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To cite this article: S A Mohamed *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1167** 012048

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Greening strategy through implementation of sustainable landscape design towards low carbon school

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Abstract. The increased societal attention and urgency towards combating global climate change and transitioning the position towards Low Carbon Cities (LCC) has prompted many green initiatives developed by government agencies including schools to seek solutions through promoting eco-school planning development as part of the Environmental Education (EE) awareness being emphasis in curricula. This research explores the underlying mechanism of the greening elements as one of the planning initiatives which enable the inclusion of how low carbon practice action plans can be conducted in school. The methodology adopted emphasized the ground case study at Sekolah Kebangsaan Tangok, Bachok, Kelantan to testify to the integration of theory and practice of sustainable low carbon in the school community with environmental education. Such integration draws on attention to contextual knowledge of reducing carbon dioxide emissions as one of the most important factors in the implementation and execution of greening components for a sustainable school program. The discussion of findings concentrated on the implementation of greening strategies from sustainable landscape design and framework for carbon measures from three components, which are the trajectory of low carbon target, benefits analysis matrix, and constraint analysis that can be implemented in school to track the level of CO₂ emissions and sequestration. This research provides a significant contribution in creating 'commercialized' environmental knowledge to the school communities that paved the way towards transition for Low Carbon Society as the social sustainable strategy that inculcates climate change adaptation for the future generation.

Keywords: Low Carbon Practices, Sustainable School, Greening components, Low Carbon Landscape Design

1. Introduction

1.1 Climate Change Phenomenon

The intense discussion on the global phenomena of climate change and global warming associated with the continued increase of greenhouse gas (GHG) concentrations in the atmosphere has gained



tremendous popularity and has been discussed worldwide [1-3]. An important key discussion was held in 1992 with the establishment of an international environmental treaty namely the United Nations Framework Convention on Climate Change (UNFCCC) to mutually reduce the atmospheric concentrations of greenhouse gases upon ratification of committed signatories. Owing to a complex ratification process, the Kyoto Protocol, adopted in 1997 became the first implementation measure of International Environmental Agreements (IEA) under UNFCCC that served as a binding GHG emission reduction target for 37 industrialized countries and economies in transition through the adoption of the outlined policies and measures on mitigation. In the first commitment period of the Kyoto Protocol, the reduction aims to cover the emissions of the six principal sources of GHG as listed in Annex I of the Protocol, which are Carbon dioxide (CO₂), Methane (CH₄), Nitrous oxide (N₂O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur hexafluoride (SF₆) [4]. However, the criticism on the effectiveness of the implementation in Kyoto Protocol to curb the rising level of GHG emissions laid a strong foundation for a new direction of universal agreement on climate change during the annual Conference of the Parties (COP) in 2016 with the adoption of Paris Agreement [4-5]. The hybrid approach to climate change governance in Paris Agreement shows the consequential transition from the top-down approach in Kyoto Protocol towards bottom-up approaches which reflects the legally non-binding that significantly aimed to limit the global average temperature below 2 °C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels [6].

Inasmuch, the heightened attention of discussions and efforts has been focused on the effect of CO₂ emission as the primary of GHG and the largest contributor to Global Warming Potential (GWP), where it is accounted for about 70% of gaseous volume which trapped heat in the atmosphere [7]. Intergovernmental Panel of Climate Change (IPCC) have claimed that the impact of CO₂ emissions on climate change is indisputable, hence it is important to seek ways to manage the effect before it becomes worse. The escalating levels of CO₂ emissions have therefore prompted the Intergovernmental Panel of Climate Change (IPCC) to claim the impacts of CO₂ emissions on climate change are indisputable, henceforth leaving the multiple challenging tasks; firstly, to administer the unavoidable effects predicted and, secondly, to manage the previous increases in CO₂ emissions levels. Undeniably, the rising level of CO₂ concentration caused by human activities, particularly in the last two centuries, shows an escalating trend, which is marked from 280 ppm to more than 380 ppm by volume, and the rate is thriving continuously. As a result, the increase of global average temperature is heading towards 3 °C; crossing 1.5 °C as pledged in the Paris Agreement [8]. Therefore, reacting to climate change issues requires a multifaceted approach. The first approach refers to mitigation, which focused on reducing the emissions of and stabilizing GHG levels in the atmosphere. While the second approach raises the effort for adaptation strategies, in which adapting to life in a changing climate that is already within us requires adjustment to actual or forecasted future climate. Either mitigation or adaptation strategies are taken, it is imperative to ensure a global temperature increase less than 2 °C through a collaborative effort by limiting the emission of CO₂ into the atmosphere to roughly around 800 gigatons of CO₂ (GtCO₂).

