledge about preferences of other participants - Change of views - Change in understanding	- Understanding of others' perceptive - Understanding concerns of others - Respecting others viewpoints	- Building new relationships or improving existing ones - Willingness to cooperate - Showing commitment - Showing interest in other participants - Being interested in common good - Developing trust between participants	- Reaching consensus about decisions - Satisfaction about the final decisions

Applications of social learning in the environmental arena are relatively new [11]. This arena includes natural resource management [11,22–25], environmental education [15,26], ecological economics [15], sustainable societies [17] and climate change adaptation [27–30]. However, few studies have focused on climate change mitigation, and, specifically on the transport sector (e.g., [31]). This paper addresses this gap, presenting empirical data on the role of social learning in mitigating transport CO_2 emissions. This is its first contribution.

Social learning is thought to generally contribute to improving decision-making processes and, specifically, as a crucial complement to environmental decision-making [28]. However, the empirical literature on social learning is still evolving and remains limited [5,18,32,33], particularly on the extent to which social learning contributes to decision making [32], and assessing transport CO_2 mitigation measures [1]. This is the study's second contribution.

Accordingly, the study has two objectives. First, it highlights the outcomes of social learning in the transport CO_2 emissions mitigation arena. Second, it examines the extent to which social learning contributes to decision making in the same field. It applies a case study methodology in line with the prevailing empirical research on social learning [21]. Bahrain, an oil-exporting GCC country, was chosen as the study's location because of its depleting oil resources. Thus, reducing the country's energy demand (and consequently CO_2 emissions) is imperative. Additionally, energy and carbon intensity indicators are highest in Bahrain compared with other GCC countries [4], indicating the need to adopt energy-efficient measures.

2. Methods

To achieve the study's objectives, workshops targeting general public participants were conducted. Pre- and post-workshop surveys were implemented to gather participants' views and preferences regarding selected transport CO_2 mitigation measures. The compiled data were used to investigate how social learning could contribute to the mitigation of transport CO_2 emissions. Subsequently, the extent to which social learning influenced the decision-making process was assessed. Data were input into a deliberative decision-making model and results were compared with those obtained from a previously developed participative model [34] that lacked a social learning objective. Details on the applied methodology are provided in Figure 1.

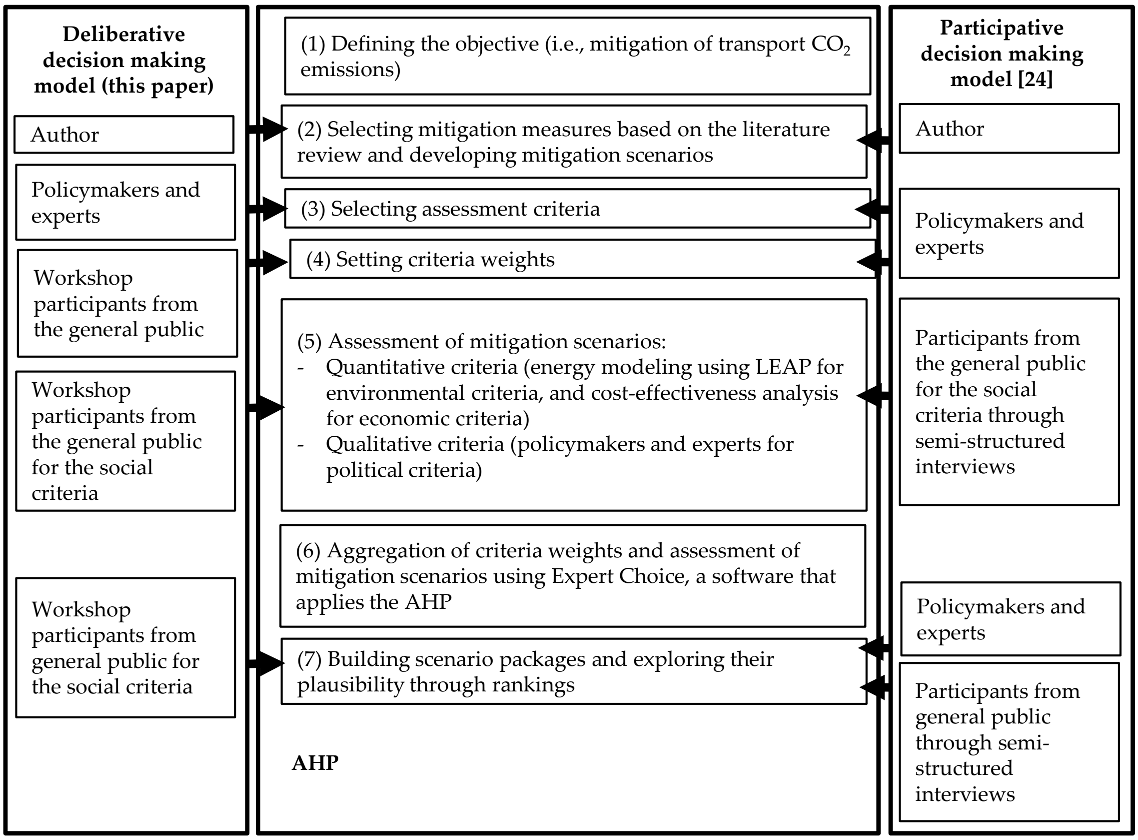

Figure 1. Overview of the applied methodology. **N**otes: CO_2 = carbon dioxide; AHP = Analytic Hierarchy Process; LEAP = Long Range Energy Alternatives Planning System.

2.1. Transport CO_2 *Mitigation Measures*

Five key mitigation measures were investigated. These were: introducing annual vehicle registration fees based on CO_2 emissions, setting fuel economy standards, market penetration of hybrid cars, market penetration of dedicated Compressed Natural Gas (CNG) cars, and further development of the public transport system. Several assumptions were used to build mitigation scenarios. A total of nine mitigation scenarios were explored (Table 2) [35].

