How Socio-Technical Landscape Can Innovate Energy Transitions in Cities? A Conceptual Framework

Usman Sattar

Department of Social Work, College of Law and Political Science, Zhejiang Normal University, Jinhua (321004), Zhejiang, P. R. China

***Abstract*—This paper provides a conceptual frame that how socio-technical landscape components of the Multilevel Perspective can stimulate energy transitions in cities by taking a case of Beijing city. It adopts a theoretical coding method with the help of a methodical literature review to define the main sectors of energy consumption/carbon emission and socio-technical landscape components in a coherent way to support energy transitions. The recurring strands of the main sources of carbon emission—local and regional transportation, coal combustion, industrial production, fugitive dust, and others, are described first. Lately, the main factors of socio-technical landscape—political support, macro-economic trends, spatial structure, demographic trends, media, and societal values, are described as a framework of multi-sectoral cooperative interplay to minimize energy consumption, carbon emission, and improving the air quality of the city. The study intends to illuminate the pathways of energy transitions for urban planners and policy makers to make our urban localities even more resilient and a sustainable.**

***Keywords*—urban planning, innovative landscape, sustainable development, energy consumption**

I. INTRODUCTION

Climate change issues are alarming the global world that we develop our societies in a way that we could sustain it in the long run. Our development patterns and population dynamics are posing mounting threats for all of us. People are shrinking in urban areas all over the word. That's why cities are important turning points to realize sustainable development agenda [1]. Our population increase and urban development patterns especially in the developing world can play a decisive role in leading us toward a sustainable future. Beijing is the capital city of the fastest growing economy in the world—the People's Republic of China. This study takes

Beijing as a case, and studies its main sources of energy consumption and carbon emission sectors. Furthermore, it takes a panorama view of the emission sectors with the help of a theoretical lens—multilevel perspective (MLP)[2]. The study only studies the landscape components of the Beijing city and defines that how mainstream six components of the MLP can potentially reduces carbon emission from six main sectors of carbon emission in cities.

II. RESEARCH METHOD

A methodic literature review with theoretical coding method is undertaken to conduct this study [3], [4]. In the context of the study purposes, many theoretical frameworks are already available. For example, structuration theory appropriately responds to the complex processes leading to the formation of specific practices, and systems, by giving more attention to 'structure and agency' [5], [6]. New urbanists suggest principles of sustainable urban design to create a carbon neutral and durable urban form by focusing on spatial arrangements [7], [8]. Social practice theorists are similarly interested in the formation and transformation of social practices within a specific socio-spatial context [9], [10]. The capacity building of such an environment-pro systematic change is also in the heart of socio-ecological systems (SES), which discuss the dynamic processes of human interaction with nature [11]–[13]. A significant number of studies have adopted these theories to explain the agenda of urban sustainability. However, this study is guided by the MLP framework[2], [14]–[18].The study confines potential capacities of Beijing into a framework for transforming the consumption patterns at the landscape level. The diverse capacity components, together with potential agents and their interventions, are given for a categorical and systematic understanding of capacities to reshape the existing patterns of carbon emission [19]. At first, this work segregated the research findings of different scholars/studies broadly into a specific *level* of incubation—landscape component (LC). Later on, different research works are coded and shaped into different subject areas and specific components to work on. Lastly, reoccurring points are framed in guiding principles to work on for a sustainable development in Beijing.

III. RESULTS

The study finds six socio-technical landscape components to work on for transforming the ongoing main sources of carbon emission in Beijing.

Table 1. Landscape Components

LC.1	Political ideology
LC.2	Spatial structure
LC.3	Macro-economic trends
LC.4	Demographic trends
LC.5	Media landscape
LC.6	Societal values

Table 2. Subjects and Multi-Level Capacity Components for CO_2 Reduction

Year	Ref.	Subject area	Landscape Components (LC)					
			1	2	3	4	5	6
2016	[21]	General			•			
2016	[22]	General		•				•
2016	[19]	General	•		•	•		
2016	[23]	General	•					•
2017	[24]	Transport		•	•	•		
2017	[25]	Transport			•	•		
2017	[26]	Transport	•	•	•	•		
2016	[27]	Energy		•		•		•
2015	[28]	Energy			•			
2017	[29]	Energy			•	•		
2017	[30]	Market						
2015	[31]	Market	•				•	•
2015	[32]	Market						•
2016	[33]	Lifestyle						•
2016	[34]	Lifestyle						•
2015	[35]	Lifestyle					•	•
2016	[36]	Industry		•		•		
2016	[37]	Industry		•	•			•
2015	[28]	Industry	•		•			
2016	[27]	Spatial		•	•	•		
2015	[38]	Spatial		•		•		
2003	[39]	Spatial	•			•		•

