The Roles and Synergies of Actors in the Green Building Transition: Lessons from Singapore

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Abstract: Transforming the building sector toward sustainability based on green building (GB) technologies is a multi-faceted, multi-actor process of socio-technical transition. Understanding the different roles of primary actors in both technological and non-technical dimensions of GB transition is pivotal for effectively engaging multiple GB stakeholders during this process. However, relevant research is rare in the GB literature. This paper conducts an actor analysis based on a conceptual framework constructed on the actor and power relation typology from the multi-actor perspective approach and regime insights from the multi-level perspective theory. A qualitative case study of Singapore is adopted to exemplify the roles of the government, developers, citizens and NGOs, determined by their respective power and multi-actor power relations, and to evaluate their synergetic influence on the technological, social and governance dimensions of the GB transition. It was found that the government leads all three dimensions of GB transition and it has an indirect impact on promoting the technological transformation and social adaption by synergizing the other three actors. As the intermediary between government and non-government actors, NGOs indirectly influence GB transition by primarily assisting the government. Developers and citizens directly contribute to technological transformation and social adaption, respectively, and they have an indirect impact on the opposite dimensions through interacting with one another. We argue that a successful GB transition entails synergies from multi-actor interactions and the interplay of technical and non-technical development. This paper offers a heuristic framework for multi-actor analysis in the multi-faceted GB transition and generates policy lessons for other cities.

Keywords: green building transition; actors; multi-actor perspective; Singapore

1. Introduction

Cities are situated at the forefront of sustainable development and act as the main sites and sources of environmental problems. The urbanization process often causes climate change and environmental degradation. It is evidenced that a high urban population generally comes with large per capita energy consumption and carbon emissions (Figure 1). Meanwhile, cities, as the hubs for investments, partnerships, education and culture—owing to their larger size and number of public, economic and civil society institutions—bear large potential to promote sustainable urbanization and low-carbon transitions [1]. Within cities, the building sector is among the largest contributors to resource consumption and carbon emissions. It is reported that the building sector accounted for 35% of the total energy consumption and 38% of all energy-related CO₂ emissions in 2019 [2]. Hence, transforming the building sector toward being more low carbon and environment friendly is a crucial step in sustainable urbanization.
Green building (hereinafter called GB) encompasses a vast array of building practices and technological innovations that make buildings more sustainable and pro-environment [1,3]. It has been recognized as an effective technological instrument for greening the physical environment and ultimately realizing the sustainability transition of the building sector. Various GB certification schemes are now in the marketplace worldwide to promote GB adoption in the construction industry, including Green Mark in Singapore, LEED in the United States, BREEAM in the United Kingdom and China 3 Star. From the socio-technical transition perspective, the building sector’s transition toward sustainability based on GB technologies is a multi-faceted, multi-actor socio-technical transition process [3]. The GB
transition goes beyond technological development and entails other non-technological changes (e.g., institutional and social change) [3,4]. This requires the wide engagement of multiple stakeholders. Thus, understanding the different roles of major actors in both the technological and non-technological dimensions of GB transition is pivotal for the effective engagement of multiple GB stakeholders during this process.

Prior studies contribute to some useful discussion on identifying and clustering the major stakeholders in GB development and they analyzed different roles and contributions of different GB stakeholders in GB development (see, for example [4–6]). However, a substantial body of relevant literature does not have actors as a primary research focus, although actors are somewhat implicated in the research. There is a lack of in-depth, structured investigation of actors and their interactions and many relevant studies appear to focus on the respective roles of different stakeholders. Second, the existing analyses of GB actors often focus on the actors’ roles in the technological development and overlook how actors influence the non-technological dimensions of GB development in different ways. Third, the important roles of citizens and NGOs receive less attention in the literature than government bodies and industry players.

Motivated by the research gaps, this paper aims to investigate the different roles of GB actors in multiple dimensions of GB transition and evaluate their influences. We first draw on the actor and power relation typology from the multi-actor perspective approach (MaP) and the insights regarding transition regime from the multi-level perspective (MLP) theory to construct a conceptual framework. Based on the conceptual framework, we structure a qualitative case study to empirically analyze the roles and synergies of four incumbent actors in the technological transformation, social change and governance support of the socio-technical regime. Singapore is selected as the case study, because, as a city-state with a high level of per capita energy consumption and carbon emissions (shown in Figure 1), it exemplifies success in sustainable urbanization and GB development and it is positioned as Asia’s greenest city [7].

Other than the previous studies, this paper specifically contributes to a structured understanding of the inherent “multi-actor” nature of GB transitions, by examining the different roles of four representative GB actors and their influences on GB transition. To the best of our knowledge, this research is among the earliest papers applying the transition approaches to the actor analysis in GB development. Moreover, this paper touches on the interplay of technology, socio-culture and governance in the GB development process, rather than the one-fold technology dimension, deepening our understanding of GB development as a deep-structured and multi-faceted transformation of the building sector. The findings offer practical lessons and policy implications for Singapore and other cities in terms of how to achieve GB transition by effectively synergizing various actors.

The remainder of this article proceeds as follows: Section 2 presents the literature review; Section 3 introduces the conceptual framework, hypotheses and methodology; Section 4 presents the results, through detailed analysis on the roles and synergies of actors in the socio-technical regimes; Section 5 presents the discussion; and Section 6 provides the conclusion.

2. Literature Review

GB transition, as a type of socio-technical transition focused on sustainability, involves reconfiguring different socio-technical sub-systems, which entails interactions between various actors, agents and stakeholders in a society [8]. A GB project is a complex system involving multiple stakeholders who interact to different extents and have various conflicting objectives [5]. The stakeholders, including both government and non-profit and private sector actors, are agents of change in GB initiatives [3]. Their participation and collaboration are fundamental for a successful GB development [3,4,6].