Table 2. Assumptions used to build mitigation scenarios (adapted from [35]).

Mitigation Measure	Scenario	Assumptions	Economic Inputs
Hybrid gasoline cars	Low penetration, low fuel economy	1%, 17.7 km/L	Average cost difference per car = USD 6250
	High penetration, low fuel economy	40%, 17.7 km/L	
Compressed natural gas cars	Low penetration	1%, 13.2 km/L	Cost of fuel station USD 1.5 million (a station per 1000 cars), difference in maintenance cost = USD 1033 every 5 years, difference in car price: USD 7000 for new car and USD 2000 for retrofitting.
Fuel economy standards (by 2030)	Low	15.4 km/L (the USA target for 2015)	USD 716
	High	23.5 km/L (the USA target for 2025)	USD 2067
Registration fees (RF) (using price elasticity of demand of −0.4)	Original RF	- The CO_2 limits are not tightened over time (starting from < 141 g CO_2/km till > 300 g CO_2/km, with 20 g CO_2/km intervals) - Fees start from 0 up to USD 600	
	RF 190	- Fees start from 0 up to USD 190	
	RF 100	- Fees start from 0 up to USD 100	
Public transport		- Introducing light rail transit (LRT) system and improving the current bus rapid transit (BRT) system. - 2.8 billion veh-km is saved	- Total capital cost: USD 5.3 billion - Total maintenance cost: USD 513 million

Notes: A discount rate of 3.3% was used to calculate the costs. This rate is the average for the period 2000–2010 for Bahrain. Registration fees are set here based on grams of CO_2 emissions per kilometre (gCO_2/km). Savings from improving the public transport system are measured in vehicle-kilometres (veh-km).

2.2. Social Learning Outcomes

In this paper, I identified outcomes resulting from social learning covering the four dimensions: cognitive, moral, relational and agreement (Table 1). Evidence and discussion of these outcomes is presented in Section 3.

2.3. Questionnaire Forms

Almost identical questionnaires that were used for the participative decision-making model applied in earlier studies [34,35] were applied for this study. This enabled comparisons to be made between the results of the deliberative and participative models. The questionnaires consisted of six sections: information on selected transport CO_2 mitigation measures, participants' views regarding these measures, preferences elicited through pair-wise comparisons, weights assigned to evaluation criteria, ranking of mitigation scenario packages and socio-economic information on the participants.

2.4. Sampling

Convenience sampling was used for this study. Three workshops, each with 14 participants from the general public, were conducted. Approximately 50% of participants were Bahrainis, in addition to the experts invited to attend the workshops. The sample from the general public was not intended to be statistically representative. Rather, it aimed to provide a societal cross section or "snapshot" [21,36–38].

2.5. Workshop Organisation

Participants at each of the workshops were divided into two small heterogeneous groups. The workshops were organised as three sessions: presentations, discussions and completion of individual questionnaires (Figure 2). The researcher's role during the workshops was that of a learning agent [15]. She delivered the presentations, acted as a facilitator, raised discussion questions and adjusted these questions where necessary. Observers were recruited to take notes, report responses and observe how group discussions developed. The workshops were also filmed and prior written consent was sought from participants and anonymity was guaranteed by not distributing the films.

The participants' responses were gathered prior to presenting the results of previously conducted environmental and economic assessments [35]. Responses were again sought at the end of the workshops to explore the impacts of the deliberations and social learning on how participants perceived transport CO_2 mitigation measures. The workshops also included feedback sessions. These were held after the groups' discussions to provide further opportunities for participants to learn about the views of those with whom they had not interacted.

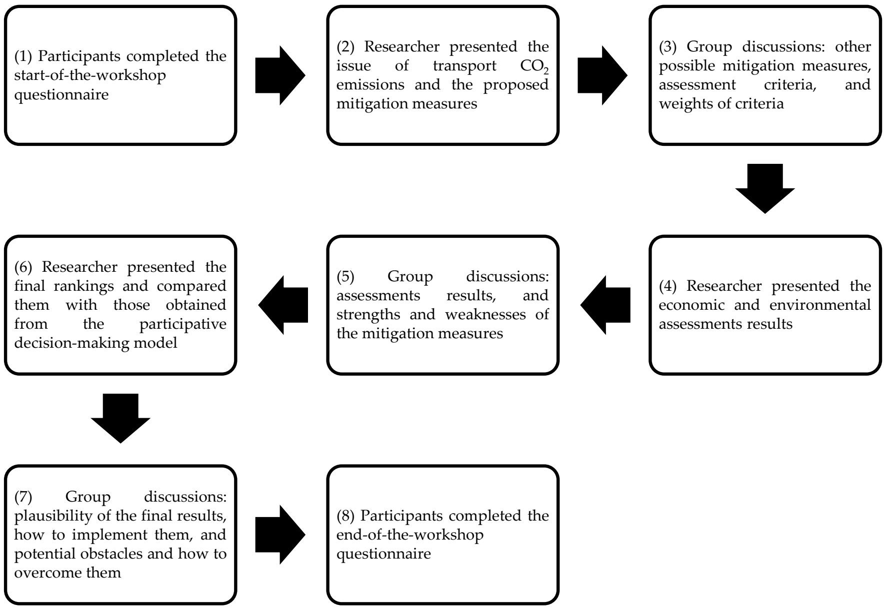

Figure 2. Flow of the workshops.

2.6. Decision-Making Models

A deliberative decision-making model was applied in this paper for assessing transport CO_2 mitigation measures for the road passenger transport sector in Bahrain. The results from this model were compared to those of a participative decision-making model developed in [34] (see Figure 3). These models, which were based on the Analytic Hierarchy Process (AHP), a Multi-Criteria Analysis (MCA) methodology, concurrently assessed different scenarios for the same mitigation measure [34]. The multiple models for Bahrain differed with respect to a single mitigation measure: annual vehicle registration fees based on CO_2 emissions, entailing three possible alternative scenarios [34]. The first scenario, designed by the author (the original registration fee (RF) scenario), assumed a maximum annual fee of USD 600, whereas the second and the third scenarios assumed lower maximum fees of USD 190 and 100 (RF 190 scenario and RF 100 scenario), respectively, as suggested by stakeholders (see Table 2).