1. (LC.1) Political Support

Beijing's political insights about handling environmental issues are apparent from the acknowledgment of commitments in the Paris Accord, recently [40]. No doubt the vision in 1949—the socialist ideology with Chinese characteristics—has led Beijing from consumption to a production city followed by remarkable developments [39], [41], [42]. Furthermore, researchers[37], [43] reiterate to adopt long-term balanced growth by paying equal attention to cleaner production technologies, transforming industries, and changing construction practices to minimize energy consumption, ambient air pollution, and dust pollution in Beijing. The city vows to work on "Socialist Eco-civilization" to transform socio-ecological systems into more sustainable one [44].

2. (LC.2) Spatial Structure

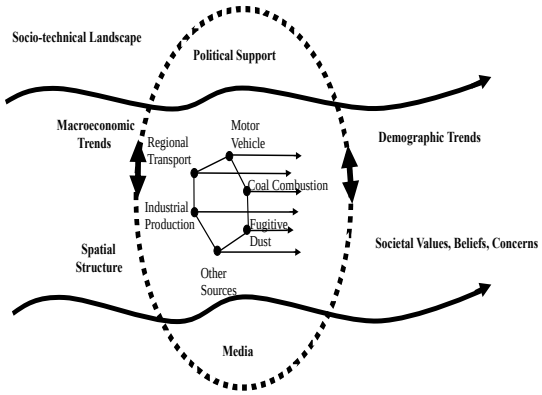
Beijing should retain only core functions of political institutions, cultural, and international exchange centers for scientific and technological innovation, and evacuate highly energy-intensive industries, such as iron, steel, building materials, metals, textile, chemical, papermaking, and printing from city areas [45]. Yang [27] suggests three spatial dimensions for taking into consideration for urban planning. First, the structure of buildings should be constructed in a way that maximum daylight could access inside the building's premises. Second, green spaces in neighborhoods have the potential for energy saving and, third, urban planners should consider the elements of a better socio-spatial match. Beijing is still undergoing settlements in suburbanization areas, whereas most of the public services are located in inner-city areas. Such a mono-centric form of urban sprawl has created a job-housing spatial mismatch. Ma [46] found a job-housing spatial mismatch as a primary factor for promoting car use, and suggested mixed land use, convenient approachability to public transport, and nearness to workplaces may lead to green travel behavior. Batterman [47] recommends vegetation and precipitation mechanisms, such as wash-out and rain-out, can reduce concentration in the air, and surface wetting can inhibit surface dust from roadsides and fields [48]. Mulch, airstream disruption, and spray-on soil chemical treatment are useful methods to mitigate fugitive dust concentration. Hence, the installation of water sprinkler systems on road surfaces, improving drainage structure for paved roads, and controlling vehicles' speed can reduce road dust emission. These measures have little impact on GDP, require no cost to industry, and limited technological barriers to reduce emissions in the city [49].

3. (LC.3) Macro-Economic Trends

The mainstream macroeconomic patterns have much to do in Beijing. It is a big challenge to improve the air quality of the city without compromising the economic growth of developing people. In this study area, scientific inquiries are urged. Chen [25] confirms the direct relationship of economic growth (per capita GDP) with increasing carbon emission, and it affects CO_2 emission indirectly by increasing motor vehicles [50]. They urgeto inhibit the rate of carbon emission by diminishing energy intensity from transport sector directly, and transport intensity indirectly. Beijing needs to realize its commitment (LC1) for environmental sustainability in a practical way by relinquishing inconvenient patterns of economic growth, and by promoting comprehensive endeavors in favor of ecological health of the city [26]. Beijing needs to transform its landscape arrangements to resolve the issue of built-infrastructure (LC2) that requires not only investment, but time and patience. A comprehensive strategy needs to revise laws and regulations, provisions of

permits to traders to set a healthy direction of market trends in the city.

