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Systematic Review

Public Awareness, Lifestyle and Low-Carbon City Transformation in China: A Systematic Literature Review

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Abstract: Low-carbon city transformation is an important action area of China's 14th Five-Year Plan (2021–2025) that aims to reach peak CO_2 emissions by 2030 and achieve carbon neutrality before 2060. Responding to global climate change is not only a national responsibility but also an individual responsibility and very much depends on societal participation and acceptance. While many scholars argue that public participation would be critical to low-carbon cities developing in China, there is apparently a lack of sufficient research on the level of public participation. This systematic review aims to summarize the current related research about public awareness on low-carbon city transformation in China, and learn about the challenges and barriers of public attitude and behaviour towards the low-carbon lifestyle. This study reveals that: (1) although most scholars discussed the conception and policies of low-carbon cities, research methods, the theoretical foundation and the number of cities targeted for research are limited; (2) a public's attention to low-carbon cities mainly focus on a low-carbon life, and there is a clear gap between low-carbon awareness and behaviour; and (3) although scholars had different opinions about the factors that affect low-carbon behaviour, most of them agree that education and government policy have an influence on the populations' low-carbon behaviour in China.

Keywords: systematic literature review; public awareness and behaviour; barrier; education; lifestyle; low-carbon city; climate change; China

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1. Introduction

In July 2021, several European countries (such as Germany, Belgium, Luxembourg and the Netherlands), as well as India and China (Henan Province) experienced heavy rainfall and catastrophic floods that caused many deaths and widespread damage. Between 1998 and 2017, floods affected more than two billion people worldwide [1]. Other climate-related and geophysical disasters such as heat waves, wildfires, storms and droughts also threatened lives and created severe damages [2]. Tackling global climatic change has become a global necessity accepted by many countries that have been taking action to develop low-carbon cities [3]. While the focus is usually on national responsibility and government strategies, there is limited research on the role of the public in coping with climate change [4] and low-carbon city development. Many people do not want to deal with the specifics of climate change because they think it is far away from their personal lives [5]. In addition to national responsibility, individual limited liability is also an indispensable, integral part of energy conservation and emission reduction.

The Earth's atmosphere can be considered as a global common good, and its protection can only be adequately ensured through comprehensive global efforts [6]. However, individuals contribute through greenhouse gas emissions because they are in pursuit of their own needs, enjoyment, convenience and benefit. Pursuing "needs" implicitly also indicates that individuals or groups might have (very) limited options to choose

from, depending inter alia on their respective economic means and knowledge and the respective regulatory systems. The resulting conflict can be described as a case in point of the "commons dilemma". More recently, and in the context of critical reflections on the original concept of the "tragedy of the commons", debates have focused on "new commons issues" and specifically on "urban commons". For example, transport system is one of the main components of urban "infrastructure commons", which is developed for public consumption [7] and influences carbon emissions through transport mode and modal splits. Reducing carbon emissions needs to involve the general public in any action required [8]. Few consumers feel a strong desire to make individual payments towards restoration or to maintain the atmospheric environment, because the latter is seen as a kind of public good and therefore as a general responsibility respectively. As a result, the predominant attitude is that of a free rider and thus individual actions form collective behaviours. In contrast, more people might take action if they believe their behaviour will make a considerable contribution to the environment of their urban space and thus ultimately to climate change [9]. As awareness without action is not enough [10], public participation in the low-carbon transition requires a shift in people's lifestyles and consumption patterns as well as in policy incentives [11]. In this article, we are interested in the challenges and barriers of public attitude and behaviour change towards a low-carbon lifestyle and the insights from current research that can benefit future low-carbon development research in China and beyond.

Low-carbon city transformation requires the development of low-carbon production and low-carbon consumption, as well as saving energy towards sustainability within urban areas. An individual's willingness to adhere to low-carbon consumption and behaviour directly determines the low-carbon production of enterprises [12]. While some investigations have been conducted to study the conception of low-carbon city and residential low-carbon consumption behaviour in China, an overview of current research is lacking. A comprehensive review of the relevant literature will be helpful to summarize the results of existing discussions and provide insights for future research. We have therefore conducted a systematic literature review to better understand the role of the public in low-carbon city transformation using an interdisciplinary perspective. This systematic review aims to summarize the current related research about public awareness on low-carbon city transformation in China, discuss the related concepts and theories and learn about the perceptions on what the public could do to support low-carbon city transformation.

There are several reasons why this study focuses on China. Firstly, China, as the largest carbon emitter in the world, has made a lot of efforts to reduce carbon emissions [13], which will not only contribute to the reduction of total global carbon emissions, but also will provide experience for other countries. The urbanization rate in China has crossed 64.7% [14], and the environmental problems associated with the rapid economic growth have created major challenges. As early as 2007, the Chinese government considered that China should pursue steps towards a low-carbon economy [15]. Consequently, the China National Development and Reform Commission and the World Wide Fund (WWF) identified Shanghai and Baoding as China's pilot low-carbon cities for a trial of the low-carbon city concept in 2008 [16,17]. In recent years, China took some measures to reduce carbon emissions, such as setting carbon emission reduction goals, eliminating backward production capacity, increasing carbon sink capacity, accelerating the development of low carbon cities [18], encouraging electric vehicles and developing renewable energy resources in order to avoid using more fossil fuels and to improve energy efficiency. Secondly, the large population and wide cultural diversity in China add some challenges. For example, the ground reality of high population density, growing private car ownership and the concentration of industrial enterprises, that compete in a global market and provide critical employment and finances for the respective urban agglomeration, creates critical hurdles for implementing carbon control measures. Furthermore, due to the cultural diversity and unbalanced economic development in the Eastern and Western regions of China, people's lifestyles and awareness of low-carbon usage are quite different [19]. It is thus

this complexity that makes China an interesting case for analysing the development of low-carbon city transformation.

This systematic review will be guided by the following three questions in order to get a better understanding of the impact of public awareness on low-carbon city transformation in China:

1. How are public awareness and low-carbon cities defined from different disciplinary perspectives?
2. What can the public do for low-carbon city transformation (public behaviour that contributes to low-carbon development)?
3. What are the factors that influence the public to change their behaviour and lifestyle in order to reduce carbon emissions?

This research will introduce the related theories about low carbon through the application of a systematic review methodology in order to contribute to future academic discussions in this field. This paper also contributes to providing a better understanding of the low-carbon city and low-carbon lifestyle. In addition, by discussing drivers and barriers for the public to participate in climate action and a low-carbon lifestyle, our findings will also contribute to policymaking.

2. Methods

2.1. Literature Search Procedure

Systematic reviews can summarize the results of existing evaluations and research projects [20–22], from which future research priorities can be identified [23], and it can also further develop the knowledge base [24,25]. This systematic literature review (SLR) is made of the following stages according to Petticrew and Roberts' (2006) method for systematic review in social science [26]. Firstly, we defined the research questions and aims. Secondly, we set up keywords and chose databases. Thirdly, we identified inclusion and exclusion criteria which guided us in further searching for the related literature. Then, we evaluated the included articles and assessed the quality of the results. Finally, we analysed these selected articles in depth and drew conclusions.

2.1.1. Research Aims

We undertook this systematic literature review (SLR) to discuss the impact of public awareness on low-carbon city transformation aims to:

(1) Deeply discuss the related concepts and theories of the low-carbon city, climate change and public awareness in different fields
(2) Show the process and development of low-carbon city transformation in China
(3) Learn about the challenges and barriers to public attitude and behaviour change regarding a low-carbon life and climate action, which are related to a low-carbon city transformation
(4) Identify main journals and authors in these fields

2.1.2. Key Words

Following the aim and research questions, the search terms were divided into three groups:

1. public awareness,
2. low-carbon,
3. city transformation.