Previous studies contribute to some useful discussion on identifying and clustering the major stakeholders in GB development. In a literature review on the stakeholder studies of green buildings, it is revealed that primary stakeholders, including clients, contrac-
tors, buyers, government and designers, are the main focus of current research, which, to some extent, demonstrates their higher levels of impact on successfully implementing GB projects [6]. After reviewing the academic literature on green building drivers, Darko et al. [9] summarized that architects, construction units, clients, engineers and developers are the major stakeholders in previous GB driver studies. Based on quantifying the stakeholder influence in decisions/evaluations relating to sustainable construction in China, Li et al. [10] found that the government is the most influential entity in sustainable construction followed by owners and end-users. They also point out that the NGO is listed at the bottom, signifying the need to empower NGOs to fulfill this responsibility of ensuring a credible process and acceptable outcome.

Different roles and influences of multiple GB stakeholders in GB development have been analyzed in previous studies. Based on a case study of a commercial GB project in Hong Kong, Mok et al. [5] found that some industry players—such as client, project development team, executive project manager, lead design consultant and main contractor—are powerful and influential stakeholders that play a critical role in providing information and stakeholder communication, while local government and district councils are generally peripheral actors that fulfill an advisory role and have passive involvement in the project. Gibbs and O’Neill [11] focus on the green entrepreneurs in the GB sector, referring to the private sector’s small- and medium-sized enterprises, such as consultants, builders, architects and building material suppliers, and their roles in the transition toward a green economy as system builders and agents of change. In his Singapore-based study, Han [4] suggested that the leading and steering role of government is key to the success of its GB development and it is conducive to the effective implementation of a green urban initiative. In the study of Li et al. [12], the architectural, engineering and construction firms are the main players in the design and construction stages of building projects and, thus, they can significantly affect the environmental performance of building projects in Singapore. From an economics perspective, Zhang et al. [13] argued that developers and occupants, as the ultimate decision-makers of green building supply and demand in the GB market, are the two main market participants affecting the economic viability of GB development, while the government, due to the market failures in the sustainability area, play an important role in influencing GB market supply and demand, using a variety of sticks (e.g., mandates) and carrots (e.g., explicit or implicit subsidies).

However, several research gaps could be identified from the literature review. First, a substantial body of relevant literature does not have actors as a primary focus, although actors are somewhat implicated in the research. There is a lack of an in-depth, structured investigation of actors’ roles and interactions and many relevant studies appear to focus on the respective roles of the different stakeholders. Second, the existing GB literature prevalingly views GBs as technological innovations and real estate commodities and it often adopts economics and engineering approaches. Hence, previous studies analyze the roles of GB players in technological development and overlook how they influence the non-technological dimensions of GB development. Third, the important roles of citizens and NGOs receive less attention and discussion compared to government bodies and industry players.

3. Methodology
3.1. Conceptual Framework and Hypotheses

Motivated by the research gaps, we aim to investigate the different roles that GB actors play in the multi-faceted GB transition process as well as how they synergistically influence the GB transition. In this paper, GB development and GB actors are embedded within a transition system of the building sector and a wider system of actors rather than a reified lone building and specific individual. We refer to two heuristic frameworks of the MaP and MLP in socio-technical transitions to construct the conceptual framework for our analysis.

The MaP proposed by Avelino and Wittmayer [14] provides a typology for actors and multi-actor power relations and serves as a heuristic framework for systematically
and explicitly analyzing the complex diversity in the roles of different actors and their interactions. In the MaP, “actor” is defined as a social entity that is able to act [14]. MaP identifies four categories of actors: state, market, community and the third sector. The actor clusters differ in three sector features: (1) informal–formal; (2) for profit–non-profit; and (3) public–private. The state is characterized as non-profit, formal and public; the market is classified as formal as well but private and for profit; the community is classified as private, informal and non-profit; and, finally, the third sector is classified as an intermediary sector between the three others [15]. In this paper, we specifically focus on four typical and influential GB actors, the government (including its public agencies), real estate developers, citizens and GB-related non-government organizations (NGOs) at the level of sector rather than individual actors. They, respectively, represent the state, market, community and the third sector. Government, citizens (the ultimate consumers of GBs) and developers (real estate firms) have been commonly identified as three of the major stakeholders of GB in the literature, while the third sector receives less attention but is undoubtedly implicated in GB development revealed from prior studies. Developers are selected to represent the market actor for two reasons. First, they are ultimate decision-makers of green building supply [13]. Second, they often participate in the whole process of GB development, from planning to operation, and organize and coordinate most of the other industry players involved from different points in the value chain, such as architects, consultants, contractors and suppliers [16].

According to MaP, different actors exercise different types of power, defined as the capacity to mobilize resources to achieve a socio-technical transition [15]. The ‘horizontal’ typology of power relations in MaP distinguishes among three types of power relations between two actors: (1) A has power over B (i.e., A has the capacity to mobilize B as a resource; (2) A has more/less power than B to achieve something (i.e., A has the capacity to mobilize more or fewer resources than B); (3) A and B have a different kind of power (i.e., A has the capacity to mobilize resources in a different way than B does) [14]. The power relations affect the responsibilities and dependencies of these actors in the sustainability transition process [14,15]. Power and power relations matter to the “empowerment”, the process by which actors gain a sense of intrinsic motivation to engage in GB transition.