Figure 1. Socio-technical landscape components and carbon emission factors in Beijing



4. (LC.4) Demographic Trends

Beijing has always been facing a growing number of migrants. A massive flow of people is still seeking settlements in the city, which is the root-cause of environmental hostility in Beijing. Researchers [45], [51] suggest controlling population size, which is already on the agenda and, therefore, population growth showed a changing curve from rapid growth (2.9%) to slow growth (0.9%) in 2015. A recent study [26] suggests improving the quality of current population—educating people for playing their due role to enhance environmental situation by using clean energy and limiting transportation intensity in daily life [25]. Beijing can improve the urbanization process by refining the household registration system, improving quality of local citizens, defining the rate of population rise, and distributing the population in a rational way appropriate to the spatial structure and the overall environment of the city [26], [52].

5. (LC.5) Media

Since 2001, after joining the WTO, the commercialization of the media has gained significance in opinion-making[53]. Sina-Weibo (a social media application) remained useful for timely information about the emergency situation in Beijing [54]. During the Olympics in 2008, local media successfully crystallized eco-friendly norms among people, which confirm the media's ability to ingrain eco-friendly consumption lifestyles in the long-term, as well [55]. Another aspect highlighted by [56] is the element of confidentiality that usually there is limited access to macro level travel surveys, which restrict scientific inquiries to improve the environmental situation. Beijing's government can publish large surveys to encourage scientific inquiries. Moreover, increasing public awareness about causes and consequences of CO_2 emission can help alternative lifestyles/practices. The advertisement of success stories of other cities that have previously been minimized air pollution in the past, can further adjust public trend to adopt low-carbon lifestyles. Celebrities can support in promoting low-carbon lifestyles, by nudging public opinion [57].

6. (LC.6) Societal Values

The mitigation report of IPCC informs that social practices, people's lifestyle, and cultural forces have a significant influence on energy consumption and potentially useful for sustainability transitions [33]. The initiatives for sustainability transitions should not only concentrate on consumer behavior, but also their contexts or needs within which those practices are formed [58]. Air quality issues are man-made. Focusing on people's lifestyles, [45] suggests enhancing the quality of peoples' behavior by raising awareness through human development programs. Nudging is an effective way for shaping choice direction if customized by a judicious choice architecture [34].

Table 3. Conceptual Framework of Capacity Components at Landscape Level

Components	Actors	Interventions	Ref.
LC.1 Political support	Government bodies	long-term optimal decision making, setting new metrics of measuring progress	[60] [26] [28] [43]
LC.2 Spatial Structure	Real estate builders, construction regulatory bodies, city planners	Buildings with better daylight environment, thermal insulation structure and decentralized heating system.	[27] [56] [46] [38]
LC.3 Macroeconomic Trends	Economic think tanks, advisory committees	Optimize economic targets through circular economy approach	[26] [27] [52]
LC.4 Demographic Trends	Household registration management	optimize population size with city's capacity.	[53]
LC.5 Media	Television channels and hosts, marketing agencies	Promoting low-carbon practices, cleaner technologies	[53]
LC.6 Societal Values	Education and community leaders	Intervening in societal norms, MOA model for a sustainable direction—nudging.	[59] [34] [58]

Another study [59]proposed a motivation, opportunity, and ability (MOA) model for shaping community behavior in a sustainable direction. The mindset of people can potentially be fabricated by group activities and role models, which direct sustainable green choices for food, shopping, and energy consumption. Therefore, the socio-spatial architecture of shared values, beliefs, and other societal concerns should be carefully adjusted to intervene in consumption practices.

IV. CONCLUSION

Landscape components propose a long-term economic-environmental planning ingrained in political insights, the

transformation of spatial structure—renovate buildings for better daylight interiors, green surrounding community areas built by real estate builders, and optimizing macro-economic targets with circular economy approaches for minimizing carbon emissions in cities. The study realizes the importance of innovative energy research in the context of social sciences to save human–environment coupled systems from the devastating effects of CO_2 emission in cities.

Following MLP as a baseline for socio-technical transitions, this study considers "six sectors" of $PM_{2.5}$ emissions [19]—transport, coal combustion, industrial production, fugitive dust, and other sources "as regimes" of CO_2 emission in Beijing. The study provides a framework underlying city's transformative capacity to deal with the environmental pollution at the landscape level. Following the research gap [23], [60], this study frames non-linear strands of multilevel capacity components, subjective domains, agents, and their interventions into an integrated framework. The framework provides a holistic orientation to urban stakeholders—planners, organizers, leaders, and controllers—by referring to potential adjustment strategies relevant to their specific area of work for a resilient and sustainable urban development.