For the first group, we used "public awareness" OR its substitute: "public concern" OR "public attitude". "Public behaviour" OR "lifestyle" were used because some studies have found that awareness could affect individual behaviours [27] and inspire lifestyle change [28], then affect consumption behaviours [29,30], and reduce emissions to a certain extent [31].

As for the second group, carbon dioxide (CO_2) is the main greenhouse gas that leads to global warming and climate change [32], and human activities are the main cause of

high levels of CO_2 and PM2.5 [33], so we used "climate change" OR "low-carbon" OR "PM2.5". Public environmental awareness and people's lifestyle will play an important role in dealing with climate change and reducing carbon emission, which is also a very important part of city transformation. The last three decades have seen unprecedented urbanization in China, and the socioeconomic development in Chinese cities and large numbers of new urban migrants have driven significant increases in energy use and related Green House Gas (GHG) emissions [34].

In terms of city transformation, we used the synonym of "city": "urban" OR "cities". The search terms logic was as follows (Table 1):

Table 1. Key words library (KWL).

Groups	Search Terms
Public Awareness	"public awareness" OR "public concern" OR "public attitude" AND "public behaviour" OR" lifestyle"
	AND
Low-carbon	"climate change" OR "low-carbon" OR "PM2.5"
	AND
City transformation	"city transformation" OR "cities" OR "urban"
	AND
China	China

2.2. Databases and Literature Search

The KWL was used for the search in the following sources: The Web of Science (WOS), EBSCO host and CNKI (China National Knowledge Infrastructure) databases. We used all the keywords in KWL in WOS under "Title, Keywords, or Abstracts (TKA)" and EBSCO host under "Abstracts" with English (EBSCO does not allow for TKA) and used "public awareness" AND "low-carbon" AND "city transformation" in CNKI under "Full Text (FT)" with Chinese (because our initial search for keywords under TKA or Abstract only revealed were very few results in CNKI). The search period covered the time from 1 January 2008 to August 2021, and the type of papers were all related articles (empirical and theoretical) and review articles. The start period is linked to the initiation of the low-carbon trials by the Chinese government. We chose the Web of Science and EBSCO host with English because Web of Science offers rich English sources in all fields, and the EBSCO hosts has a large number of English literature about economics, psychology, communication, management, health and philosophy. In CNKI, we chose the Chinese language because this research discusses the impact of public awareness on low-carbon city transformation in China, and CNKI is the main database in China, where most important articles also are Chinese. Although we chose and analysed the articles from an interdisciplinary perspectives, there is still some restriction of disciplines because we investigated papers coming from Environment, Social Science, Economics, Business and Management, Psychology, Ethics, Behavioural Science and Tourism, which is according to our research questions and aims, excluding Physics, Chemistry, Mathematics, Agricultural and Biological Science, Engineering and Medicine.

In addition, this SLR is conducted according to the Preferred Reporting Items for the Systematic Review and Meta-Analyses (PRISMA) Statement in order to integrate the results of studies included and ensure a more reproducible approach [35–37].

2.3. Inclusion and Exclusion Criteria

This SLR applied the following inclusion and exclusion criteria:

1. Time span: 1 January 2008–1 August 2021
2. Language: English or Chinese
3. Type of papers: all related papers (empirical and theoretical) and reviews (conference papers, books and book chapters; technical reports were excluded)
4. Study location: mainland China, Hong Kong, Macau or Taiwan

5. Subject areas: Environmental Science; Educational Research; Social Science; Economics; Communication; Business and Management; Political Science; Public Administration; Urban Planning and Study; Ethics; Psychological Science; Behavioural Science; Tourism.
6. Excluding any articles related to Physics, Chemistry, Mathematics, Agricultural and Biological Science, Engineering, Medicine.
7. Focus on:
    - urban environmental problem and low-carbon city development
    - public behaviour and attitudes about low-carbon lifestyle (including tourism, transport, building, consumption)
    - the relationship between people's lifestyle and climate change
    - the method, data collection, questions and results are clear.

2.4. Data Extraction and Evaluation

The initial search from Web of Science, EBSCO host and CNKI (China National Knowledge Infrastructure) databases produced 265, 62 and 3570 articles, respectively. We merged databases and excluded all duplicates, and selected articles according to subject area and theme, resulting in 912 articles in total (including 84 English and 828 Chinese papers). After applying our inclusion and exclusion criteria, 48 articles (21 English, 27 Chinese) were included in the final analysis through manually reading. The data collection process is shown in the PRISMA flow chart (Figure 1):

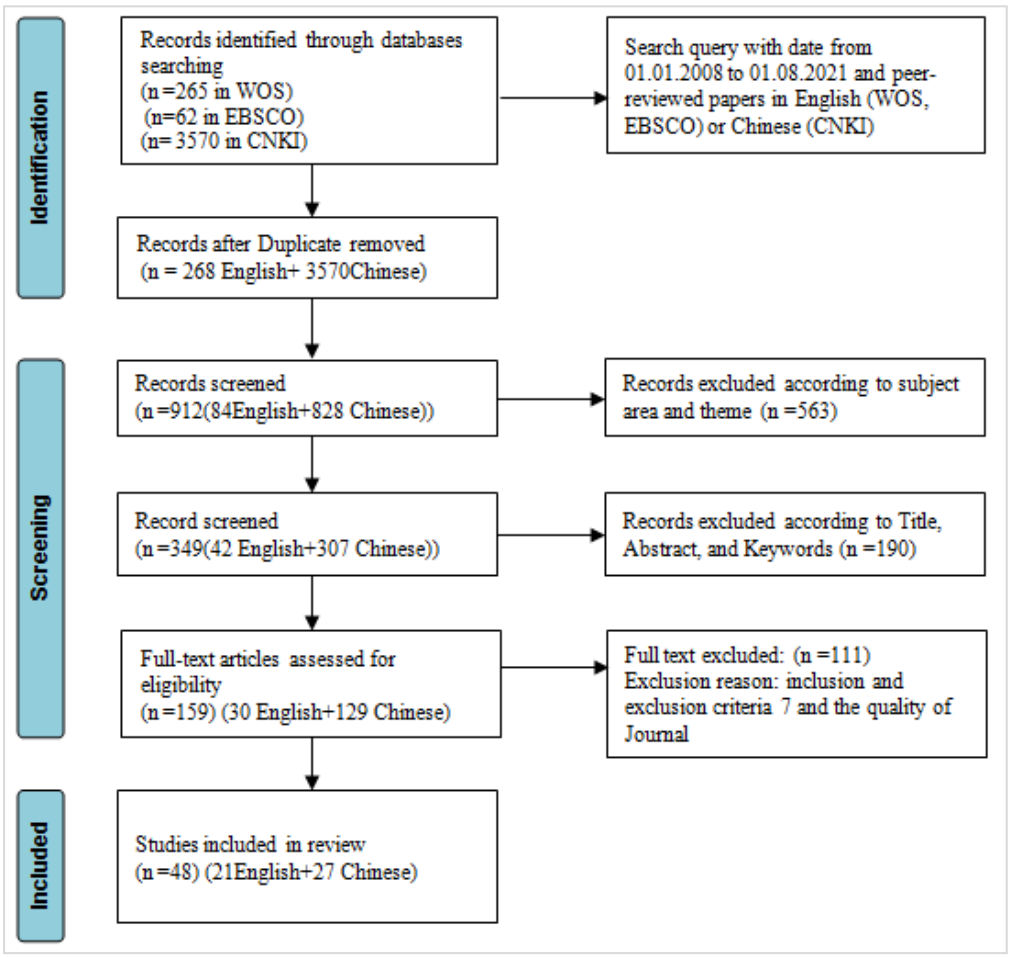

Figure 1. Data Collection Process.