A GB transition goes far beyond the technological transformation and we aim to discover the actors’ roles and influences in both the technological and non-technological aspects of GB transition. Hence, we further incorporate the insights from the MLP theory proposed by Geels [17,18] to construct the conceptual framework. MLP differentiates the societal contexts of socio-technical transition according to three levels: niche, regime and landscape [17,19]. Within the context of GB transition, the niche level denotes the micro-scope innovations and practices regarding GB technologies. The socio-technical regime at the meso-scope refers to the incumbent building system defined by prevailing technologies, regulations, user patterns, the market situation, infrastructure and cultural discourses. The highest landscape level describes any exogeneous conditions at the macro-scope that shape and affect the building sector and GB development. The regime, capturing the meta-coordination between different technological and non-technological sub-regimes, is of primary interest among three levels, because transitions by nature are shifts from one regime to another [20,21]. Thus, we specifically analyze actors’ roles in the regime level of GB transition. Sustainability transitions entail socio-technical transformation and socio-political change [14,22]. We pay attention to three prevailing sub-regimes of GB transition, technology, socio-culture and governance.

The conceptual framework is presented in Figure 2. The regime is reified and visualized as a plane constituted by multiple layers, denoting that GB transition involves a variety of technological and non-technological sub-regimes. The actor mix is projected in three layers, illustrating the participation of four actors in the technology, socio-culture and governance sub-regimes. We follow this conceptual framework to structure our analysis of the roles of these four actors and their synergetic influences on the technological, social and
governance dimensions of GB transition. Based on the literature and conceptual framework, we raise two hypotheses:

**Hypotheses 1.** Due to different types of power and power relations between actors, four actors play different roles in the technological, social, and governance dimensions of GB transition.

**Hypotheses 2.** The state plays a central and leading role and it directly influences the GB transition; the private developers and citizens, as the ultimate decision-makers of GB supply and demand in the market, have a substantial impact on the technological and social development of GBs; as an intermediary sector between the other three, the GB-related NGOs play a mediating role in the GB transition.

### 3.2. Research Method and Study Area

This paper adopts a case study to address our research questions and test our hypotheses. This research applies the case study method for three reasons. First, case study is applicable when the research question considers “how” and “why” [23]. This research aims to create a thorough understanding of different actors’ roles in GB transition, particularly how they influence the GB transition, which is a “how” question. Second, qualitative case study research is a valuable tool for answering complex, real-world questions [24]. In this research, GB transition is a complex system and large-scale process, requesting a holistic, in-depth investigation within a real-world context. Third, case studies can reveal more details through multiple sources of data compared to experimental or quasi-experimental studies, where the data collection and analysis methods are known to obscure some details [25].

Singapore is chosen as the case study, because it is a role model for successful green urbanization and exemplary GB development worldwide [7]. Thus, the Singaporean case is unique and helpful for unearthing how actors drive a successful GB transition. We use the GB-related information and data combined with the academic evidence in the local context to construct a more comprehensive picture of Singaporean GB transition. The use of local GB-related information and data are reliable since they are mostly sourced from the official websites of government agencies, thereby ensuring internal validity of the analysis.

### 3.3. Introduction to GB Development in Singapore

As a city-state with a small landmass and lack of natural resources, Singapore has paid tremendous attention to its environmental sustainability since its foundation. Traced back to as early as the 1960s, the Singaporean government envisioned Singapore as a green and clean garden city and formally incorporated environmental sustainability goals into national planning [26]. In the 2000s, the government recognized the nexus between buildings and environmental sustainability and gradually integrated GB development into Singapore’s urban planning and governance based on the advancements of building
technologies over the last two decades. These lay the solid foundation for the structured GB transition in Singapore.

The Singapore GB transition officially started with the launch of the Green Mark (hereinafter called “GM”) scheme in 2005 as its own GB certification tool specifically tailored to its local climate and conditions \[4,26\]. The GM is a rating system designed to evaluate a building’s environmental impact and to recognize its sustainability performance for a variety of building types, setting detailed requirements for different indicators. The building project is awarded credits for meeting technical targets and the total sum of credits defines the award rating building project can obtain. From 2005 to 2021, the GM assessment criteria remained mostly unchanged during 2005 and 2016 and underwent major amendments after 2016. The comparison among three versions of GM criteria reveals that the Singaporean GB transition path became more holistic with an emphasis on social and human scope and post-occupancy performance (Table 1). The primary edition of GM assessment criteria (2005–2016) paid great attention to the physical building performance, especially for energy efficiency, indicated by 56% of the total maximum scores allocated to the energy efficiency category \[27\]. The 2016 edition attaches more importance to the human aspect of GB \[28\]. In 2020, after 15 years of development, the government systematically streamlined and consolidated the latest GM criteria into an all-in-one GM 2021 Framework, which holistically focuses on whole-life carbon, health and wellbeing, resilience, intelligence and maintainability \[29\].

| Version | Credit Categories | Award Ratings |
|---------|------------------|---------------|
| The version during 2005 and 2016 | (1) Energy Efficiency (2) Water Efficiency (3) Environmental Protection (4) Indoor Environmental Quality (5) Other Green Features and Innovations | Platinum, Gold Plus, Gold and Certified (in descending order) |
| The 2016 version | (1) Climate Responsive Design (2) Building Energy Performance (3) Resource Stewardship (4) Smart and Healthy Building (5) Advanced Green Efforts | Platinum, Gold Plus and Gold (in descending order) |
| The 2021 version | (1) Climate Responsive Design (2) Building Energy Performance (3) Resource Stewardship (4) Smart and Healthy Building (5) Advanced Green Efforts | Gold Plus or Platinum certification, or SLE (Super-Low Energy) certification. |

Since 2005, Singapore has gradually deepened the transformation of the building industry. First, the GB development was integrated into a whole-of-nation movement to advance Singapore’s national agenda on sustainable development in 2021, going far beyond the technological changes in the building sector. Second, beyond new and existing residential and non-residential buildings, the GM scheme comprehensively applies to different types of built environments, including parks, infrastructures, districts, rapid transit systems and even occupant-centric spaces within buildings, such as supermarkets, restaurants and healthcare facilities \[30\]. Third, as of the end of 2021, Singapore has over 4000 GM-rated building projects \[31\]. Further, 49% of Singapore’s buildings have been greened, which is equivalent to over 157 million m\(^2\) of gross floor area (GFA), exponentially
growing from 1.1 million m$^2$ in 2005. These successfully mark Singapore as a typical example of GB transition.