ACKNOWLEDGEMENT

This study is adapted from the author's Ph.D. work submitted to the School of Sociology and Political Science, Shanghai University, Shanghai. P.R. China.

REFERENCES

[1] UN and United Nations, "The Sustainable Development Goals Report," 2017.
[2] F. W. Geels, "Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study," *Res. Policy*, vol. 31, no. 8–9, pp. 1257–1274, 2002.
[3] J. Saldana, *The Coding Manual for Qualitative Researchers*, 2nd ed. SAGE Publications, Inc., 2013.
[4] H. Joshi, "Social Research Methods (4th Edition) by Alan Bryman," *Abhigyan VO - 32*, no. 4, p. 77, 2015.
[5] M. Jones and H. Karster, "Gidden's Structuration Theory and Information Systems Research," *MIS Q.*, vol. 32, no. 1, pp. 127–157, 2008.
[6] E. H. Kennedy, M. J. Cohen, N. T. Krogman, E. H. Kennedy, and N. Krogman, "Social practice theories and research on sustainable consumption THE SOCIAL ORGANIZATION OF ENVIRONMENTAL ISSUES Social practice perspectives provide a unique and powerful lens through," *Røpke*, vol. 1, no. Standing, pp. 3–22, 2013.
[7] K. Kullmann, "Grounding Landscape Urbanism and New Urbanism," *J. Urban Des.*, vol. 20, no. 3, pp. 311–313, 2015.
[8] R. Weller, "Landscape (Sub)Urbanism in Theory and Practice," *Landsc. J.*, vol. 27, no. 2, pp. 255–278, 2008.
[9] G. Spaargaren, "Theories of practices: Agency, technology, and culture. Exploring the relevance of practice theories for the governance of sustainable consumption practices in the new world-order," *Glob. Environ. Chang.*, vol. 21, no. 3, pp. 813–822, 2011.
[10] a. Warde, "Consumption and Theories of Practice," *J. Consum. Cult.*, vol. 5, no. 2, pp. 131–153, 2005.
[11] C. Azar, J. Holmberg, and K. Lindgren, "Socio-ecological indicators for sustainability," *Ecological Economics*, vol. 18, no. 2. pp. 89–112, 1996.
[12] A. Smith and A. Stirling, "Social-ecological resilience and socio-technical transitions: critical issues for sustainability governance," *Bright. STEPS Cent. Work. Pap.*, vol. 8, no. 8, pp. 1–25, 2008.
[13] F. R. Westley *et al.*, "A theory of transformative agency in linked social-ecological systems," *Ecol. Soc.*, vol. 18, no. 3, 2013.
[14] F. W. Geels, "Multi-Level Perspective On System Innovation: Relevance For Industrial Transformation," in *Understanding Industrial Transformation*, 2006, pp. 163–186.
[15] F. W. Geels, "A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies," *J. Transp. Geogr.*, vol. 24, pp. 471–482, 2012.
[16] F. W. Geels, "The multi-level perspective on sustainability transitions: Responses to seven criticisms," *Environ. Innov. Soc. Transitions*, vol. 1, no. 1, pp. 24–40, 2011.
[17] F. W. Geels, B. K. Sovacool, T. Schwanen, and S. Sorrell, "The socio-technical dynamics of low-carbon transitions," *Joule*, 2017.
[18] F. W. Geels, B. K. Sovacool, T. Schwanen, and S. Sorrell, "Sociotechnical transitions for deep decarbonization," *Science (80-.).*, vol. 357, no. 6357, pp. 1242–1244, 2017.
[19] H. Zhang *et al.*, "Air pollution and control action in Beijing," *Journal of Cleaner Production*, vol. 112. pp. 1519–1527, 2016.