Quantitative and qualitative data constituted inputs for both decision-making models. The results from economic and environmental assessments constituted quantitative inputs (as calculated by Alsabbagh et al. [35]), whereas the preferences of policymakers, experts and the general public constituted qualitative data collected via pair-wise comparisons.

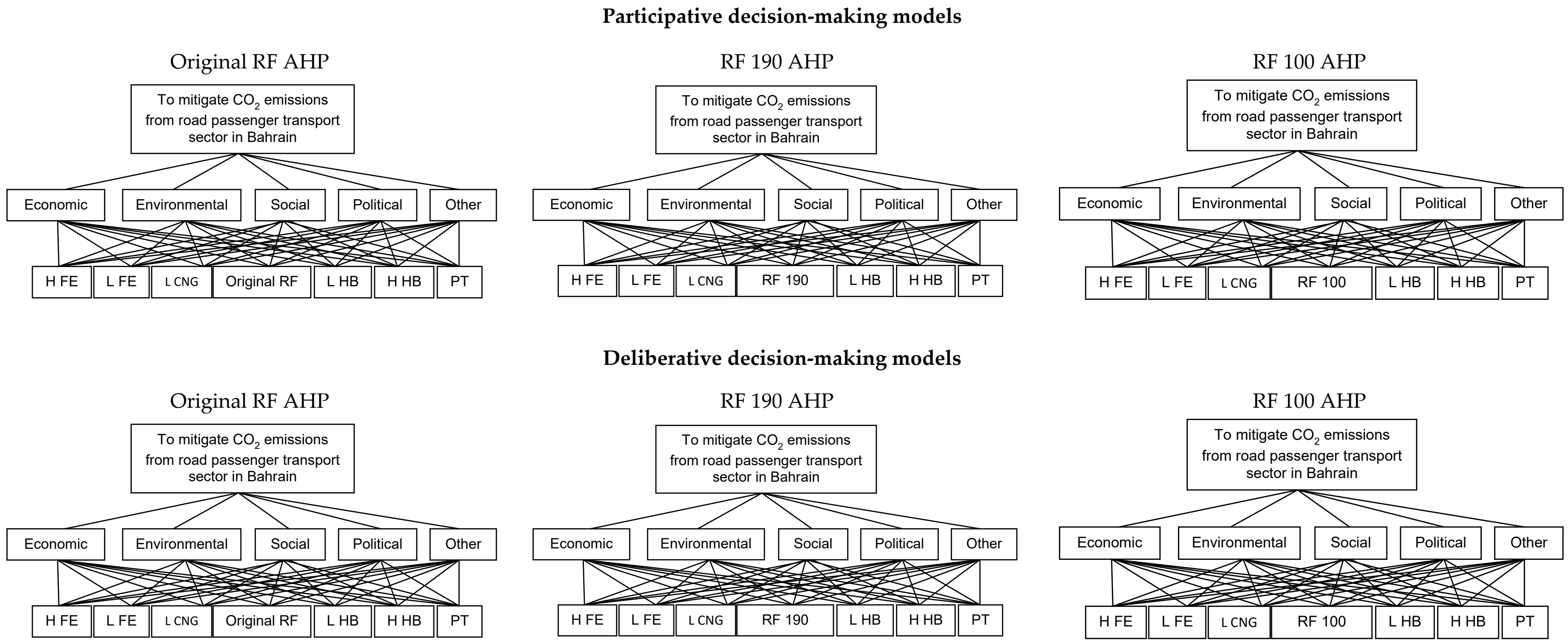

Figure 3. The design of the participative and deliberative decision-making models.

Three AHP models were designed for the participative decision-making models and another three AHP models were designed for the deliberative decision-making models. The participative and deliberative decision-making models differed in two aspects: who assigned criteria weights and how social preferences were elicited. In the participative model, introduced by Alsabbagh et al. [34], policymakers and experts assigned the criteria weights, and the public preferences were collected through semi structured interviews. However, in the deliberative model, workshop participants from the general public assigned criteria weights and provided social preferences of the transport CO_2 mitigation scenarios.

Notes: Original RF AHP means AHP model where the maximum annual vehicle registration fee is USD 600, RF 190 AHP means AHP model where the maximum annual vehicle registration fee is USD 190, RF 100 AHP means AHP model where the maximum annual vehicle registration fee is USD 100.

The two decision-making models differed in how the general public's preferences were elicited. Semi-structured interviews were used by Alsabbagh et al. [34] for the participative model. However, public preferences gathered during social learning-oriented workshops were used for the deliberative model. A comparison of the two decision-making models provided empirical evidence on the extent to which social learning influenced the decision-making process (Figure 3).

2.7. Data Analysis

Statistical analysis and non-parametric tests (e.g., the Wilcoxon non-parametric test and the Friedman test) were conducted using the IBM SPSS package (version 21). The Expert Choice software was used to calculate the final priorities and rankings obtained from the decision-making models. Scenario packages were developed using the scores obtained from the latter software. The plausibility of the scenario packages was assessed using a modified Delphi ranking type method entailing questionnaires completed by the workshop participants.

3. Results

The results are arranged according to the research objectives. First, the outcomes of social learning in the transport CO_2 emissions mitigation arena are presented, based on the four main dimensions described in Table 1. I then discuss the empirical evidence on the extent to which social learning contributes to decision making.

3.1. Outcomes of Social Learning in the Transport CO_2 Emissions Mitigation Arena

3.1.1. Cognitive Dimension

Cognitive changes were evident among participants during the workshops. For instance, their views shifted with the generation of new knowledge. Knowledge was acquired from four main channels: interactions with workshop materials and presentations, discussions with experts, discussions with participants and exchanges of views and preferences across groups. Heterogeneous grouping provided participants with opportunities to learn about the views and preferences of people from diverse cultures and countries. This knowledge acquisition, in particular, was critically important in enriching discussions. At the conclusion of the workshops, most participants stated that they had learnt about different dimensions related to the topic of the workshop.