4. Results

Based on the conceptual framework, we empirically analyze how four influential GB actors contribute to the technological transformation, social adaption and transition governance in the socio-technical regime of GB transition, exemplified by the case study of Singapore’s GB development.

4.1. Technological Transformation

Technological transformation is undoubtedly the backbone for the socio-technical transition. The success of GB transition relies on the persistent technological evolution of GBs and the scale-up adoption and commercialization of GB. In Singapore, the solid technological development of GBs has substantially spurred the GB transition, which has been prompted by incremental advances in building technologies over recent years.

The Singaporean government is the forerunner in GB development, taking the lead in technological development by establishing the GM scheme and investing in R&D in GB technologies. First, it set a comprehensive technical agenda to steer the whole industry. The nationwide, voluntary GM scheme was established as an official, standardized benchmark for the whole building sector that developers can follow. Since its launch in 2005, the Singaporean government has regularly amended the official GM assessment to stay abreast of technological advancements. Along with the technical standard, the government provides corresponding technical support and consulting services, through cultivating a green workforce and investing in GB-related research and development (R&D) in both the public and private sectors [26]. The BCA Academy, an education and research arm of BCA, was established to train green building specialists [26]. Second, the government and its public agencies lead or fund the national and international sustainability-related research centers. A number of pilot R&D projects—for example, BCA’s flagship R&D project the Zero Energy Building (ZEB) in 2009—serve as living labs for experimenting with various green technologies and eco-features before market-wide diffusion [26].

Real estate developers, as the incumbent constructors in urban development and suppliers of the real estate market, are the primary force in the technological transformation of GB transition through their adoption and physical delivery of GBs. They have the capacity to mobilize multiple resources—such as people, assets, materials or capital—in the building sector. Some large-scale, leading firms in the Singaporean real estate market have proactively engaged in the GM scheme by greening their projects. Among them, City Developments Limited is the industry leader in GBs and the first to win the Green Mark Champion Award in 2008, a reward established by the government in recognition of the efforts of developers who constructed 50 projects awarded Gold and above [32]. Moreover, CapitaLand won over 130 Green Mark Awards for its properties and sites in Singapore by 31 December 2019 and 97% of CapitaLand’s existing offices, malls, integrated developments and serviced residences (by m$^2$) have achieved a green rating [33]. However, the Singaporean evidence empirically reveals that, overall, the Singaporean developers hesitate to go green due to several barriers to entry, such as high cost and project delay [31,32], despite the significant economic premiums of GBs in Singapore, as evidenced by the studies of Deng and Wu [17] and Heinzle et al. [33]. The evidence highlights two commonly seen lock-ins related to developers facing technological transformation: one is developers taking existing building practices for granted and legitimating the status quo; the other is the conflict between the private interest of for-profit developers and the public interest.

To address the developer-related lock-ins, the Singaporean government effectively increased developers’ intrinsic motivation to engage in the technological development of GB transition through the policy instruments of mandates and incentives. First, various economic incentives are offered to incentivize developers to take the first step in new green practices. For example, a SGD 20 million GM cash incentive scheme for new buildings (valid
from December 2006 to December 2009) was introduced to attract developers at the initial stage of GB development. The GM Gross Floor Area Scheme (April 2009 to April 2019) aims to encourage developers to opt for higher GM ratings (i.e., Platinum or Gold Plus). Multiple monetary incentives are also provided to spur building owners and developers to upgrade and retrofit their existing buildings for higher energy performance [34]. Apart from these tangible incentives, the government launched the BCA Green Mark Champion Award in 2008 to award outstanding developers for their significant green effort and strong commitment toward corporate social responsibility, indicated by a substantial number of Green Mark buildings at Gold rating or higher. This may reward developers with intangible marketing and branding benefits.

Second, the government enacted a groundbreaking mandatory regulation—that is, Building Control (Environmental Sustainability) Regulations—in April 2008 to more fiercely push the private sector to embark on GBs. All new buildings and existing buildings undergoing major retrofits with a GFA of 2000 m² and above are prescribed to satisfy the minimum sustainability requirements, which are equivalent to the technical criteria for obtaining the lowest award rating (i.e., Certified) from the voluntary GM scheme. Additionally, new projects in some selected strategic growth areas governed by the state are more strictly prescribed to opt for higher GM ratings (i.e., Platinum or Gold Plus). From January 2017 onwards, this mandatory minimum environmental sustainability regulation was extended to include existing buildings.

The combination of a voluntary GM scheme, mandates and both tangible and intangible incentives has positively spurred on the developers and accelerated the scale of GBs. However, these instruments are far from a panacea. We observe from the data that the mandatory GB policy has limited effectiveness in promoting private developers in Singapore. By enforcing the minimum GB requirement in the mandate, the government can effectively nudge developers to construct the lowest level of GBs (i.e., semi-GBs in Figure 2), but it can hardly motivate developers to proactively venture into greener certified buildings (i.e., cert-GBs in Figure 3). The majority of developers tend to adopt a passive stance and mostly just comply with minimum requirements, leading to a market shift from non-GBs to the lowest level of GBs. It is empirically evidenced that the incremental costs of GBs significantly hinder developers from constructing greener certified buildings that are more costly [35]. Only the large-scale, leading firms in the Singaporean real estate market are more proactive and pursued certified green building, both before and after the regulation. This finding is consistent with the Singaporean analysis by Van der Heijden [36], which reveals that opting for green is less appealing to medium- and small-sized enterprises, which have limited abilities. Therefore, the government cannot predominantly focus on big building owners, as their achievements might create a false impression that the GM scheme has produced spectacular results. Instead, small and medium developers require more support and empowerment from the government to increase the uptake of instances of “beyond compliance”.