[20] M. Hodson, F. W. Geels, and A. McMeekin, "Reconfiguring urban sustainability transitions, analysing multiplicity," *Sustain.*, vol. 9, no. 2, 2017.
[21] L. Zhao *et al.*, "How to achieve low/no-fossil carbon transformations: With a special focus upon mechanisms, technologies and policies," *J. Clean. Prod.*, pp. 1–9, 2016.
[22] A. Martos, R. Pacheco-Torres, J. Ordóñez, and E. Jadraque-Gago, "Towards successful environmental performance of sustainable cities: Intervening sectors. A review," *Renewable and Sustainable Energy Reviews*, vol. 57. pp. 479–495, 2016.
[23] P. J. Vergragt, L. Dendler, M. de Jong, and K. Matus, "Transitions to sustainable consumption and production in cities," *J. Clean. Prod.*, vol. 134, Part, pp. 1–12, Oct. 2016.
[24] Y. Jin *et al.*, "Environmental impacts of transformative land use and transport developments in the Greater Beijing Region: Insights from a new dynamic spatial equilibrium model," *Transp. Res. Part D Transp. Environ.*, vol. 52, pp. 548–561, 2017.
[25] W. Chen and Y. Lei, "Path analysis of factors in energy-related CO2 emissions from Beijing's transportation sector," *Transp. Res. Part D Transp. Environ.*, vol. 50, pp. 473–487, 2017.
[26] F. Fan and Y. Lei, "Factor analysis of energy-related carbon emissions: A case study of Beijing," *J. Clean. Prod.*, 2015.
[27] Z. Yang, Y. Fan, and S. Zheng, "Determinants of household carbon emissions: Pathway toward eco-community in Beijing," *Habitat Int.*, vol. 57, pp. 175–186, 2016.
[28] J. Wei, K. Huang, S. Yang, Y. Li, T. Hu, and Y. Zhang, "Driving forces analysis of energy-related carbon dioxide (CO2) emissions in Beijing: An input-output structural decomposition analysis," *J. Clean. Prod.*, 2015.
[29] X. Zhu and R. Li, "An Analysis of Decoupling and Influencing Factors of Carbon Emissions from the Transportation Sector in the Beijing-Tianjin-Hebei Area, China," *Sustainability*, vol. 9, no. 5, p. 722, 2017.
[30] Z. Mao, S. Zhang, and X. Li, "Low carbon supply chain firm integration and firm performance in China," *J. Clean. Prod.*, vol. 153, pp. 354–361, 2017.
[31] D. Yang, Y. Lu, W. Zhu, and C. Su, "Going green: How different advertising appeals impact green consumption behavior," *J. Bus. Res.*, vol. 68, no. 12, pp. 2663–2675, Dec. 2015.
[32] A. S. Binninger, N. Ourahmoune, and I. Robert, "Collaborative consumption and sustainability: A discursive analysis of consumer representations and collaborative website narratives," *J. Appl. Bus. Res.*, vol. 31, no. 3, pp. 969–986, 2015.
[33] K. Schanes, S. Giljum, and E. Hertwich, "Low carbon lifestyles: A framework to structure consumption strategies and options to reduce carbon footprints," *J. Clean. Prod.*, vol. 139, pp. 1033–1043, 2016.
[34] M. Lehner, O. Mont, and E. Heiskanen, "Nudging – A promising tool for sustainable consumption behaviour?," *J. Clean. Prod.*, vol. 134, pp. 166–177, 2016.
[35] J. S. Brooks and C. Wilson, "The influence of contextual cues on