Despite the mutual agreement of nationally determined contributions (NDC) amongst most world countries as the representation of a vital commitment to climate action, yet, the mutual plan to cap the increase of global temperature below 2 °C has never been realized [9]. The lower commitment given in NDC deterred the integration efforts to embody the scaling up of low-carbon strategies and consolidate the resilient climate infrastructure that can guide every country in formulating the potential adverse impact of climate policies through its development prospects and economic growth. The urgency also is seen in achieving the UN Agenda 2030 for Sustainable Development Goals (SDGs). In particular to the environmental context, the Goal 13 of Climate Action, outlined several urgent actions to combat climate change and its impacts by enhancing the raising awareness on environmental conservation as well as empowering institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning. These stated strategies then be aligned with climate action and the sustainable development objectives at the local, national and global levels through defining key sustainability challenges to support policies.

1.2 Malaysia's Low Carbon Development Policy and Guidelines

In the context of domestic policy, the Malaysian government is applying measures through development planning and guidelines to combat the effect of climate change caused by the rising levels of CO₂ emissions. In a global context, for example, Malaysia has committed itself to cut 45% of its Gross Domestic Product (GDP) per capita GHG emission by 2030 in accordance with Paris Agreement, whereby, 10% of this goal contingent upon international assistance in accordance with Paris Agreement [10]. Such movement also is indeed a continuity from 2009, in which Malaysia has undertaken to reduce 40% of GHG emissions intensity as compared to the 2005 level GDP per capita. This pledge is conditional by the transfer of technology and financial support from developed countries as per affirmed during the Conference of Parties (COP-15) in Copenhagen, Denmark [11]. Nevertheless, the ambitious commitment as pledged to reduce carbon emissions intensity as outlined to be achieved by 2020 in so far, has not expressed optimism regarding the accomplishment efforts [12]. The hindered efforts on implementing the reduction strategies effectively are related to the poor implementation of the law that are not in compliance with sustainability to be regarded as mandatory. As a result, the commitment has not been well greeted with careful adaptation strategies, due to the limited support received from existing legislation as well as restrained environmental awareness amongst local residents [13].

In a similar situation on reducing the CO₂ levels, the struggle on global decarbonization efforts depends heavily on the capability of developing countries towards charting the low carbon development path. In light of this, Malaysia has testified its effort to reduce the carbon emissions intensity following the pledge in 2009 by charting a pathway towards Low Carbon City (LCC). Nevertheless, the limited government capacity and the absence of a centralized management agency with the lack of incipient environmental awareness constraints the achievement target of carbon reduction in Malaysia [14]. Such absence of centralized management and policy integration is evident in the establishment of the Government Transformation Programme (GTP) in 2010 aimed to guide the government's direction concerning the most pressing issues and thus expected to contribute to making the country a developed and high-income nation as per its Vision 2020. The derivation of the six initial National Key Result Areas (NKRAs) within GTP namely Reducing Crime, Fighting Corruption, Improving Student Outcomes, Raising Living Standards of Low-Income Households, Improving Rural Basic Infrastructure and Improving Urban Public Transport; indeed, does not relate to any initiatives on carbon emission reduction or environmental sustainability as one of the vital issues within the NKRAs matrix.