The GB-related NGOs play their part by assisting the government in empowering the developers. Officially launched in October 2009, the Singapore Green Building Council (SGBC) is the primary influential NGO in GB transition [36]. As the third sector actor, the SGBC mediates between the government and developers in the technological arena. First, it offers technical reference for construction industry professionals in building products and services by establishing the Singapore Green Building Product (SGBP) Certification Scheme, which is a complementary support for the GM scheme. Moreover, it assists the government to organize the major industry and public anchor events (e.g., the annual Singapore International Green Building Conference) and regular industry seminars to increase awareness of the industry, so as to effectively motivate the engagement of developers and other industry stakeholders.

The above evidence reveals that, in order to successfully drive technological transformation, it is essential for the powerful and resourceful government to directly lead and steer the technical transition path. Based on its strong political, institutional and economic power
in the building regime, the government can exercise power over developers and NGOs and mobilize them as resources in driving the technological development of GBs. Second, developers make a direct contribution to the technological development of GBs through their adoption and physical delivery of GBs, based on their great capacity for resource mobilization in the building sector. Due to some lock-ins and market failures relevant to developers in this sustainability issue, it is necessary for governments to empower developers by providing technical support and using the policy instruments of incentives and mandates. Third, although NGOs are less powerful than governments, they share similar collective goals in terms of GB development (i.e., the power dynamic of “cooperation” under the “more/less power” power relation according to MaP [14]). Hence, positioned as a bridge between the government and developers, they could indirectly contribute to technological transformation by assisting the government with the empowerment process for developers.

Figure 3. The number of private residential building plan approvals between 2005 and 2019. Notes: data is sourced from the Real Estate Information System and the Building and Construction Authority website in Singapore. Cert-GB refers to the project certified with any GM award rating under the GM scheme. Semi-GBs are those projects that merely satisfy the minimum sustainability requirements prescribed by the 2008 mandatory regulations but are not certified by the GM rating system. The remaining projects are non-GBs. Some non-GBs, which have gross floor areas of less than 2000 m² and, thus, are not constrained by mandatory regulations, continued to emerge after the regulations.

4.2. Social Adaptation

As GB-related technologies and practices have become mainstream in the construction industry, GB adoption is no longer confined to technical and economic hurdles [37,38]. While technological innovations are the starting point and backbone for socio-technical transition, the fulfillment of sustainability goals and large-scale sustainability transitions requires change in the predominant norms, routines and habits in society [39]. The fundamental technological transition based on GB technologies counts on citizens’ conformance to new technologies; that is, the social adaption of civil society. The achievements of widespread social adaptation along with the technological advancements of GBs substantially contribute to the success of Singaporean GB transition.

In this dimension, the Singapore government still takes a lead in steering the social adaptation toward GBs, endowed with a traditional role in “inducing the social changes and direct behavioral changes in areas such as health, finance and climate change” [40]. Since NGOs have the potential to make a qualitative contribution to systemic social change [41], the government often embarks on a proactive program of public education and behavioral campaigns in collaboration with the SGBC. For example, Project Carbon Zero in 2009 was organized to nudge the energy-saving behavior of young children and students and the behavioral interventions effectively reduced the electricity consumption in the treatment group by 1.8% during the contest period [42]. Forming a public–private partnership,
SGBC has joined hands with leading organizations, such as IBM and the Ministry of Education (MOE), to launch Project Green Insights to raise awareness of energy efficiency in schools [36]. The synergy from the collaboration in these public events has successfully contributed to mobilizing citizen participation and enhancing social learning for the public.

The collective of the citizens (i.e., the civil society), as GB consumers and users, is a powerful social force that is able to exercise ideological and economic power to drive social change. In other words, as the influential agents in social adaptation, they have a direct influence on the social dimension. The evidence reveals that the civil society in Singapore has a high level of social awareness and acceptance of GBs, forming a sound social base, conducive to the steady progress in social change. In a public engagement survey conducted by the Singaporean government in 2020, close to 90% of over 5000 survey respondents had very good, good and neutral impressions of Singapore’s progress in GBs and 94% of over 5000 respondents were aware of the positive impact of green buildings and recognized them as a key strategy to fight climate change [43]. This survey shows citizens’ overall positive impressions of Singapore’s progress in GBs and a high level of public acceptance thereof. Citizens also have indirect influence on technological transformation. First, as consumer power gradually grows [44], citizens as GB consumers significantly determine GB demand and have substantial influences on GB supply. Moreover, individuals as building users significantly influence the actual building performance of GBs and the environmental effects of GBs, implicitly leading the technological advancement toward human-oriented user engagement. Therefore, citizens have an indirect impact on the technological transformation by interacting with developers. However, there still exists some social lock-in for citizens. In a Singapore-based on-site household survey conducted in 2018, among 632 residents living in seven GB projects and nineteen non-GB projects, only 46% of GB respondents were aware that they were living in a GB. This implies that the greenness of a building remains “a bonus rather than a necessity” for housing investors [45,46]. Hence, the conflict between the private interests of citizens and the public interest of society may impede people’s GB purchases and pro-environmental behaviors. Furthermore, it has been found that green buildings cannot be used as the designers intended, because occupants do not understand the principles of how these buildings function [47].