3. Results

3.1. General Results

The 48 articles that we identified through our research and selection process were classified according to their publication years for the first step (Figure 2 and Sheet S2). The evidence shows that the scholarly discourse on low carbon is mainly reflecting the relevant governmental policy changes. The reviewed articles published in 2016 and 2021 made up nearly 30% of the total, with 14.58% and 13% respectively, while slightly more than one-tenth of the reviewed articles were published in 2011, 2015, 2017 and 2020. Early publications, i.e., those published before 2014, focused on related policies, the conception and meaning of low-carbon city development. China pledged to peak CO_2 emissions by 2030, reducing emissions of CO_2 per unit of GDP by 60–65% (from the 2005 level) by the target year of 2030, in accordance with the Paris Climate Change Conference of 2015 [38]. Later, publications started to pay attention to the relevant links between climate change and carbon emission, and there was more literature about citizen's low-carbon behaviour, low-carbon consumption, low-carbon tourism and household carbon emissions. The second peak of publications observed for 2021 shows a focus on carbon emission reduction after the Chinese government announced that it would target carbon neutrality success by 2060 and launched a sequence of low-carbon policies (may also be attributed to the effect of the COVID-19 lockdown). In addition, there was just one reviewed article published in 2010, indicating that the related discussion and research was limited to ten years ago because China only developed low-carbon cities after 2008.

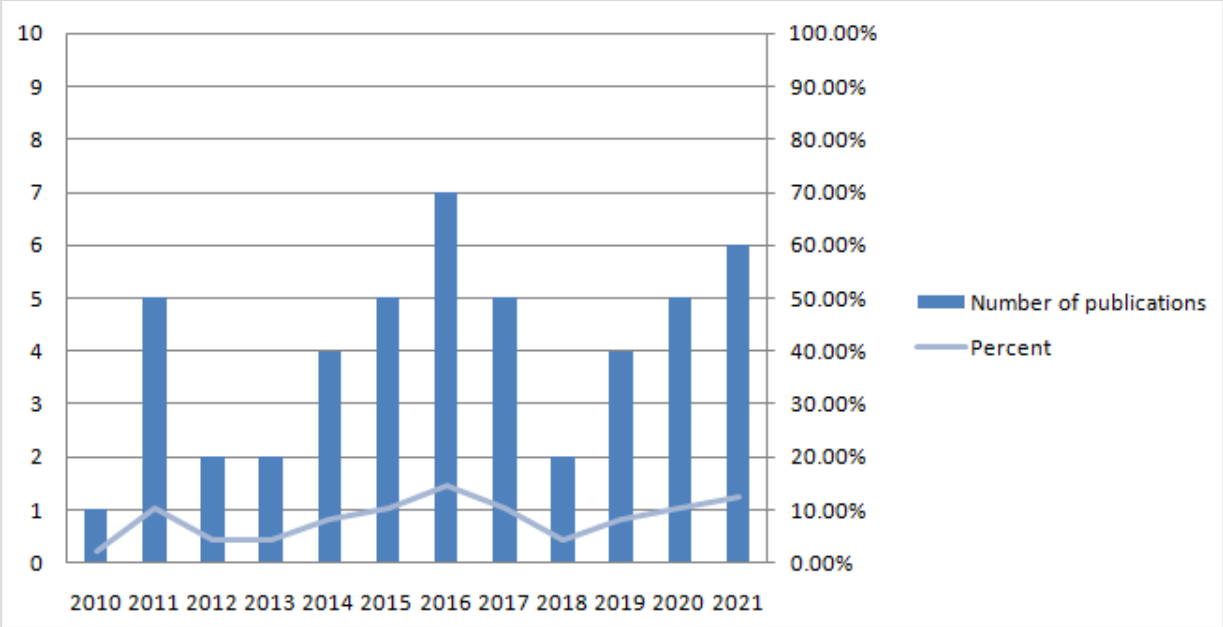

Figure 2. Number of papers per year with percentage.

The geographic regions and cities explicitly covered in the 48 publications are summarized in Figure 3 and Sheet S3. Specific cities drew the attention of researchers related to the administrative status and policy support of the city [39]. Twenty-five articles focused on specific areas, which covered 19 provinces and 19 cities in China, while the remaining 23 articles discussed low-carbon development in China without mentioning any cities or provinces. Six articles focused on the comparison of different provinces in China, such as Shanghai, Jiangsu and Guangdong. In terms of cities, Xiamen, Beijing and Shanghai were more frequently analysed in the reviewed articles, with six, five and five articles, respectively. Therefore, we learn that most researchers focused on developed cities in China, or some south-eastern coastal cities in China.

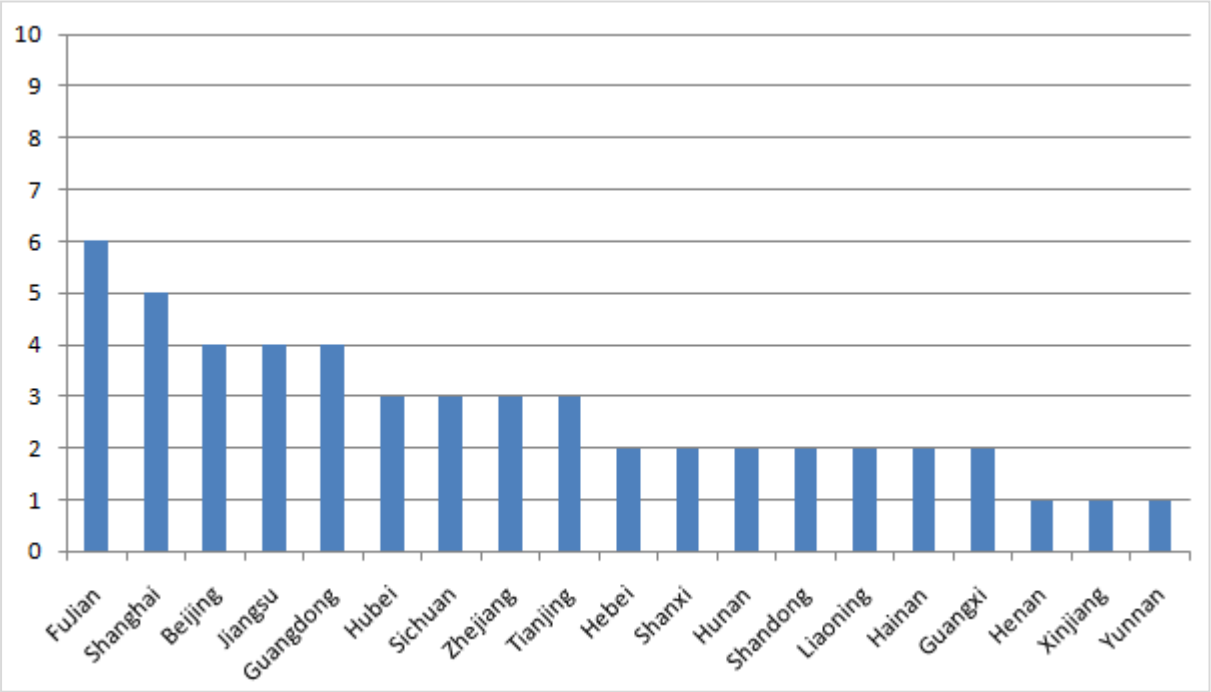

Figure 3. Number of papers covering specific cities/regions.

Thirdly, we grouped publications according to the specific disciplines and/or thematic themes covered (Figure 4, Sheets S4 and S5). Research was mainly published in journals focusing on fields like the environment, sustainability and economics; political science; urban planning; ethics; psychology, etc. Not surprisingly, most articles (12) were published in journals with a focus on sustainability followed by social sciences (10) and the environment (9). There were six articles in the field of energy, and the number of articles in journals on management and political science was the same with three of each.