Additionally, participants acquired knowledge about other participants' preferences. Through group discussions, participants learnt about and acknowledged each other's preferences, which provided a basis for social learning. An example of this learning occurred during one of the group sessions when participants gained the insight that Bahraini women could be interested in sports cars. Although this was a novel insight for male participants, they respected and accepted the concerned woman's choice. This evidenced a double-loop learning cycle [16].

Another evident outcome of social learning is related to the changes in views. The responses in the two questionnaires completed by participants at the beginning and end of the workshops were comprehensively analysed. The results, shown in Table 3, demonstrate that while almost all questionnaire responses had changed, only those related to knowledge of climate change and hybrid cars, support to changing registration fees and willingness to use public transport were of statistical significance at an alpha level of 0.1. By the end of the workshop, all participants were familiar with climate change, its causes and impacts. Support for changing registration fees, setting fuel economy standards and using public transport had all increased. However, opposition to raising fuel prices and to Compressed Natural Gas (CNG) car ownership had also increased. This implies that participants who initially did not have a clear view regarding these measures were convinced by the majority to oppose them, as observed during discussions. Another important observation was an increase in supporters of the RF scenario at the conclusion of workshops. An analysis of responses in the initial and concluding questionnaires revealed a 30% increase in the number of proponents of the policy.

Table 3. A comparison of participants' views obtained from questionnaires completed at the beginning and conclusion of workshops.

No.	Item	Response	Start	End	Significance of Change
1	Have you ever heard/known about causes and impacts of climate change?	Yes	27	42	0.03
		Heard about climate change but not mitigation	15	0	
		No	0	0	
2	In your view, who should be responsible for reducing the impacts of car-use on climate change?	Government	6	9	0.11
		Public	0	3	
		All are responsible	24	27	
		Government and manufacturers	12	3	
3	Do you support imposing a new registration fees system based on the car's CO_2 emissions?	Yes	30	39	0.08
		No	12	3	
4	Would you be prepared to pay extra on the annual registration fee to keep your current car?	Yes	18	27	0.08
		No	24	15	
5	Would you consider changing to smaller and more efficient car if the suggested registration fees system is implemented?	Yes	27	27	1.00
		No	12	12	
		Don't know	3	3	
6	Would you support the setting of controls over the efficiency of cars, in terms of fuel use, entering the country?	Yes	39	42	0.32
		Don't know	3	0	
		No	0	0	
7	In your view, will such a control make a difference with regard to saving environment and non-renewable resources?	Yes	42	42	1.00
		No	0	0	
8	Are you willing to use public transport if reliable and affordable services are offered?	Yes	27	36	0.08
		Don't know	12	3	
		NA	3	3	
		No	0	0	
9	Have you ever heard about hybrid cars?	Yes	33	42	0.08
		No	9	0	
10	Would you consider buying a hybrid car in the future?	Yes	27	33	0.71
		No	6	0	
		Don't know	6	6	
		Maybe	3	3	
11	Do you think that such hybrid car technology fits within the Bahraini context?	Yes	36	30	0.10
		No	3	0	
		Don't know	3	12	
12	Have you ever heard about natural gas cars?	Yes	33	39	0.32
		No	9	3	
13	Would you consider buying a natural gas car in the future?	Yes	6	6	0.56
		No	33	36	
		Don't know	3	0	

Table 3. *Cont.*

No.	Item	Response	Start	End	Significance of Change
14	Do you think that such technology fits within the Bahraini context?	Yes No Don't know Maybe	3 30 6 3	3 39 0 0	0.10
15	Do you support raising the fuel price?	Yes No Don't know Re-direct subsidy	12 21 3 6	15 27 0 0	0.14
16	Do you think that raising fuel price will help reducing CO_2 emissions and fuel consumption?	Yes No Maybe	15 21 6	27 12 3	0.22

Change in preferences was also observed in workshops and can be considered as an outcome that falls within the cognitive dimension. For the initial questionnaire, participants assigned the highest score to improving the public transport system (Table 4). Conversely, in both the initial and concluding questionnaires, the CNG cars option was ranked lowest by all participants. Further in-depth analysis showed that although the ranking order for the transport CO_2 mitigation scenarios was not an exact match for the multi-AHP models, variations in these rankings were not statistically significant at an alpha level of 0.1.

Table 4. Preferences of workshop participants (un-normalised weights).

Mitigation Scenario	Original RF AHP		RF 100 AHP		RF 190 AHP	
	Start	End	Start	End	Start	End
H FE	0.53	0.55	0.83	0.74	0.37	0.37
L FE	0.36	0.37	0.68	0.41	0.19	0.19
L CNG	0.16	0.15	0.22	0.12	0.08	0.08
RF	0.22	0.60	0.44	0.49	0.33	0.33
L HB	0.52	0.48	0.97	0.73	0.67	0.67
H HB	0.25	0.17	0.97	0.23	0.32	0.32
PT	1.00	1.00	1.00	1.00	1.00	1.00

Notes: Original RF AHP denotes an AHP model in which the maximum annual vehicle registration fee is USD 600, RF 190 AHP denotes an AHP model in which the maximum annual vehicle registration fee is USD 190, RF 100 AHP denotes an AHP model in which the maximum annual vehicle registration fee is USD 100, H FE denotes setting high fuel economy standards, L FE denotes setting low fuel economy standards, L CNG denotes low penetration of natural gas cars, RF denotes setting annual vehicle registration fees based on CO_2 emissions, L HB denotes low penetration of hybrid cars, H HB denotes high penetration of hybrid cars, PT denotes improving the public transport system.