Due to the supply–demand and builder–user nexus between citizens and developers, Singaporean developers are implicated in the process and make an indirect contribution to social adaptation by interacting with citizens through their physical delivery of GBs. First, developers positively stimulate individuals’ GB consumption by enhancing the social performance and occupant experiences of GBs. Although the GB criteria in Singapore primarily focus on energy efficiency, especially before 2018, the empirical evidence in Singapore by Zhang and Tu [46] reveals that GB residents illustrate a higher level of satisfaction with their living environment compared to non-GB residents; thus, the social benefits of GBs matter more to Singaporean consumers than environmental benefits and GB residents value intangible green features (i.e., greenery, ventilation, indoor environments and waste facilities) over tangible green features (i.e., energy efficiency) in their living experience. These findings suggest that the social benefits of GBs are highly likely to compensate for the cost deficiency in GBs. However, it is also observed that these GB features are rarely advertised in the sales of GBs in Singapore. Second, developers implicitly contribute to reducing the negative behavioral impacts of individuals on building performance and to cultivating their pro-environmental behaviors based on the behavioral potential of GBs. The empirical evidence in Singapore reveals that residential GBs are effective at encouraging some pro-environmental daily tasks (e.g., recycling, purchasing energy efficient appliances, etc.) [46]. This is because, on the one hand, Singapore’s GBs are often equipped with “robust” green features (e.g., an automatic drip-irrigation system for the landscape, motion sensors with built-in photo sensors in toilets and staircases, etc.), which could reduce users’ misbehaviors and make buildings less sensitive to occupant behavior [48,49]. On the other hand, the green facilities commonly provided in GBs (e.g., the green education corner,
additional chute for recyclable refuse, bicycle racks, etc.) are useful for promoting green education and shaping green behavior in daily life. As suggested by environmental psychology theories, the intimate and consistent connection between people and their working and living environments may generate more subconscious but durable behavioral effects that can be translated into a lasting sustainable lifestyle [30]. Hence, the theoretical and empirical evidence strongly highlights the behavioral potential of GBs that are equipped with specific facilities and deliver sustainable education in daily life. GBs could be an avenue for enacting different “nudging” behavioral interventions in the short term and supporting long-term behavioral changes.

However, the roles of developers in promoting the social adaptation through their technological adoption of GBs are often underplayed, requesting government intervention to empower developers to engage in the social dimension. The Singaporean government effectively motivates developers to engage in shaping social changes by setting the detailed technical guidelines in the certification criteria. Since the launch in 2005, the Singaporean government has amended the official GM assessment criteria on a regular basis according to the changes in sustainability focus, so that developers can receive up-to-date, standard technical guidance. The increasing focus on user engagement in the latest GB criteria after 2018 implies that the Singaporean government has gradually recognized the importance of human behavior considerations in the design and operation of GBs. As indicated by the higher scores allocated to the categories relating to human well-being, the emphasis of the criteria has changed primarily from energy efficiency to well-being and occupant behaviors, which is beneficial to social adaptation. However, the behavioral impact of GBs on citizens’ behaviors in the 2021 version still received insufficient attention. At present, the way in which GBs could be implemented to change building users’ behaviors to be greener is still in a preliminary stage in both academia and the industry, even in Singapore. For the government, the potential of GBs as a “behavioral incubator” can strengthen the influence of governance on social adaptation, by providing new, durable behavioral approaches for deepening widespread social adaptation. It could be complementary to those traditional behavioral interventions whose effects are “positive and persistent, but short-lived due to the rebound effect” [51] (p. 11). Hence, it is worthwhile for the state to invest more in R&D in this area and promote the application of relevant research in the industry.

In short, the above analysis suggests that a powerful and resourceful government has the capacity to directly cultivate the social adaptations of citizens based on its strong ideological power in society. Meanwhile, the government also indirectly affects the social adaptation of GB transition by empowering citizens, developers and NGOs to positively contribute to the social adaptation process, as these actors have different capacities and roles in the social dimension of GB development. Specifically, developers and citizens exercise different types of power in both technological and social dimensions that could enable and support one another due to the supply–demand and builder–user nexus between them. The power dynamic between them is called synergy, a specific manifestation of the “different power” power relation according to MaP [14]. Their synergetic power is critical to stimulate social change and further boost technological transformation. NGOs still function as facilitators and assist the government with the empowerment process for developers and citizens in this dimension.

4.3. Transition Governance

The long-term nature, inherent complexity, multiple actors and uncertainty of sustainability issues require government support [52,53]. Governance can be understood as public decision-making beyond, but also including, the state and other non-state actors participating in governance [8]. In the GB transition context, a transition governance involves the government as well as the looser processes of influencing and negotiating with these public and private sector stakeholders to achieve GB transition. Functioning transition governance has become an important contributing factor in the successful GB transition in Singapore.
In Singapore’s transition governance, first and foremost, the government is the most predominant and central actor. Based on highly concentrated institutional power around the central government [4], the Singaporean government adopts a top-down approach to steer the GB transition as the forerunners. In the technology dimension, the GM scheme is administered by the government, different from other rating systems administered by non-government organizations or private actors (e.g., LEED by the United States, Green Building Council). This administration is beneficial for government to remain the central authority and maintain a close relationship with the market sector to coordinate green efforts. In the social dimension, the government directly empowers the public by playing its role in inducing social change and directing behavioral change. These explicitly describe its dominating roles in effectively governing technological transformation and social change. It could be explained that, following an ecological modernization and technocratic approach, Singapore has long emphasized the central role of the government and the importance of market-oriented and technocratic approaches for effective environmental management [54].

Second, rather than a simple adoption of the top-down approach, the Singaporean government effectively formed a horizontal collaboration with diverse stakeholders to catalyze an effective transition governance system. Sections 4.1 and 4.2 describe how the government has successfully and effectively mobilized developers, citizens and NGOs as resources and empowered them in the process of technological transformation and social adaptation.

Third, the government fully engaged all public agencies involved in building development under the “Public Sector Taking the Lead in Environmental Sustainability” initiative [30]. The actions of GB transitions are comprehensively performed by diverse public agencies (Figure 4).