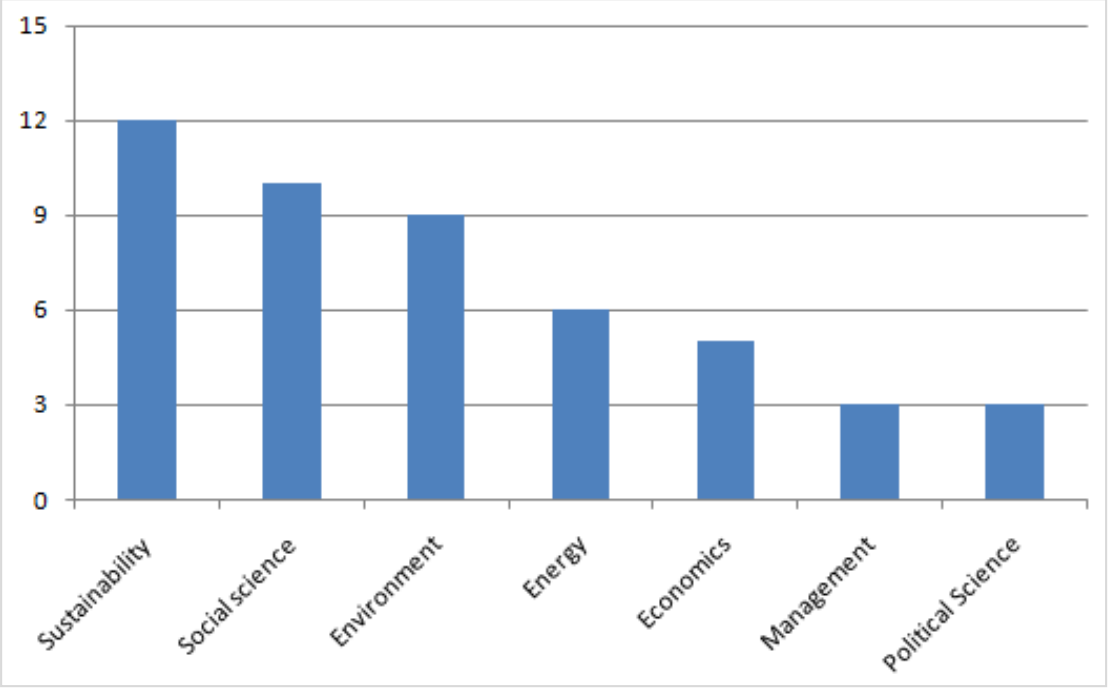

Figure 4. Number of papers according to thematic focus of respective journals.

Fourthly, we arranged the selected 48 articles according to the three research questions of this SLR (Sheets S6–S8). As for the relationship of low-carbon behaviour and low-carbon transformation, 24 articles discussed the related history, development and current situation, and the public's role in strategy. In addition, there were eight articles about the public's attitude and awareness of low-carbon development, and 16 articles about the factors that affect public low-carbon behaviour and lifestyle. These will be further explained in parts Sections 3.2–3.4 of this article.

3.2. Research Question 1

How are public awareness and low-carbon cities defined from different disciplinary perspectives?

3.2.1. Definitions

As China has launched a low-carbon economy strategy with some delay compared to other more advanced countries, most articles by Chinese scholars in our results have focused on discussing related definitions, theories and research methods, although a limited number of articles dedicate some attention to the relationship between public awareness and low-carbon city transformation. Twenty-nine articles selected discussed the related definitions from the aspect of low-carbon cities, low-carbon economies and low-carbon consumption (Table 2).

Table 2. Definitions were mentioned in the selected articles.

Definitions	Authors
Low-carbon cities	Sun et al., 2021; Hunter et al., 2019; Chen et al., 2013; Tang et al., 2016; Shi, 2015a; Wang, 2012; Dou et al., 2017; Dai et al., 2011; Yang et al., 2017; Lu et al., 2020;
Low-carbon economy	Dou et al., 2017; Shi, 2015a; Liu, 2010; Hu et al., 2014; Tao, 2011;
Low-carbon consumption	Zhou et al., 2020; Xue, 2020; Liu et al., 2019; Zhuang, 2019; Shi, 2015b; Zhao et al., 2015; Shi, 2015a;Yang et al., 2014; Yang et al., 2017; He et al., 2011; Cheng et al., 2021; Liu, 2010; Tang et al., 2014; Zhang, 2016; Dou et al., 2017; Wang et al., 2011; Hu et al., 2014; Tang et al., 2018; Wang, 2011; Chen et al., 2012; Zhang et al., 2021; Rong et al., 2020; Ding et al., 2017; Ye et al., 2017; Tao et al., 2013.

In respect to low-carbon cities, the literature showed that many scholars have derived definitions from different perspectives, but ending with quite similar meanings. A low-carbon city refers to a city with a low-carbon economy as its development model and direction [39], a low-carbon life as its underlying concept and behavioural characteristics of citizens, and a low-carbon society as the government's management aim [40]. Low-carbon city planning and design need to be energy-saving; they should consider low-carbon buildings, public transportation, communities, energy supply and use, waste treatment, recycling utilities and resources, communications and so on [41,42]. The development of low-carbon cities also requires improvement in people's awareness [40,43,44]. Lu et al. (2020) [19] and Sun et al. (2021) [45] discussed policies and development for the 81 pilot low-carbon cities in China.

As for a low-carbon economy, the literature discussed it from its development, background and definition in China. Global climate change caused by mass GHG emissions has become one of the most urgent challenges facing society today [41]. To address climate change and ensure sustainable development, the low-carbon economy is now the most widely accepted development pattern [46]. A low-carbon economy requires people to change their lifestyle [47], energy consumption [48], and economic development patterns [49], which relate to social production, social life, consumption, economic development, ecological environment and so on [50]. It can also reflect the harmonious relationship between nature and man [49].

Over half of the reviewed articles focused on low-carbon consumption. Analysing the willingness of people to practice low-carbon consumption will be a realistic guide to improve environmental quality and reduce carbon emissions. Resident consumption includes eight categories: food, clothing and basic daily utilities, transportation and telecommunications, medical and health care, education and culture, entertainment and housing [51]. The existing definitions of low-carbon consumption tend to focus on people's daily life: citizens initiatively reduce high-carbon consumption activities in their daily life [52], including food, accommodation, transportation, and clothing, especially buying and using products and dealing with waste, which have low pollution levels, low energy consumption and low emissions [53–56], meaning that the whole process of consumption needs to be low-carbon [57]. This type of lifestyle comprises economical, healthy, and low-carbon daily practices and life modes, characterized by energy saving and moderate consumption [58]. The aim of low-carbon consumption is to reduce carbon emissions [51], and to act responsible toward the next generation [59]. While low-carbon consumption means also refraining from lavish or wasteful consumption, it will not necessarily decrease the quality of life [51], but can improve people's happiness [4]. In addition, some scholars discussed consumption from the perspective of energy consumption [34,60–65], arguing that direct and indirect household energy consumption accounts for a large proportion of the total energy consumption. The impact of indirect household energy consumption was higher than that of direct energy consumption [62]; residential, clothing and transportation are the most energy-intensive [60]. Others discussed tourism [66–70], arguing that cognition of tourists on low-carbon tourism is not deep enough [68,71].

3.2.2. Theoretical Framework

In the articles reviewed, the most referred theory is the theory of planned behaviour (TPB) from Ajzen [72] (eight articles mentioned it)(Table 3), which is widely used in the field of environmental behaviour and consumption [48] and is more comprehensive compared with the theory of reasoned action (TRA) from Fishbein and Ajzen [27]. According to TPB, people's behaviour can be affected by their attitude and willingness, and then the intention (motivation) is influenced by the attitude and subjective norms and perceived behavioural control. Moreover, behind each of these variables there are three types of beliefs: behavioural beliefs, normative beliefs and control beliefs. The more positive their attitude, or the greater pressure from external forces, such as from family, friends and colleagues, the more likely the individual is to take action [48,66,69].