Similarly, inattentive policy integration is also reflected in the formulation of the National Green Technology Policy (NGTP) in 2017 and the accompanying Renewable Energy Policy and Action Plan roadmap which, similarly, do not link up with any of the components of the NKRAs. Therefore, an attempt to harmonize the policy directions towards a common goal of sustainable utilization of natural resources seems unreachable. The unveiled of NGTP as an outcome of the Eleventh Malaysia Plan (2016-2020) which has earmarked green growth as one of the six-game changers to alter the trajectory of the nation's growth, although seems fragmented rather than integrated, however, became a turning point in the initiatives on sustainable growth and development in which one of the many initiatives is to showcase Putrajaya and Cyberjaya as the pioneer of green cities. Thus, the establishment of the Low Carbon Cities Framework and Assessment System (LCCF) initiated in 2011 and further improved in 2017 provides a binding national framework for assessment systems to guide and assess the development of cities in reducing carbon emissions and charting towards SDG [15]. However, the readiness of LCCF implementation among Local Authorities to apply in development control facing several challenges and issues that exists in multifaceted of policy implementation [16]. Figure 1 outlines the pathway towards low carbon development policy planning and guidelines in Malaysia.

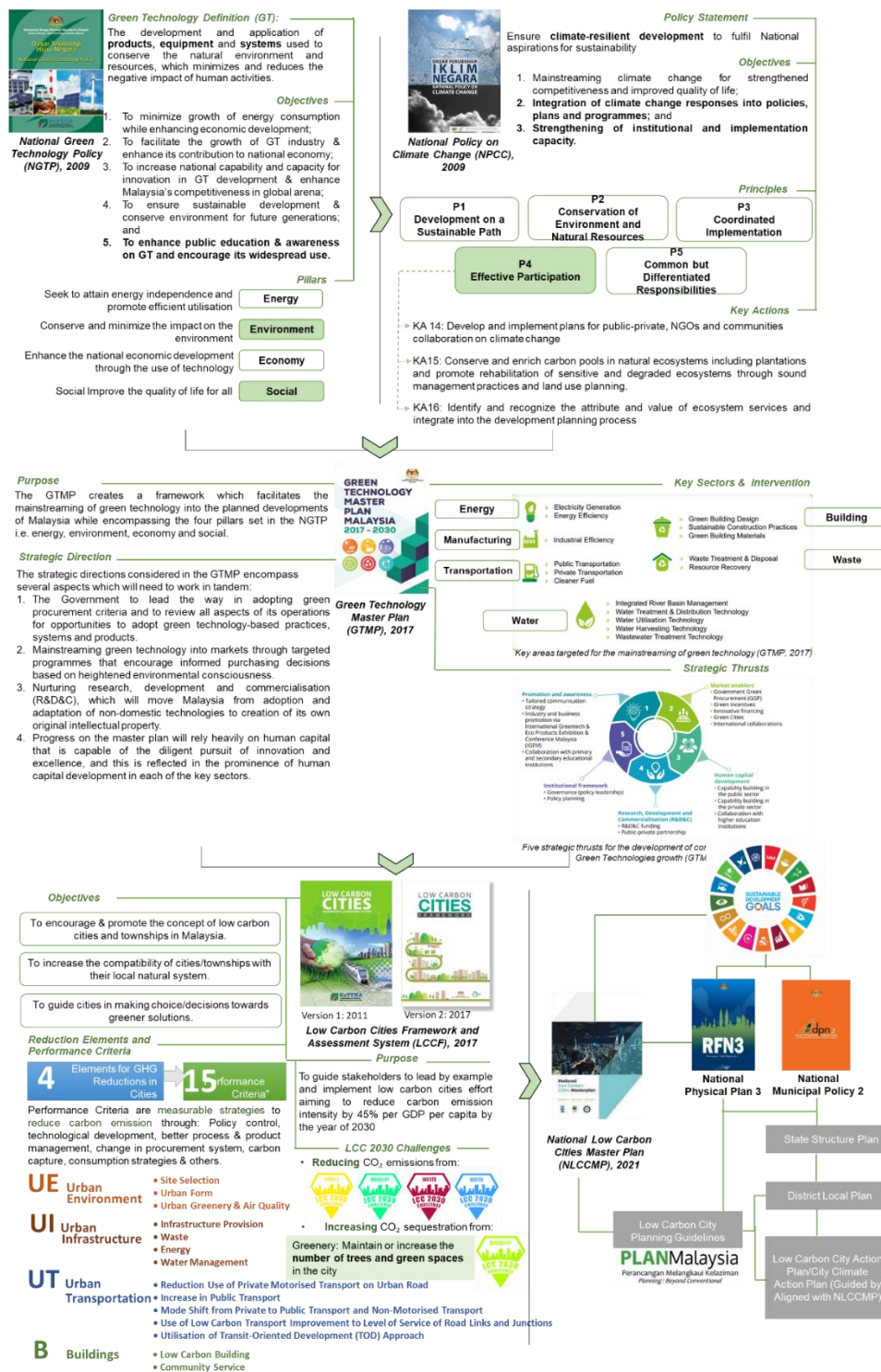


Figure 1. Pathway of Low Carbon Development Policies and Guidelines in Malaysia

1.3 Environmental Education for Low-Carbon School

In line with the enormity of global environmental problems increased in recent decades, the awareness on the environmental education program in school also have been increasingly widespread. The Tbilisi Declaration (1978) defined Environmental Education (EE) as a learning process with the aim to upsurge the knowledge and awareness about the environment and associated challenges. The cornerstone of EE is indeed, involves a process of continuity; stemming from recognizing the environmental values, developing necessary skills, tools and expertise to address the challenges as well as fostering attitudes, motivation, and commitment to make informed decisions and take responsible action [17]. The United Nations Environmental, Scientific, and Cultural Organization (UNESCO) lists five components as an integral part of this learning process; namely, awareness and sensitivity to the environment and environmental challenges; knowledge and understanding of the same; attitudes of concern for the environment and motivation to improve or maintain environmental quality; skills to identify and help resolve environmental challenges and lastly, participation in activities that can help resolve these challenges [17]. The environment in EE is considered in its totality central to the understanding that the natural environment and man-made environment are interdependent, thus, making the EE interdisciplinary in nature.

In line with the need for environmental conservation which has become the main topic in development activity both globally and in Malaysia, as well as the movement on sustainable development as pledged in Stockholm Conference in 1972, various ministries, departments, and agencies including educational institutions such as schools that have the significant potential to act as a catalyst for community engagement around sustainability [18] are implementing the effort for reducing carbon emissions. As such, the Ministry of Education, Department of Environment, and Institut Alam Sekitar dan Pembangunan (LESTARI), Universiti Kebangsaan Malaysia (UKM) has initiated Sustainable School (Sekolah Lestari – Anugerah Alam Sekitar) to inculcate schools to support the Malaysia Low Carbon Cities movement. Sustainable School (*Sekolah Lestari*) definition is learning to understand the interaction between humans and the environment, and how the environment can be managed sustainably and responsibly for the sustainability of life on earth. Low-carbon practices are very crucial to be taught to school students. This learning process involves education about the environment, through the environment, and for the environment. This is a long-term socially sustainable strategy to inculcate climate change adaptation for the future generation. School is the best educational platform for students to learn and practice by example. In addition, a collective and mutual practice among teachers and students could result for better understanding, creativity and interest in the design of Sustainable School (*Sekolah Lestari*). There are 5 components in Sustainable School: Administration (management), Curriculum, Greening, Co-curriculum, and Special Element.