- Primarily championing the development and transformation of the built environment, the BCA is designated as the lead agency responsible for the policy design, promotion and implementation of the GM scheme. It employs a series of legal instruments to reinforce the GM scheme, such as launching the Green Building Masterplan as an action plan and enacting related regulations for adequate statutory support (e.g., mandatory GB requirements in the Building Control Act). Under the GM framework applied to different types of built environments beyond buildings, the BCA coordinates efforts across its fellow public agencies.

- As the land-use planning and conservation agency and the main government-land sales agent, the Urban Redevelopment Authority (URA) specifically sets stricter mandatory GB requirements for Government Land Sale (GLS) sites (prescribed to achieve GM Platinum or Gold Plus standards as part of the sales condition) than other normal land sites. Moreover, the BCA cooperates with the URA to carry out the GM
GFA Incentive Scheme for private developments, as the URA is responsible for issuing the planning permission for each project.

- The Housing Development Board (HDB), the largest developer and main provider of public housing in Singapore, makes a substantial contribution to greening the public housing and new town development. The fact that 80% of Singapore residents live in public housing indicates great potential and initiative of the government in promoting GB adoption in the public sector. By April 2018, 360 HDB projects met the GM criteria, including 140 building projects awarded a GM Gold rating or higher, the highest number for any organization to date [55]. Punggol is the first eco-town in Singapore designed under the HDB’s 2011 Sustainable Development Framework. It becomes a typical green town model, as all public housing projects in Punggol have also been awarded with GM Gold or Gold Plus ratings and some signature projects achieved Platinum. These new town developments serve as “living laboratories” for government to demonstrate sustainable urban planning and design, boost green technology adoption and encourage green living.

- Other agencies perform their own duties by taking responsibility for different types of built environments, such as the Land Transport Authority for greening road infrastructure and the National Parks Board for greening parks and landscape in collaboration with BCA.

Hence, the government has a direct impact on constituting a functioning transition governance, in which it plays a predominant and central role, and its public agencies, while the other three non-government actors form the “supporting cast”. This functioning transition governance could provide governance support for technological transformation and social adaptation. Through the horizontal collaboration with diverse private stakeholders, such as developers, citizens and NGOs, the government can effectively empower them in the technological and social dimensions of GB transition, as mentioned in Sections 4.1 and 4.2. Through the vertical collaboration with its diverse public agencies, the government can synergize the power of these agencies by the task division and inter-agency cooperation and effectively coordinate the efforts within the public sector.

5. Discussion

Applying a conceptual framework based on the actor and power relation topology from the MaP approach and the regime insights from the MLP theory, the above case analysis in the Singaporean context set out to investigate how the government, real estate developers, citizens and NGOs differently contribute to the GB transition. The findings suggest that actors play different roles in the regime level of GB transition and have different influences on the technological, social and governance dimension of GB transition, determined by their different types of power and the multi-actor power relations, supporting our hypotheses raised in Section 3.1.

As the most powerful and influential actor in the GB transition process, the government plays a leading and steering role and it has a direct influence on all the technological, social and governance dimensions. As the central actor, the government has a direct influence on transition governance, while its public agencies and the other three non-government actors play the roles of the “supporting cast”. Based on its strong ideological, physical, political and economic power, the government can exercise power over its public agencies and the other three actors (i.e., the power relation of one-side dependence) through horizontal and vertical collaboration and multiple policy instruments. This functioning transition governance can effectively provide governance support for GB transition. In the technological and social dimensions, the government remains the major actor and it has a positive direct influence by steering and leading the development pathway. Moreover, the government has positive indirect influence on technological transformation and social changes in GBs, by interacting with developers, citizens and NGOs. It has substantial capacities to synthesize the respective power of private stakeholders (i.e., developers, citizens and NGOs) by mobilizing them as resources and cooperating with them in technological
transformation and social changes. Therefore, the predominant role of the government in GB transition, which is conducive to the synergy from multi-actor collaboration and a collective strategic direction (roadmap) toward transition, is fundamental to the successful GB transition.

Han [4] and Jain et al. [56] made a similar argument that the central role of Singaporean government is one of the most influential contributing factors in the success of GB development. The state, as the only institution with a general mandate to promote the public good, bears the responsibility for ensuring sustainable progress, because a steering logic is embedded in sustainable development, requiring goal-directed intervention by the state [52]. Compared to Singapore, Delhi in India adopts the industry-led GB development approach, resulting in the lack of a stable actor network and the failure of scale-up GB adoption [56]. Moreover, the City of Freiburg in Southern Germany’s shift from an initial bottom-up path during the 1970s and 1990s toward a top-down approach since the 2000s has made it a model case of urban sustainability in general and green building in particular [3]. The evidence in other contexts provides complementary support for the importance of the leading and steering role of the state.

Despite the merits, some researchers argue that the government’s predominance might lead to the lack of appealing for an increasingly pluralized and dynamic society or a lock-in effect that hinders the growth of vibrant society and bottom-up introduction of policy measures [4]; also, the government’s dominant involvement in the GB transition has resulted in the adoption of a passive stance by the construction and property industries [57,58]. This might explain, at least partially, why the majority of developers have adopted a passive stance after the mandatory GB regulation in the above case analysis of Singapore. Thus, beyond the mere top-down approach, how to empower other stakeholders and engage other non-state actors in GB transition is a critical transition–management challenge for the government.