Table 3. Theories were mentioned in the selected articles.

Theory	Authors
Theory of Planned Behaviour (TPB)	Tang et al., 2016; Shi, 2015b; Zhao et al., 2015a; Shi, 2015a; Liu, 2010; Hu et al., 2014; Zhao et al., 2015b; Li et al., 2016;
Value-Belief-Norm (VBN)	Liu, 2010; Zhao et al., 2015b;
Knowledge-Attitude-Behaviour (KAB)	Zhao et al., 2015a;
Social capital	Li et al., 2021;
Social exchange theory	Zhao et al., 2015a; Zhao et al., 2015b.

Stern [73] is another scholar in the field of sustainable consumption behaviour that the authors in our sample refer to. Stern argued that self-interested values will make people pay attention to the environment based on their own benefits; altruistic values will make people pay attention to and protect the environment based on the development of human beings [48]. Stern created the value-belief-norm (VBN) theory, which is based on the value theory, norm-activation theory, and the New Environmental Paradigm. VBN believes that individual values will affect behaviour in an environmentalist context [66,74].

Some scholars also mentioned the knowledge-attitude-behaviour theory from Hungerford and Volk [75], which believes that knowledge will affect environmental behaviour through attitude [66].

In the reviewed articles, several other theories and models have been mentioned. Some scholars use the consumer lifestyle approach (CLA) to calculate direct and indirect household emissions and investigate the impact of consumer attitudes [60,63,76]. Behavioural economics suggest that subjective factors, such as beliefs and preferences, can affect individual decision making [31]. Zhou XY et al. [62] and Liu XY et al. [63] use the input–output analysis model to investigate the factors that influence Chinese household carbon emissions. In addition, the participatory developmental theory is recalled by Dai J et al. [77], which encourages the public to initiatively participate in low-carbon city development. Li CD et al. [78] uses social capital to analyse the impact of haze pollution on public and the government reaction towards this impact. Based on the social exchange theory, Zhao LM et al. [66] believes that perceived benefits will affect people's choices.

3.2.3. Methodology

There are several methods utilized in the articles reviewed. Some authors attempted to use mixed methods including elements of qualitative and quantitative methods to analyse public awareness, consumption behaviour, and the factors that affect their behaviour. We found that 18 articles applied surveys using questionnaires with the number of valid samples being 500–600, 200–400, 2000–4000, which accounts for 38%, 33% and 22%, respectively (c.f. Table 4).

Table 4. Methods were utilized in the selected articles.

Methods	Utilization in Selected Articles
Questionnaire	Rong et al., 2020; Xue, 2020; Ye et al., 2017; Tao et al., 2013; Wang et al., 2016; Tang et al., 2016; Shi, 2015a; Zhao et al., 2015; Shi, 2015b; Dai et al., 2011; Jiang et al., 2016; Cheng et al., 2021; Tang et al., 2014; Zhang et al., 2016; Han et al., 2017; Hu et al., 2014; Wang et al., 2011; Zhao et al., 2015; Li et al., 2016; Wang et al., 2016; He et al., 2011;
Big data	Li et al., 2021; Li et al., 2020; Lu et al., 2018; Yang et al., 2017;
Field survey	Xue, 2020; Zhang et al., 2016;
Interview	Wang et al.,2011; Zhang et al., 2016;
Penal data	Zhao et al., 2021; Lu et al., 2020;
Experimental method	Tang et al., 2019.

Table 4 exclude: conceptual and theoretical research, review and research based on other data sources.

The uncertainty of the response rate in traditional questionnaires may cause uncertainty in the research's results [78]. With the increased use of social media, new opportunities have opened up for research in public attitudes and behaviour. Big data based on the internet is widely used to study the public's concerns. Li et al. [79] and Lu YL [80] adopted big data to discuss public environmental concern. On Google, Yahoo and Baidu, the behaviour of the general public has been expressed widely which has produced a lot of data on public awareness regarding many topics of interest [79].

Wang et al. [52] used interviews to explain the psychology of consumption behaviour. There are two types of interviews: face-to-face and online. Firstly, face to face interviews not only record the original ideas of interviewees, but the interviewer can also observe their facial expressions and corresponding emotions, and effectively improve the content and purpose of the interview. This also applies to online interviews, which are not limited by space and region wherein the respondents can respond in a more relaxed and truthful way [52].

In addition, some scholars use experimental methods and field surveys to evaluate tourist behaviour. For instance, Tang CC et al. [70] adopted experimental methods, set travel conditions, and independently implemented repeat experiments on 30 subjects to analyse the characteristics of tourists' low carbon behaviour, and to observe how different factors influence decision making in the travel process. Zhang et al. [68] went to the targeted place, combining field surveys, questionnaires and interviews to conduct research and learn about tourists' low-carbon willingness.

Some scholars also conduct research based on other data sources, such as the China Center for Climate Change Communication's telephone survey [81], the China Household Finance Survey [31,45], and the Chinese Cities' Statistical Yearbook [19], which can be seen at Sheet S6. There are others who carry out conceptual research or theoretical research to summarize the experience about low-carbon development in China, giving some policy advice about how to develop low-carbon cities in the future [40,48,49,51,57,82].

3.3. Research Question 2

What can the public do for low-carbon city transformation (public behaviours that contribute to low-carbon development)?

There is a large part of the population, and many enterprises in cities, which are the sources of greenhouse gas emissions. Moreover, there is a strong alignment between low-carbon and locally appropriate sustainable development strategies for cities. A low-carbon city is, above all, a sustainable, efficient, liveable and competitive city. The aim of low-carbon city development is to create and put into practice city construction and social development models that will help to reduce carbon emissions under the premise of ensuring continuous improvements to the quality of life, whether it is economic development, consumption or transformation of lifestyles [51]. The core of low carbon development in cities is to make full use of natural conditions to reduce the consumption of natural resources and energy and to develop green communities, green industries and more environmentally-friendly transportation [41]. Climate action needs to focus on addressing specific pectoral challenges, particularly those related to energy, transport, and other municipal services. Climate governance is not an issue of emission reduction, but a question of how to make people change their high-carbon emission lifestyles.

Several authors emphasized that a low-carbon lifestyle and the reduction of emissions by people's consumption are very important parts of reducing urban carbon emissions [31,34,45]. The path of development is a key factor in how climate change progresses and therefore the actions and reactions of the general public are vital factors in this process [83]. Therefore, public participation plays a vital role in addressing climate change [81], because the problem cannot be solved unless everyone is aware of this issue and takes responsibility for him or herself.

Some studies have shown increasing interests in household carbon emissions [31]. Some scholars used CLA [60,63,76] and an input–output model [62,64] to investigate a household's carbon emission in respect to specific consumption types, such as electricity use, food consumption, transportation and so on. There are several types of consumption behaviour that have a huge potential to save energy and reduce emissions in Chinese cities, and the top five are clothing, food, accommodation, energy consumption, and transportation [54,64,76]. Firstly, reducing the amount of non-essential clothing purchases is an important aspect [50]), since excessive purchasing can lead to a large amount of indirect emissions. [60,62]. Secondly, changing food habits towards consuming local agricultural products can save a great deal of energy and resources and be helpful to the general health [41]. Thirdly, a dramatic saving of energy, thereby reducing emissions, can be achieved by tweaking the settings on energy-hungry appliances, such as air conditioners and heaters, or by changing domestic equipment to energy-saving models [61]. Common household activities usually consume a lot of energy as they require direct energy to fulfil practices such as preparing food, storing foodstuff, illuminating and warming homes, and operating TVs or computers [34]. The second-largest culprit of energy carbon emissions

in China comes from the construction industry [65]. Building and occupying low-carbon residential accommodation involves a plethora of aspects including land planning, the selection and use of building materials, construction, interior decorating, economically planned power and water supplies, effluent treatment, greening of available areas, public transport and effective property management [41]. Lastly, Dou et al. [41] discusses the importance of low carbon-emitting mobility, such as public transport, bikes and cars that utilize alternative power sources, and which use less energy, therefore reducing carbon emissions on each trip. Thus, the general public is encouraged to follow a low-carbon lifestyle [39].