Changes in views and preferences of the participants, as described above, resulted in behavioural change. After the workshops, I was contacted by one of the participants who told me that attending the workshop had influenced his decision regarding the purchase of a car. When he came to the workshop, he was planning to buy a used car. He was concerned about the price of the car and the mileage and had almost reached an agreement with the seller. However, after attending the workshop, he checked the car's fuel economy and its technical specifications and cancelled the purchase. He found out that his old car was actually more fuel efficient than the one he was going to buy and he understood that buying the used car would result in more fuel consumption and, consequently, higher carbon emissions. A participant also contacted me saying that she was going to buy a sport utility vehicle (SUV) before she attended the workshop and that she was wealthy enough to pay for it. However, after her participation in the workshop, discussions with the experts and with other participants, she had changed her mind and purchased a sedan car that was more fuel-efficient than the SUV. These two examples provide evidence of a triple-loop learning cycle [16].

3.1.2. Moral Dimension

Mutual understanding can be identified as an outcome of social learning that is related to the moral dimension. The small group settings during the workshops facilitated mutual understanding. Throughout the workshops, participants were encouraged to express their opinions, share their experiences and explain and justify their selections. They were also asked to provide clarifications, examples and reasons rather than just stating their views. This approach enhanced their learning and understanding of each other's views as evidenced in the literature [12]. During group discussions, they also learnt about each other's cultural values and beliefs. Regardless of whether or not they agreed with each other, they consistently respected each other's views and opinions. This demonstrated a single-loop learning cycle [16].

3.1.3. Relational Dimension

Participants in the workshops showed willingness to cooperate and act collectively to reach an applicable and feasible solution to mitigate transport CO_2 emissions in Bahrain. Participants took the initiative to propose other mitigation measures not mentioned in the questionnaires and attempted to assess their applicability to Bahrain. They also showed commitment to the issue in hand, attended the full workshop and participated in group discussions. Participants also developed trust in each other and in experts as well.

3.1.4. Agreement Dimension

Consensus about the final ranking of the mitigation scenarios and scenario packages was reached by the end of the workshops. In fact, this consensus was reflected in the individually-completed questionnaire at the end of the workshop. The agreement on the ranking of the scenario packages improved considerably in comparison to that completed at the start of the workshop. Further details are presented in Section 3.2.

Section 3.1 highlighted outcomes of social learning in the transport CO_2 emissions mitigation arena, which is explored for the first time in this research, thus achieving the first objective of the study. The following section addresses the second objective, focusing on the contribution of social learning to decision making.

3.2. Extent to Which Social Learning Influences Decision Making

Table 5 provides details of a comparison of rankings of transport CO_2 mitigation scenarios obtained from the multi-AHP models used in the deliberative and participative decision-making models [34]. Table 5 illustrates variations in the rankings; however, social learning does not appear to have had a statistically significant impact on the final rankings of the scenarios with an alpha level of 0.1. When integrated with the results of environmental and economic assessments, and political preferences, setting high fuel economy standards ranked highest for both models. This demonstrated that its performance was consistently the best, regardless of who assigned the criteria weights and how social preferences were elicited.

Further analysis showed no statistically significant (at an alpha level of 0.1) variations between the results of the decision-making models based on the conduct of initial and concluding workshop surveys. However, high penetration of hybrid cars was clearly ranked lower in the concluding workshop surveys compared with the initial surveys. This can be interpreted in terms of the influence of social learning and interactions among participants. Discussions within groups during the workshops emphasised the need to start with small trials before incentivising high penetration of hybrid cars. Additionally, there were no statistically significant differences between the results of the deliberative and participative models at 0.1 level. This implies that the participatory technique used to elicit social preferences (i.e., workshops), and consequently social learning, did not significantly impact on the results of the decision-making models. However, the priorities were not perfectly matched.

Table 5. A comparison of ranking orders of mitigation scenarios in the first and second decision-making models.

Mitigation Scenarios	Original RF AHP			RF 100 AHP			RF 190 AHP		
	1st Model	2nd Model Start	2nd Model End	1st Model	2nd Model Start	2nd Model End	1st Model	2nd Model Start	2nd Model End
H FE	1	1	1	1	1	1	1	1	1
L FE	2	5	4	3	5	4	2	5	5
L CNG	7	7	7	7	7	7	7	7	7
RF	6	6	5	6	6	6	5	6	6
L HB	5	4	3	5	3	3	4	4	3
H HB	4	3	6	4	2	5	3	3	4
PT	3	2	2	2	4	2	6	2	2

Notes: Original RF AHP denotes an AHP model in which the maximum annual vehicle registration fee is USD 600, RF 190 AHP denotes an AHP model in which the maximum annual vehicle registration fee is USD 190, RF 100 AHP denotes an AHP model in which the maximum annual vehicle registration fee is USD 100, 1st model refers to the participative model entailing collection of the general public's preferences through interviews, 2nd model start refers to the deliberative decision-making model entailing collection of the public's preferences through pre-workshop questionnaires, 2nd model end refers to the deliberative decision-making model entailing collection of the public's preferences through post-workshop questionnaires, H FE denotes setting high fuel economy standards, L FE denotes setting low fuel economy standards, L CNG denotes low penetration of natural gas cars, RF denotes setting annual vehicle registration fees based on CO_2 emissions, L HB denotes low penetration of hybrid cars, H HB denotes high penetration of hybrid cars, PT denotes improving the public transport system.

3.3. Plausibility of Mitigation Scenario Packages

Mitigation scenarios were combined into scenario packages, because no single scenario significantly outranked the others. When these were presented to workshops' participants, social learning apparently contributed to building consensus among participants in ranking scenario packages. The results of the modified Delphi ranking type revealed a considerable improvement in consensus from 0.536 in the initial workshop survey to 0.854 in the concluding survey. Interestingly, the consensus level among workshops participants was considerably higher than that of policymakers, experts and the general public when obtained through surveys conducted for the participative model (Table 6).

Table 6. Analysis of the plausibility results for participants in the first and second decision-making models.