As the major GB market participants, developers and citizens are two critical actors who are more directly involved in technological and social development of GBs. Developers have the capacity to mobilize different physical resources—such as human, technology, material, monetary and other resources—in the building sector, so they have a direct influence on technological transformation by adopting and constructing GBs. Comparatively, with the ultimate demand, the collective of citizens is the social force in civil society and it has a direct influence on catalyzing social adaptation to GBs. Due to the supply–demand and builder–user nexuses between developers and citizens, both are implicated in the processes of social change and technological development, respectively. The constant technological transformation requires developers to provide the competitive commodity of GBs and new building technologies. This process must be facilitated by a corresponding social adaptation in civil society. Citizens’ widespread social acceptance of GBs contributes to GB consumption and further economically incentivizes GB supply; moreover, their behavioral changes toward sustainability are conducive to the proper use of GBs and the realization of the environmental benefits of GBs implicitly leads technological advancement toward user engagement. Hence, citizens have an indirect effect on technological transformation by interacting with developers. Moreover, developers also have an indirect impact on social adaptation through their interaction with citizens, as the consumption of GBs by citizens is advantageous to improving social acceptance of GBs and shaping citizens’ pro-environmental behaviors. Therefore, the different types of power of developers and citizens in technological and social dimensions could enable and support one another, creating synergetic power dynamics.

There are lock-ins related to developers and citizens in the technological and social dimensions. For example, developers’ roles in behavioral changes in civil society have been undervalued in both academia and industry, largely because they do not have sufficient intrinsic motivation in this regard; moreover, citizens often overlook the importance of their influences on the GB performance at the post-occupancy stage. Compared to citizens and developers, the government is more powerful, as it can mobilize different resources and
engage other stakeholders in the building industry beyond them. Therefore, it is necessary for government to empower both of these actors and synergize their power by initiating a variety of technology-push and demand-pull policies and behavioral programs, reflecting the indirect influence of the government on these two dimensions through the interaction with citizens and developers.

As the intermediatory sector with the capacities of mediating between the production and consumption and between the state and non-state actors, NGOs tend to indirectly facilitate the technological and social changes by assisting the government. They are less powerful than the government in the building regime but can share similar, collective goals with the government. Hence, NGOs can primarily assist the government with empowering developers and citizens in the GB transition. Revealed in the Singaporean case, the efforts of NGOs primarily include the formation of partnerships, both within and outside of the NGOs, the promotion of social learning for both industry and civil society through public events and engaging the public in behavioral programs relating to sustainability and GBs. These efforts explicitly correspond to the three ways of the third sector’s contribution to the systemic social transformation summarized by Lyth et al.: enhancing social connectivity through boundary work, mobilizing participatory citizenship and contributing to social learning [41].

Compared to the previous studies in the GB literature, our research has three innovations. First, applying the actor and power relation topology from the multi-actor perspective theory enables us to conduct a structured investigation of the roles of four influential GB actors and the multiple forms of interdependencies and interactions between actors. Second, we investigate the roles of the third sector (i.e., the NGOs) and their effects on a GB transition, which have been commonly overlooked in the existing GB literature. Third, by incorporating the regime insights from multi-level perspective theory into our conceptual framework, we analyze actors’ roles and their influences in the technological, social and governance dimensions of GB transition and find that the actor interactions critically affect the interplay between dimensions, going beyond the predominant focus on technology in the prior research.

6. Conclusions

Drawing on the actor and power relation topology from MAP theory and the regime insights from the MLP theory, this paper discusses the roles of four representative, influential GB actors (i.e., government, developers, citizens, NGOs), determined by their respective power and multi-actor power relations and their different influences in the technological, social and governance dimensions of GB transition. Exemplified by a case study of Singapore, we reach the following conclusions:

(1) The government with its diverse public agencies plays a central and leading role, with direct influences on all three dimensions of GB transition, as it has power over other non-government actors. The government also has indirect influence on the technological transformation and social adaptation by empowering developers, citizens and NGOs in different ways to synthesize their respective power and address lock-ins facing other actors.

(2) Developers have a direct influence on technological transformation by adopting and constructing GBs based on their strong power and capacities to mobilize different resources in the building sector. They also have an indirect impact on promoting social adaptation through interaction with citizens, as the GB consumption of citizens is advantageous to improving social acceptance of GBs and shaping citizens’ pro-environmental behaviors.

(3) As the ultimate demand side, the collective of citizens as a social force has direct influence on catalyzing social adaptation to GBs through their involvement in GB transition. It also has an indirect effect on technological transformation through interaction with developers, as their GB consumption could incentivize developers to adopt GBs.
(4) Affected by the synergy from the supply–demand and builder–user nexus between developers and citizens, the technological and social development in GB transition can be mutually reinforced.

(5) As the intermediatory sector with the capacity to mediate between the production and consumption and between the state and non-state actors, NGOs indirectly facilitate the technological transformation and social adaptation by assisting the government.

The findings contribute to a structured understanding of the roles of GB actors in both technological and non-technological dimensions of the socio-technical transition in the GB context. Our conceptual framework constructed on the MaP and MLP theories can be used as a heuristic framework for actor analysis in GB transition and other socio-technical transition contexts. It can be adjusted to specify a broader variety of actors in a broader dimension of building regime. Furthermore, we empirically contribute to the incorporation of actor and agency issues into MLP framework by explicitly relating actors to the regime level, which is an important shift in focus for analyzing transitions.

Due to large differences in the exogenous conditions of sustainability transition between Singapore and other cities, the findings may not be generalized on a global scale. However, it could be replicated among Asian countries that share Singapore’s top-down policy making and have strong governments capable of serving central roles. The Singapore case provides policy lessons and recommendations for other cities at the onset of their GB transition at the city level. It is hoped that the policy implications and practical lessons can potentially generate boomerang effects and trigger competitive diffusion or learning across cities and countries.

This paper has some limitations. First, the case analyzed in our research is specific to a city-state, making it less suitable for unearthing generalizable patterns across cases than large-N studies or comparative case studies. Second, because it is challenging to quantitatively measure the roles and influences of actors, we do not include a quantitative analysis in our empirical study. For better understanding of the influences of the actors in the transition process, it will be valuable for future research to employ an integrated, quantitative approach. Third, due to the inability of data and information, we only touch on four specific major actors in three dimensions of GB transition. It is hoped that more actors and regime dimensions could be explored in future research.

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