There are many other ways that low-carbon behaviour can be implemented in daily life (as shown in Table 5 and Sheet S7), but these are limited to in-depth discussions in selected articles of specific low-carbon practices and how the public can apply these in their daily lives. These authors have mentioned low-carbon consumption, low-carbon food, low-carbon buildings, low-carbon transportation (walking, cycling, public transportation and new clean energy vehicles), low-carbon tourism and so on, which will reduce large amounts of carbon emissions, and they advise the public to practice these. Most scholars use related methods to calculate carbon emissions from different consumption types, or research consumer behaviour in daily life, which point out that some direct and indirect consumption behaviours will produce large carbon emissions, but they tend to discuss the factors that affect public awareness and behaviour.

3.4. Research Question 3

What are the factors that affect the public to change their behaviour and lifestyle in order to reduce carbon emissions?

In the articles we reviewed researchers adopted questionnaires, interviews, big data, and other methods to discuss the different factors that affect people's behaviour, such as environmental attitudes, awareness and concerns, social responsibilities, values, environmental knowledge and education, culture, policy, communication, the economy, technology and so on (Table 6, Sheet S8). We classify these factors into three categories and make a "Model of factors affecting people's low-carbon behaviour" (Figure 5). We found that there is a gap between awareness and action, which means that we have a long way to go towards a low-carbon society, so further examination of the factors that affect people's behaviour will be necessary in later research.

Table 5. Behaviour contributing to low-carbon city transformation.

Category	Behaviour Contributes to Low-Carbon City Transformation	Authors
Low-carbon consumption	Buy low-carbon products	Sun et al., 2021; Dou et al., 2017; Chen et al., 2013; Zhuang 2019; Shi, 2015b; Zhao et al., 2015; Wang, 2012; Dai et al., 2011; Zhao et al., 2021; Wang et al., 2017; Wang et al., 2011; Han et al., 2017; Tang et al., 2018; Chen et al., 2012; Li et al., 2016; Wang et al., 2016;
	Recycle, reduce waste, energy saving (reduce over-packaging, reduce use of plastic bags and other one-time products)	Tang et al., 2016; Dou et al.,2017; Zhao et al., 2015; Shi, 2015b; Wang, 2012; Dai et al., 2011; Zhang et al., 2016; Han et al., 2017; Wang et al., 2011; Zhao et al., 2015; Tao, 2011; Sun et al., 2015;
Leisure and recreation	Leisure and recreation are low carbon (indirect consumption)	Liu t al, 2019; Tang et al., 2018;
	Low-carbon tourism	Tang et al., 2014; Zhang et al., 2016; Wang et al., 2011; Zhao et al., 2015;

Table 5. *Cont.*

Category	Behaviour Contributes to Low-Carbon City Transformation	Authors
Clean energy	clean energy, renewable energy	Xue, 2020; Liu et al., 2019; Li et al., 2019; Chen et al., 2013;
Food	Low-carbon food	Liu et al., 2019; Ding et al., 2017; Dou et al., 2017; Shi, 2015a; Shi, 2015b; Dai et al., 2011; Tang et al., 2014; Han et al., 2017; Tang et al., 2018; Wang et al., 2011; Chen et al., 2012;
Clothes	Reducing the energy in garment consumption	Ding et al., 2017; Shi, 2015b; Shi, 2015a;
Housing	Using energy-saving equipment (TV, Air Conditioner, Refrigerator, lighting)	Rong et al., 2020; Zhuang, 2019; Wang et al., 2011;
	Close the electricity, TV, airconditioning on time	Zhang et al., 2016; Wang et al., 2011;
	Using natural gas, saving heating and electricity	Rong et al., 2020; Ding et al., 2017; Tao et al., 2013; Hubacek et al., 2012; Han et al., 2017;
	Extending building lifespan and the recycling of building wastes	Tao et al., 2013;
	Garbage sorting	Tang LC et al., 2016; Cheng X et al., 2021; Han YL et al., 2017;
Transportation	low-carbon transportation	Sun, et al., 2021; Li et al., 2019; Ding et al., 2017; Dou et al., 2017; Tao et al., 2013; Chen et al., 2013; Shi, 2015a; Shi, 2015b; Wang, 2012; Zhao et al., 2021; Tang et al., 2014; Han et al., 2017; Tang et al., 2018; Chen et al., 2012;
	Public transportation	Xue 2020; Wang et al., 2016; Dai et al., 2011;Wang et al., 2011; Zhao et al., 2015;
	Cycling, shared Bicycle	Hunter et al., 2019; Zhuang 2019; Wang et al., 2016; Dai et al., 2011; Wang et al., 2017; Yang et al., 2017; Wang et al., 2011;
	Walking	Hunter et al., 2019; Wang et al., 2016;
Communication	Environmental education	Wang et al., 2016;
	Learn about low-carbon policy	Wang et al., 2016;
	Introduce low-carbon products to relatives and friends	Tang et al., 2016;
Social activities	Participate in low-carbon activities	Tang et al., 2016; Wang et al., 2011; Zhao et al., 2015;
	participate in social management	Li et al., 2021; Li et al., 2020;
	Concern about environmental problems	Li et al., 2021; Li et al., 2020; Lu et al., 2018; Jiang et al., 2016;
	Pay for personal emission	Wang et al., 2017.

Note: most of the authors didn't discuss in depth the specific low-carbon behaviours, just mentioned these behaviours.

Table 6. Factors affecting public's behaviours.