Results		First Model		Second Model
		Policymakers and Experts	General Public	General Public
Overall ranking	SP1	5	4	5
	SP2	3	3	3
	SP3	1	1	1
	SP4	2	2	2
	SP5	4	5	4
W coefficient		0.566	0.674	0.854

Note: 1st model refers to the participative model entailing collection of the general public's preferences, 2nd model refers to the deliberative model entailing collection of the general public's preferences through post-workshop questionnaires, SP means scenario package.

4. Discussion

Although this study applied a case study methodology, the findings can be generalisable to other socio-economic contexts [39]. This is particularly appropriate in this case as the literature on climate change advocates the transference of mitigation actions and learning gained from small-scale studies [40]. Furthermore, policy transfer studies in the environmental arena are very limited [41], especially those related to transport measures between cities in developing countries [42]. Accordingly, this study makes the following contributions to knowledge.

4.1. Implications for Decision Making

The literature on participation recommends public involvement from the early stages of the decision-making process [7,43,44]. However, not all participation-oriented decision-making models are suitable in particular contexts, especially those characterised by top-down decision-making [45]. Nonetheless, empirical evidence presented here suggests that a deliberative approach can contribute to improved decision making related to the mitigation of transport CO_2 emissions in developing countries. Our results indicate that deliberation and social learning have the capacity to make statistically significant changes in how the public perceives mitigation measures. Social learning, as reported by one study [46], did not significantly alter participants' views on issues about which they were already knowledgeable. However, it did contribute to changing their views on issues about which they were misinformed. This study shows that social learning can contribute to improving public acceptance towards taxation policies which are less favoured by the general public [46]. Moreover, the study's findings suggest that while this may, to a certain extent, be true, the public may be willing to pay when their feedback is considered during the decision-making process. For instance, general public participants demonstrated their acceptance of extra vehicle registration fees after attending the workshops. Social learning contributed to a 30% increase in acceptance of this policy. This implies that it could be used as a tool for improving acceptance of a specific policy. Accordingly, improving acceptance of policies can be added to the list of social learning outcomes that are described in Table 1.

Additionally, social learning can contribute to building consensus. Although this has already been documented in the literature, as in the case of flood risk management [14], this study is the first to provide empirical data that supports this finding. Its findings show that social learning has significantly contributed to building consensus throughout the decision-making process. However, the empirical evidence suggests that it may have a limited influence in terms of changing the general public's ranking of preferences regarding transport CO_2 mitigation measures. Although it can contribute to increasing acceptance of specific policies, it does not appear to contribute to high prioritisation of those policies. Therefore, social learning may have limited role—at least in the short term—in producing a list of the general public's priorities that completely matches that of policymakers.

Another area of contribution of these results relates to obtaining the general public's preferences using two different participatory techniques: semi-structured interviews (in the participative model) and workshops (in the deliberative model) (Figure 3). The preferences of the general public in both models were not an exact match; however, differences in the ranking of the mitigation preferences can still be noticed. Accordingly, future research should be undertaken to investigate how other participatory techniques influence the decision-making process.

These findings are critical to the decision-making process. Although this study was conducted in a developing country, its methodology and findings may be utilised within both developing and developed countries. Social learning may be targeted during the decision-making process, as in this study, and empirically proved effective in increasing acceptance and consensus. Accordingly, a process of involving the public in decision making can be designed and tools and materials can be selected based on these findings.

4.2. Implications for Bahrain

The findings of this study are of special relevance to the government's policy goal of "preparing action plans to reduce carbon emissions from the Kingdom of Bahrain" (p. 48) [47]. In general, they provide the government with evidence on feasibility for formulating environmentally effective, economically feasible and socially accepted policies to promote reduction of transport CO_2 emissions.

Drawing on the findings of this study, the government's next step could be to either adopt a single mitigation measure or a policy package. It could introduce high fuel economy standards, which were ranked highest in the multi-AHP models for both decision-making models, and were prioritised by policymakers, experts and general public participants.

The mitigation policy package options are either to adopt the one that performs best against environmental, economic, social, political and other criteria (the fifth policy package in this case), or the one with the greatest social and political acceptance (the third policy package) (Table 6). Adopting the former would require the provision of financial incentives as this entails the widespread adoption of hybrid cars by the public. Additionally, it would require considerable efforts to ensure public acceptance of the RF 190 scenario as its acceptance level is low. As suggested here, this could be achieved through social learning. However, adopting the latter package would be easier as this has already been ranked highest by the various stakeholder groups. This indicates acceptability regarding implementation of the entailed policies.

However, important issues need to be addressed prior to implementing any of these measures. From an ethical perceptive aimed at ensuring that less well-endowed individuals are not affected, alternatives to private transport first need to be provided before introducing taxation policies. Social equity and inclusion are other considerations for ensuring a fair distribution of impacts (costs and benefits). This would also ensure that public participation is not hindered by transport constraints [48]. It is also important to note that taking small steps at a time can still contribute to CO_2 emission reductions [49]. In particular, the results of this study have indicated that public acceptance of taxation policies has improved, in addition to acquisition of knowledge and change in preferences.

The changes that were identified as outcomes of social learning can contribute to reducing CO_2 emissions from the transport sector in Bahrain and also in the other GCC countries. Being high-income, oil-exporting countries that rely almost completely on fossil fuels for their energy production, GCC countries show high values for both per capita energy consumption and CO_2 emissions. The results of this study can inform policymaking regarding how to change the preferences and the behaviour of the general public. This is of extreme importance to the GCC countries for two main reasons. First, the general public in the GCC countries are habituated to energy-intensive lifestyles, and acceptance of radical technological change is needed to achieve significant emission reductions [50,51]. Second, the GCC countries are obliged to reduce their CO_2 emissions and meet the legally binding climate agreement (i.e., the Paris Agreement), which entered into force in November 2016.