the perceived status of consumption-reducing behavior," *Ecol. Econ.*, vol. 117, pp. 108–117, Sep. 2015.
[36] B. Xu and B. Lin, "Reducing carbon dioxide emissions in China's manufacturing industry: A dynamic vector autoregression approach," *J. Clean. Prod.*, vol. 131, pp. 594–606, Sep. 2016.
[37] Y. Li, R. J. S. Beeton, T. Sigler, and A. Halog, "Modelling the transition toward urban sustainability: A case study of the industrial city of Jinchang, China," *J. Clean. Prod.*, vol. 134, pp. 22–30, 2016.
[38] Z. Wang, Z. Zhao, B. Lin, Y. Zhu, and Q. Ouyang, "Residential heating energy consumption modeling through a bottom-up approach for China's Hot Summer–Cold Winter climatic region," *Energy Build.*, vol. 109, pp. 65–74, Dec. 2015.
[39] C. Gu and J. Shen, "Transformation of urban socio-spatial structure in socialist market economies: The case of Beijing," *Habitat Int.*, vol. 27, no. 1, pp. 107–122, 2003.
[40] S. K. Mahapatra and K. C. Ratha, "Paris Climate Accord: Miles to Go," *J. Int. Dev.*, vol. 29, no. 1, pp. 147–154, 2017.
[41] K. F. Lim, "'Socialism with Chinese characteristics': Uneven development, variegated neoliberalization and the dialectical differentiation of state spatiality," *Prog. Hum. Geogr.*, vol. 38, no. 2, pp. 221–247, 2013.
[42] Z. Yang, J. Cai, H. F. L. Ottens, and R. Sliuzas, "Beijing," *Cities*, vol. 31, pp. 491–506, 2013.
[43] L. Zhang, B. K. Sovacool, J. Ren, and A. Ely, "The Dragon awakens: Innovation, competition, and transition in the energy strategy of the People's Republic of China, 1949–2017," *Energy Policy*, vol. 108, pp. 634–644, 2017.
[44] Q. Huan, "Socialist Eco-civilization and Social-Ecological Transformation," *Capital. Nat. Social.*, vol. 27, no. 2, pp. 51–66, 2016.
[45] F. Fan and Y. Lei, "Decomposition analysis of energy-related carbon emissions from the transportation sector in Beijing," *Transp. Res. Part D Transp. Environ.*, vol. 42, pp. 135–145, 2016.
[46] J. Ma, Z. Liu, and Y. Chai, "The impact of urban form on CO2 emission from work and non-work trips: The case of Beijing, China," *Habitat Int.*, vol. 47, pp. 1–10, 2015.
[47] S. Batterman, L. Xu, F. Chen, F. Chen, and X. Zhong, "Characteristics of PM2.5 concentrations across Beijing during 2013–2015," *Atmos. Environ.*, vol. 145, pp. 104–114, 2016.
[48] L. Yu *et al.*, "Characterization and source apportionment of PM2.5 in an urban environment in Beijing," *Aerosol Air Qual. Res.*, vol. 13, no. 2, pp. 574–583, 2013.
[49] J. Meng *et al.*, "Potential health benefits of controlling dust emissions in Beijing," *Environ. Pollut.*, vol. 213, pp. 850–859, 2016.
[50] X. Luo, L. Dong, Y. Dou, H. Liang, J. Ren, and K. Fang, "Regional disparity analysis of Chinese freight transport CO2 emissions from 1990 to 2007: Driving forces and policy challenges," *J. Transp. Geogr.*, vol. 56, pp. 1–14, 2016.
[51] B. Guo, Y. Geng, B. Franke, H. Hao, Y. Liu, and A. Chiu, "Uncovering China's transport CO2 emission patterns at the regional level," *Energy Policy*, 2014.
[52] H. Fang *et al.*, "Does migration limit the effect of health insurance on hypertension management in China?," *Int. J. Environ. Res. Public Health*, vol. 14, no. 10, pp. 1–12, 2017.
[53] A. L. Huang, "Beijing: A media capital in the making," *Chinese J. Commun.*, vol. 5, no. 2, pp. 178–193, 2012.
[54] Y. Wang, T. Wang, X. Ye, J. Zhu, and J. Lee, "Using Social Media for Emergency Response and Urban Sustainability: A Case Study of the 2012 Beijing Rainstorm," *Sustainability*, vol. 8, no. 1, p. 25, 2016.
[55] A. P. J. Mol, "Sustainability as global attractor: The greening of the 2008 Beijing Olympics," *Glob. Networks*, vol. 10, no. 4, pp. 510–528, 2010.
[56] J. Ma, A. Heppenstall, K. Harland, and G. Mitchell, "Synthesising carbon emission for mega-cities: A static spatial microsimulation of transport CO2 from urban travel in Beijing," *Comput. Environ. Urban Syst.*, vol. 45, pp. 78–88, 2014.
[57] J. J. Chriss, "Nudging and Social Marketing," *Society*, vol. 52, no. 1, pp. 54–61, 2015.
[58] F. W. Geels, A. McMeekin, J. Mylan, and D. Southerton, "A critical appraisal of Sustainable Consumption and Production research: The reformist, revolutionary and reconfiguration positions," *Glob. Environ. Chang.*, vol. 34, pp. 1–12, Sep. 2015.
[59] J. I. J. C. de Koning, T. H. Ta, M. R. M. Crul, R. Wever, and J. C. Brezet, "GetGreen Vietnam: towards more sustainable behaviour among the urban middle class," *J. Clean. Prod.*, vol. 134, no. Part A, pp. 178–190, 2016.
[60] D. O'Rourke and N. Lollo, "Transforming Consumption: From Decoupling, to Behavior Change, to System Changes for Sustainable Consumption," 2015.