Categories	Factors	Authors
Individual psychological factors	Attitude	Zhao et al., 2015; Liu, 2010; Hu et al., 2014; Zhao et al., 2015; Chen et al., 2012;
	Awareness	Dou et al., 2017; Chen et al., 2013; Shi, 2015b; Li et al., 2021; Lu et al., 2018; Zhao et al., 2021; He et al., 2011; Wang et al., 2011; Tang et al., 2018; Li et al., 2016; Wang et al., 2016;
	Education and Knowledge	Xue, 2020; Li et al., 2019; Dou et al., 2017; Ye et al., 2017; Tang et al., 2016; Wang, 2012; Dai et al., 2011; Jiang et al., 2016; Wang et al., 2017; Cheng et al., 2021; Liu, 2010; Tang et al., 2014; Zhang et al., 2016; Wang et al., 2011; Han et al., 2017;Hu et al., 2014; Wang et al., 2011; Chen et al., 2012; Li et al., 2016; Sun et al., 2015; Wang et al., 2016;
	Value	Shi, 2015a; Shi, 2015b; Hu et al., 2014; Zhao et al., 2015; Chen et al., 2012; Li et al., 2016;
	Beliefs	Jiang et al., 2016; Liu, 2010; Li et al., 2016;
Habitual preference and behaviour	Consumption habits	Wang et al., 2016; He et al., 2011; Wang et al., 2016;
	past and general behaviours	Li et al., 2019; Zhao et al., 2015; Qian, 2010; Zhang et al., 2016; Zhao et al., 2015; Chen et al., 2012; Sun et al., 2015; Wang et al., 2016;
	Demographics (age)	Shi, 2015a; Tang et al., 2018;
	Demographics (income)	Liu et al., 2019; Li et al., 2019; Ye et al., 2017; Chen et al., 2013; Hubacek et al., 2012; Dai et al., 2011; Tang et al., 2018;
	Demographics (job occupation)	Wang et al., 2011; Zhang et al., 2016;
	Demographics (areas)	Zhou et al., 2020; Tang et al., 2018;
Contextual or situational factors	Economy	Zhou et al., 2020; Li et al., 2019; Dou et al., 2017; Ye et al., 2017; Zhao et al., 2015; Wang et al., 2017; Tang et al., 2014; Zhang et al., 2016; Wang et al., 2011; Han et al., 2017; Zhao et al., 2015; Chen et al., 2012;
	Social norms	Zhuang, 2009; Tang et al., 2016; Zhao et al., 2015; He et al., 2011; Wang et al., 2011; Zhao et al., 2015; Shi, 2015b; Jiang et al., 2016; Wang et al., 2016;
	Supporting facilities	Zhuang, 2009; Dai et al., 2011; Lu et al., 2018; Zhao et al., 2021; Tang et al., 2014; Chen et al., 2012; Li et al., 2016; Sun et al., 2015;
	Policies	Sun et al.,2021; Xue, 2020; Li et al., 2019; Dou et al., 2017; Tao et al., 2013; Chen et al., 2013; Hubacek et al., 2012; Zhuang, 2009; Shi, 2015a; Shi, 2015b; Li et al., 2021; Yang et al., 2017; He et al., 2011; Qian, 2010; Tang et al., 2014; Wang et al., 2011; Han et al., 2017;Hu et al., 2014; Chen et al., 2012; Li et al., 2016; Lu et al., 2020; Sun et al., 2015; Wang et al., 2016;
	Technology	Liu et al., 2019; Hunter et al.,2019; Dou et al., 2017; Chen et al., 2013; Li et al., 2020; Wang et al., 2017; He et al., 2011; Tang et al., 2014; Han et al., 2017; Lu et al., 2020; Sun et al., 2015; Li et al., 2016;
	Culture	Zhuang, 2009; Tang et al., 2016; Shi, 2015a; Zhao et al., 2015; Wang, 2012; Dai et al., 2011;Yang et al., 2017; Tang et al., 2014; Wang et al., 2011; Han et al., 2017; Tang et al., 2018; Zhao et al., 2015; Chen et al., 2012; Li et al., 2016; Wang et al., 2016;
	Media	Sun et al.,2021; Liu et al., 2019; Tang et al., 2016; Wang, 2012; Lu et al., 2018; Cheng et al., 2021; Tang et al., 2014; Zhang et al., 2016; Wang et al., 2011; Hu et al., 2014; Chen et al., 2012; Sun et al., 2015; Wang et al., 2016; Li et al., 2016.

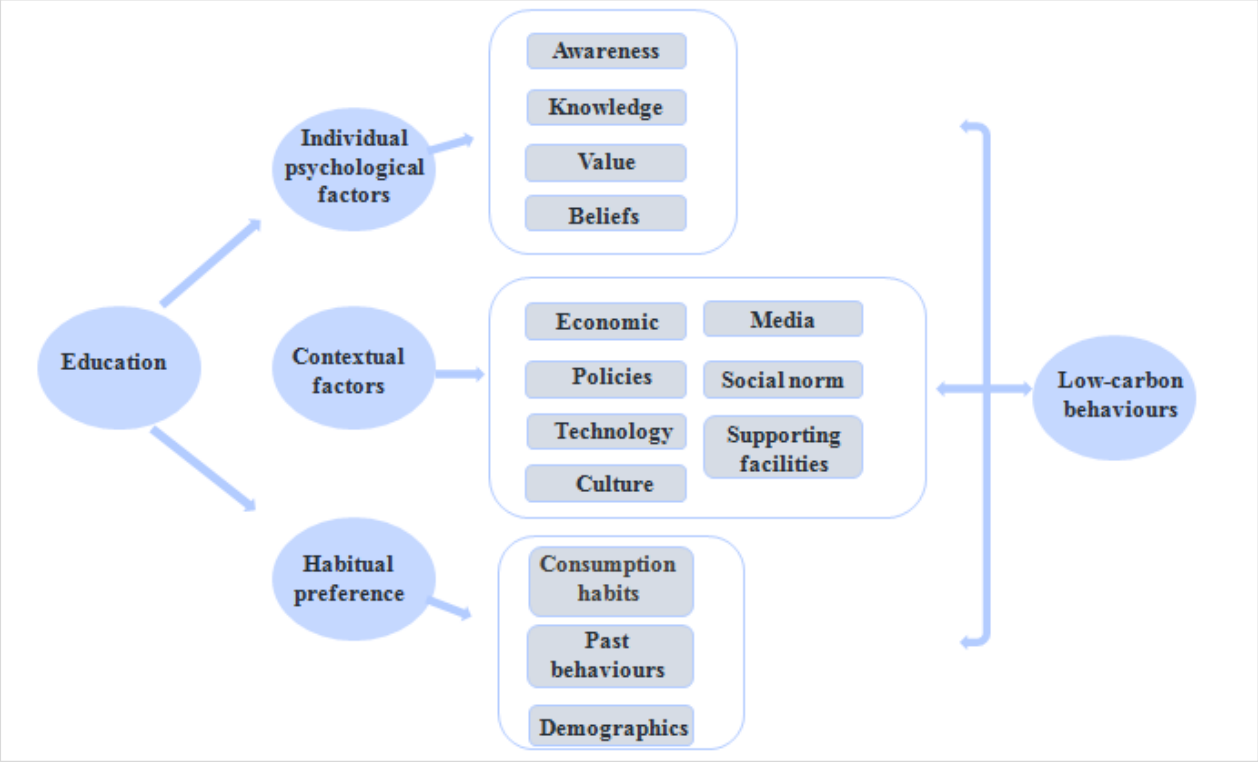

Figure 5. Model of factors affecting people's low-carbon behaviour.

Firstly, the category of individual psychological factors includes individual attitude, awareness, education and knowledge, values and beliefs. Residents' low-carbon consumption behaviour and performance are significantly related to their ecological awareness and attitude [84,85], and individuals purchasing green products are affected by their environmental concern and low-carbon responsibility [47,55,86,87]. Values, that are social products rooted in traditional culture [59], vary under different cultural backgrounds. Collectivism and the sense of safety has a significant and direct impact on green consumption intentions, especially collectivism, which has a positive effect on people's attitudes, which in turn, affects individual behaviour through mediating roles [88]. Collectivist values emphasize social identity, obligation sharing and the meeting of social expectations. When individuals have collectivist values for environmental protection, they are more likely to adopt low-carbon consumption behaviours [57].

Secondly, habitual preference and activities include consumption habits, past and general behaviour, demographics and so on. Although some researchers agree that attitude will affect people's behaviour, there is in fact a gap between awareness and action [43,66,67,81]. Some other scholars believe that most people know about climate change and have awareness of low-carbon consumption, but this does not mean people are willing to change their behaviour and lifestyle [53], because their choice and decisions will be affected by their habitual preferences, their past experiences and their personal habits [89]. The public generally tend to choose products for convenience, economy, and comfort [54,67], and some of them believe that low-carbon transformation is the government's responsibility [81]. Therefore, changing people's lifestyle and high-carbon behaviour is not an easy thing [76], and low-carbon transformation needs a long period of time to take an effect [31]. However, there are some people, especially low-income individuals, who have chosen low-carbon lifestyles a long time ago, although some of them may not actually know about the concept of a low-carbon life, and this is affected by some demographic factors, such as income and age [52].