A future longitudinal study, utilising participatory techniques aimed at assessing the impacts of social learning on the decision-making process, would provide valuable insights. Another area for future research is an examination of the impacts of other participatory techniques on the final results of the decision-making model. Further, replicating these methods in a different context entailing bottom-up decision-making would be useful for identifying the extent to which results may change when these methods are applied in different contexts. Lastly, experiments could be conducted on whether social learning can contribute to a complete change in public preferences within a short timeframe.

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References

1. IPCC. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Edenhofer, O., Pichs-Madruga, O., Sokona, R., Farahani, Y., Kadner, E., Seyboth, S., Adler, K., Baum, A., Brunner, I., Eickemeier, S., et al., Eds.; Cambridge University Press: Cambridge, UK, 2014.
2. EIA. *International Energy Outlook 2014: World Petroleum and Other Liquid Fuels*; EIA: Washington, DC, USA, 2014.
3. Vergragt, P.J.; Brown, H.S. Sustainable mobility: From technological innovation to societal learning. *J. Clean. Prod.* **2007**, *15*, 1104–1115. [CrossRef]

4. IEA. *Key World Energy Statistics*; IEA: Paris, France, 2014.
5. Cundill, G.; Rodela, R. A search for coherence: Social learning natural resource management. In *(Re) Views on Social Learning Literature: A monograph for Social Learning Researchers in Natural Resources Management and Environmental Education*; Lotz-Sisitka, H., Ed.; Rhdes University/EEASA/SADC REEP: Grahamstown, South Africa, 2012.
6. Cundill, G.; Lotz-Sisitka, H.; Mukute, M.; Belay, M.; Shackleton, S.; Kulundu, I. A reflection on the use of case studies as a methodology for social learning research in sub Saharan Africa. *NJAS-Wagening. J. Life Sci.* **2014**, *69*, 39–47. [CrossRef]
7. Reed, M.; Evely, A.; Cundill, G.; Fazey, I.; Glass, J.; Laing, A.; Newig, J.; Parrish, B.; Prell, C.; Raymond, C.; et al. What is social learning? *Ecol. Soc.* **2010**, *15*, 1–10.
8. Schusler, T.; Decker, D.; Pfeffer, M. Social learning for collaborative natural resource management. *Soc. Nat. Res.* **2003**, *16*, 309–326. [CrossRef]
9. Van Bommel, S.; Röling, N.; Aarts, N.; Turnhout, E. Social learning for solving complex problems: A promising solution or wishful thinking? A case study of multi-actor negotiation for the integrated management and sustainable use of the Drentsche Aa Area in the Netherlands. *Environ. Policy Gov.* **2009**, *19*, 400–412.
10. Khalil, K.; Ardoin, N.; Wojcik, D. Social learning within a community of practice: Investigating interactions about evaluation among zoo education professionals. *Eval. Progr. Plan.* **2017**, *61*, 45–54. [CrossRef] [PubMed]
11. Van der Wal, M.; Kraker, J.; Kroeze, C.; Kirschner, P.; Valkering, P. Can computer models be used for social learning? A serious game in water management. *Environ. Model. Softw.* **2016**, *75*, 119–132. [CrossRef]
12. Stagl, S. Multicriteria evaluation and public participation: The case of UK energy policy. *Land Use Policy* **2006**, *23*, 53–62. [CrossRef]
13. Harvey, B.; Ensor, J.; Carlile, L.; Garside, B.; Patterson, Z.; Naess, L. *Climate Change Communication and Social Learning—Review and Strategy Development for CCAFS*; CCAFS: Copenhagen, Denmark, 2012.
14. Benson, D.; Lorenzoni, I.; Cook, H. Evaluating social learning in England flood risk management: An 'individual-community interaction' perspective. *Environ. Sci. Policy* **2016**, *55*, 326–334. [CrossRef]
15. Siebenhüner, B.; Rodela, R.; Ecker, F. Social learning research in ecological economics: A survey. *Environ. Sci. Policy* **2016**, *55*, 116–126. [CrossRef]
16. Henly-Shepard, S.; Gray, S.A.; Cox, L.J. The use of participatory modeling to promote social learning and facilitate community disaster planning. *Environ. Sci. Policy* **2015**, *45*, 109–122. [CrossRef]
17. Broto, V.; Dewberry, E. Economic crisis and social learning for the provision of public services in two Spanish municipalities. *J. Clean. Prod.* **2016**, *112*, 3018–3027. [CrossRef]
18. Muro, M.; Jeffrey, P. A critical review of the theory and application of social learning in participatory natural resource management processes. *J. Environ. Plan. Manag.* **2008**, *51*, 325–344. [CrossRef]
19. Romina, R. Social learning, natural resource management, and participatory activities: A reflection on construct development and testing. *NJAS-Wagening. J. Life Sci.* **2014**, *69*, 15–22. [CrossRef]
20. Muro, M. *The Role of Social Learning in Participatory Planning & Management of Water Resources*; Cranfield University: Cranfield, UK, 2008.
21. Rodela, R.; Cundill, G.; Wals, A.E.J. An analysis of the methodological underpinnings of social learning research in natural resource management. *Ecol. Econ.* **2012**, *77*, 16–26. [CrossRef]
22. Parkins, J.R.; Mitchell, R.E. Public participation as public debate: A deliberative turn in natural resource management. *Soc. Nat. Res.* **2005**, *18*, 529–540. [CrossRef]
23. Keen, M.; Mahanty, S. Learning in sustainable natural resource management: Challenges and opportunities in the Pacific. *Soc. Nat. Res.* **2006**, *19*, 497–513. [CrossRef]
24. Cheng, A.S.; Mattor, K.M. Place-based planning as a platform for social learning: Insights from a national forest landscape assessment process in Western Colorado. *Soc. Nat. Res.* **2010**, *23*, 385–400.
25. De los Ríos, I.; Rivera, M.; García, C. Redefining rural prosperity through social learning in the cooperativesector: 25 years of experience from organic agriculture in Spain. *Land Use Policy* **2016**, *54*, 85–94. [CrossRef]
26. Barrantes, C.; Yagüe, J.L. Adults' education and agricultural innovation: A social learning approach. *Proced.—Soc. Behav. Sci.* **2015**, *191*, 163–168. [CrossRef]