Thirdly, contextual or situational factors refer to external forces that affect an individual's low-carbon consumption behaviour. In this article, the category of contextual factors

includes economy, social norms, supporting facilities, policies, technology, culture and media. The cost of low-carbon products, the convenience of purchase, the consumption culture and the social norms have an important effect on people's consumption behaviour [56]. Normally, most consumers are concerned about the price of products. The higher the price of low-carbon products, which means residents need to pay more money for the products, the lower the willingness of the public to buy [53,71]. Low-carbon technology in China still suffers from a lack of refinement, which leads to inadequacy of effective low-carbon products supply and supporting facilities, so the cost of low-carbon products is still high [90]. In addition, the culture of "saving face" is common in China [91], wherein many people are likely to purchase high-carbon products, especially luxury items [51], not for any real need but to get respect, honour and social standing from others, or to compare favourably with others [52]. If more and more people pursue low-carbon product consumption, their behaviour will also affect their friends and families. Apart from that, policies will also affect people's behaviour. Policy factors include mandatory policies and incentive policies, but mandatory policies raise people's resistance, which has a negative effect on people's behaviour [53], requiring policy makers to make reasonable rules to guide people into low-carbon consumption and change in their high-carbon lifestyles accordingly. The media also plays a vital role in low-carbon consumption, which can affect people's awareness, knowledge and social culture through the internet, TV programmes and newspapers [52]. For example, Tang M F et al. [67] found that over half of tourists learn about low-carbon tourism through the internet, thus demonstrating that mass media is the main way to promote low-carbon tourism. To change people's thinking with regard to low-carbon tourism, proper public information broadcasting is required, wherein citizens can locate and learn from reasonable and accurate sources [58].

4. Discussion

Climate governance is not only an issue of emission reduction, but also a question of how to make people change their lifestyle of generating high carbon emissions [92,93]. This systematic literature review focused on public awareness on low-carbon city transformation, discussed the related theory and conception, we addressed the question of what residents can do for low-carbon city transformation, and the factors that affect public low-carbon behaviour based on the reviewed literature.

Although most scholars discussed the conception and policies of the low-carbon city, the research methods, theory basis (that can be traced) and targeted cities of research are limited. Most researchers focused on low-carbon behaviour in big cities and based on the TPB theory, collected data from questionnaires, the Baidu index, or existing databases produced by national statistic institutes. In terms of data collection, we believe that the combination of questionnaires with big data might better reflect public low-carbon awareness and environmental concerns in later research. As for target cities or provinces, there are huge differences in citizens' lifestyles, economic means, consumption habits, and awareness among different regions of the Western, central and Eastern parts of China due to unbalanced development. Further research needs to take this problem into consideration when selecting study areas. In addition, the relatively late development of low-carbon cities in China and the focus on technical solutions, has resulted in most researchers (depending on their respective disciplinary backgrounds) focusing on low-carbon definitions, the relationship between low-carbon city construction and economy, as well as the impact of low-carbon cities on the environment, and the calculation of carbon emissions. Therefore, interdisciplinary perspective research about public awareness and low-carbon cities will be needed in the future..

The articles also show that the public understanding mainly relates a low-carbon city to a low-carbon life, and that here is a gap between low-carbon awareness and low-carbon behaviour. From the reviewed articles, we learned that while some citizens have knowledge of the conception of a low-carbon economy, it actually is rather difficult for them to change their behaviour as their low-carbon behaviour is passively affected by government, media

and enterprises who advertise low-carbon products. Then there are others who have been living a low-carbon life for many years, although they do not have any specific knowledge about the low-carbon concept. While a couple of scholars indicated the gap between awareness and knowledge, their research was not deep or comprehensive enough to derive any advice on how to improve this problem. The knowledge of additional disciplines including behavourial sciences might provide further insights. Improving the understanding of people's motivation, concerns and cultural constraints as well as including aspects of reconciliation from the philosophical perspective might unify knowledge and action.

Finally, author's opinions differed clearly regarding the factors that affect low-carbon behavior. These differences might be due to the large differences of the respective situations in the selected cities and sample regions. This also indicates that different cities should make reasonable low-carbon policies based on their respective characteristics, situations and cultures to encourage the local people to join low-carbon action [94,95]. Most auhtors agree that education and government policy have an influence on the improvement of public low-carbon behaviour. In addition, education plays a vital role in improving people's low-carbon awareness and changing traditional behaviours, which requires schools to provide more low-carbon knowledge to students and encourage them to engage already in an early age in low-carbon consumption habits.

Besides China, there are many other countries that are making an effort to reduce carbon emissions, however, most researchers believe that it is not easy to change people's behaviour and awareness. In 2003, then British Prime Minister Tony Blair published "Our Energy Future: Creating a Low-carbon Economy" which first put forward the concept of a "low-carbon economy", an economy characterised by low pollution, low energy consumption and low emissions offering a new choice for sustainable economic and social development [96]. In order to realise the greater ambition to reduce carbon emissions in the UK, the public needed to play a vital role [97]. For high-income European countries, such as the UK, Finland and the Netherlands, further behavioural changes in mobility patterns, housing or diet choices, which made up the largest contributions to household carbon footprints is most needed but also feasible [98–102]. Sköld et al. [102] analysed residents' preferences in reducing their carbon footprint based on collecting data from four European cities in France, Germany, Norway and Sweden. The study revealed a very similar result for all 4 study sights with households preferring a supporting only moderate lifestyle changes for example in the respective food habits. The authors conclude that considerable lifestyle changes, necessary for example to achieve the Paris 2015 Climate Targets, would require major policy adjustments that support inter alia the change of mobility patterns [102]. The aim of low-carbon city development is to create and put into practice city construction and social development models that will help to reduce carbon emissions under the premise of ensuring continuous improvements to the quality of life, whether it is economic development [103], consumption or transformation of lifestyle. When the different departments of cities attempt to cooperate and make rational use of natural resources and reduce carbon emissions, it will not only contribute to sustainable urban development but will also benefit individuals. As for now, there is still a long way to go to change people's high-carbon behaviours.

5. Conclusions

This systematic review contributes to the ongoing scientific debate on the relationship between public awareness and low-carbon behaviour from an interdisciplinary perspective taking the public's role in low-carbon city transformation in China as a case in point. Based on the identfied literature, we reviewed the low-carbon behaviour that will contribute to the transformation of low-carbon cities, which in turn will guide the public to better understand low-carbon life and to participate in low-carbon activities. We also pointed out the factors affecting the public's view of change in their traditional behavior.

As this paper is focused on the current scientific knowledge regarding public awareness and people's behaviour, and low-carbon city transformations in China, it does not

analyse people's attitudes and behaviour about carbon emissions in other countries. As people's awareness and behaviour are different because of culture, education and economic conditions, our conclusion may not be transferable to other countries or contexts, although it can still be used as a reference. In addition, this research will have limited contribution to disciplins such as Physics, Chemistry, Mathematics, Agricultural and Biological sciences, Engineering and Medicine because we investigate articles coming from Environmental and Social Science, Economics, Business and Management, Psychology, Ethics, Behavioural Science and Tourism, following our research questions and aims.

Our research indicates that there is still a need for further research on the relationship between public perception and low-carbon city development in China. Furthermore, our research reveals the need for future research on the following topics: (1) understanding the critical role of media for enhanced public low-carbon awareness; (2) regional differences affecting people's low-carbon behaviour; (3) the relationship between "happiness" and low-carbon development; and (4) what the specific effect of large or small numbers of migrants is on low-carbon city transformation.

This article has both theoretical and practical contributions to low-carbon city transformation. In terms of theoretical aspects, China advocates the transformation to low-carbon cities and still needs further concepts and theories to guide and educate residents and local authorities about low-carbon conception and low-carbon consumption in order to allow for them to participate. In addition, this study contributes to the knowledge on the current status of public awareness on low-carbon city transformation in China, and the role of public participation in a low-carbon city. As for practical contributions, this article will assist more consumers to better understand the importance of changing high-carbon behaviour, and what they can do to cope with climate change and their city's transformation.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su141610121/s1. The Excel spreadsheet including related tables and figures is in Sheets S1–S8.

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