27. IPCC. *Climate change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*; Metz, B., Davidson, O., Bosch, P., Dave, R., Meyer, L., Eds.; Cambridge University Press: Cambridge, UK, 2007.
28. Nilsson, A.; Swartling, Å.G. Social Learning about Climate Adaptation: Global and Local Perspectives. 2009. Available online: http://www.sei-international.org/mediamanager/documents/Publications/Policyinstitutions/social_learning_wp_091112.pdf (accessed on 12 January 2016).
29. Albert, C.; Zimmermann, T.; Knieling, J.; Von haaren, C. Social learning can benefit decision-making in landscape planning: Gartow case study on climate change adaptation, Elbe valley biosphere reserve. *Landsc. Urban Plan.* **2012**, *105*, 347–360. [CrossRef]
30. Salvini, G.; Van Paassenb, A.; Ligtenberga, A.; Carreroc, G.; Bregt, A. A role-playing game as a tool to facilitate social learning and collective action towards Climate Smart Agriculture: Lessons learned from Apuí, Brazil. *Environ. Sci. Policy* **2016**, *63*, 113–121. [CrossRef]
31. Goetzke, F. Social Interactions and Social Learning in Transportation Behaviour. 2013. Available online: http://www.dahrendorf-forum.eu/wp-content/uploads/2016/03/Social_Interactions_and_Social_Learning_in_Transportation_Behaviour__GOETZKE.pdf (accessed on 12 January 2016).
32. Cundill, G.; Rodela, R. A review of assertions about the processes and outcomes of social learning in natural resource management. *J. Environ. Manag.* **2012**, *113*, 7–14. [CrossRef] [PubMed]
33. Schwilch, G.; Bachmann, F.; Valente, S.; Coelho, C.; Moreira, J.; Laouina, A.; Chaker, M.; Aderghal, M.; Santos, P.; Reed, M. A structured multi-stakeholder learning process for sustainable land management. *J. Environ. Manag.* **2012**, *107*, 52–63. [CrossRef] [PubMed]
34. Alsabbagh, M.; Siu, Y.L.; Guehnemann, A.; Barrett, J. Integrated approach to the assessment of CO_2 e-mitigation measures for the road passenger transport sector in Bahrain. *Renew. Sustain. Energy Rev.* **2016**. [CrossRef]
35. Alsabbagh, M.; Siu, Y.L.; Guehnemann, A.; Barrett, J. Mitigation of CO_2 emissions from the road passenger transport sector in Bahrain. *Mitig. Adapt. Strateg. Glob. Chang.* **2015**. [CrossRef]
36. Muro, M.; Jeffrey, P. Time to talk? How the structure of dialog processes shapes stakeholder learning in participatory water resources management? *Ecol. Soc.* **2012**, *17*. [CrossRef]
37. Rauschmayer, F.; Wittmer, H. Evaluating deliberative and analytical methods for the resolution of environmental conflicts. *Land Use Policy* **2006**, *23*, 108–122. [CrossRef]
38. Munda, G. Social multi-criteria evaluation: Methodological foundations and operational consequences. *Eur. J. Oper. Res.* **2004**, *158*, 662–677. [CrossRef]
39. Bassey, M. *Case Study Research in Educational Settings*; Open University Press: Buckingham, UK, 1999.
40. World Bank. *Cities and Climate Change: An Urgent Agenda*; World Bank: Washington, DC, USA, 2010.
41. Marsden, G.; Stead, D. Policy transfer and learning in the field of transport: A review of concepts and evidence. *Trans. Policy* **2011**, *18*, 492–500. [CrossRef]
42. Rahman, M.S. *Integrating BRT with Rickshaws in Developing Cities: A Case Study on Dhaka City, Bangladesh*; University of Leeds: Leeds, UK, 2013.
43. Rosenstrom, U.; Kyllonen, S. Impacts of a participatory approach to developing national level sustainable development indicators in Finland. *J. Environ. Manag.* **2007**, *84*, 282–298. [CrossRef] [PubMed]
44. Banister, D. The sustainable mobility paradigm. *Transp. Policy* **2008**, *15*, 73–80. [CrossRef]
45. Schwilch, G.; Bachmann, F.; Liniger, H.P. Appraising and selecting conservation measures to mitigate desertification and land degradation based on stakeholder participation and global best practices. *Land Degrad. Dev.* **2009**, *20*, 308–326. [CrossRef]
46. Xenias, D.; Whitmarsh, L. Dimensions and determinants of expert and public attitudes to sustainable transport policies and technologies. *Transp. Res. Part A: Policy Pract.* **2013**, *48*, 75–85. [CrossRef]
47. Bahrain, G.O. Parnamaj Amal Alhokoma 2015–2018. 2015. Available online: http://bna.bh/pdf/gov_program_2015_2018.pdf (accessed on 12 January 2016).
48. Annema, J.A. Transport policy. In *The Transport System and Transport Policy: An Introduction*; Van Wee, B., Annema, J.A., Banister, D., Eds.; Edward Elgar: Cheltenham, UK, 2013.
49. Hickman, R.; Saxena, S.; Banister, D.; Ashiru, O. Examining transport futures with scenario analysis and MCA. *Transp. Res. Part A: Policy Pract.* **2012**, *46*, 560–575. [CrossRef]

50. Kohler, J.; Whitmarsh, L.; Nykvist, B.; Schilperoord, M.; Bergman, N.; Haxeltine, A. A transitions model for sustainable mobility. *Ecol. Econ.* **2009**, *68*, 2985–2995. [CrossRef]
51. Hickman, R.; Ashiru, O.; Banister, D. Transitions to low carbon transport futures: Strategic conversations from London and Delhi. *J. Transp. Geogr.* **2011**, *19*, 1553–1562. [CrossRef]