Although there are guidelines provided by the ministry and agencies on how to establish Sustainable School and lowering the carbon emission, yet there are limited scientific knowledge faced by the teachers and students especially on the Greening component of Sustainable School [19-21]. Additionally, the Greening component emphasizes initiatives to improve the environmental quality of the school that reflect the significant role of school in realizing the objectives of education for sustainable development in the Green City Action Plan (GCAP) as outlined in Eco School Malaysia Program. The Eco-Schools Malaysia program, developed by a non-governmental and non-profit organization (NGO) namely Foundation for Environmental Education (FEE) is a largest sustainable school programme in the world and have been introduced to schools in Malaysia in 2011. It considered as one of the high impact low hanging projects under GCAP to encourage young people engage in environmental conservation through active participation in an eco-project that they identify, design and implement in their local area specifically around school [22]. Such engagement from young generation is critical to create an environmentally friendly community in order to support the development initiatives such as Malaysian Green Cities, achieving Net Zero Carbon Emissions by 2050, and Malaysia's ambition to maintain 50% forest cover.

From the review on low carbon development planning guidelines planning and environmental education from greening components, thus the theoretical perspectives framed in this research consists of the integration of both Low Carbon City Framework and Environmental Education which situated in place-based context of school landscape design. These theoretical perspectives were integrated and consolidated to outline the development of conceptual framework adopted in this research specifically the greening for sustainable school landscape design in achieving the implementation of low carbon practices in the selected school study area. Through the creation of outdoor learning space for educational landscape design, the component of learning process in EE can be achieved which in turn support the government initiatives on low carbon society as well as realizing the objective of education for sustainable development. Figure 2 explain the integrated framework adopted.

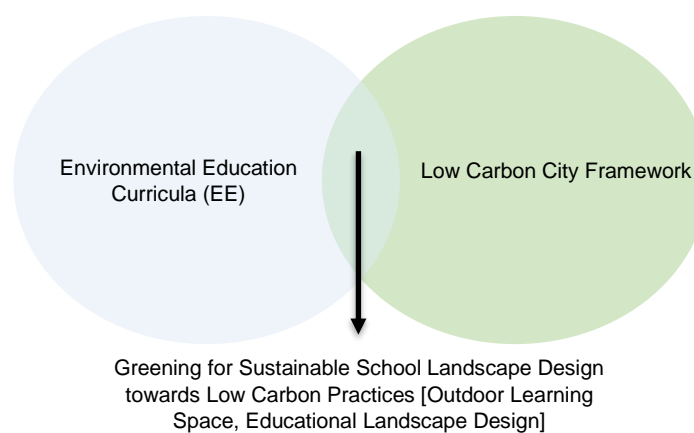


Figure 2. Integration of Theoretical Perspectives to Frame the Conceptual Framework of Greening for Sustainable School Landscape Design

2. Methodology

The research employed case study approach to explore the integration of theory in environmental education with the practice of greening for sustainable landscape design towards the creation of low carbon school. in a place-specific context. The fundamental characteristic of case study, in particular, emphasizes on the exploratory aspects to obtain an in-depth understanding in a place-specific context which proved to be advantageous and well-suited with action-oriented research [23-25].

2.1 Case Study Location

The emphasised ground case study conducted at Sekolah Kebangsaan Tangok, a primary school located in Bachok, Kelantan. The location of the school is strategically positioned within the institutional land use areas bordered by SMK Dato Perdana and SMKA Tok Bachok as two prominent secondary school in Bachok. In addition, the school also is in close proximity to three renowned higher institution learning centers in Kelantan, namely Universiti Malaysia Kelantan (UMK) Bachok Campus, Kolej Vokasional Bachok and Institut Kemahiran Tinggi Belia Negara (IKTBN) Bachok. These strategic location within the hegemony of educational areas provides strengths to cultivate on environmental awareness and opportunities to engage in community collaboration through involvement in environmental conservation effort. Being the only primary school served the Mukim Repek Barat, the school potentially became the pilot case for greening programmes by engaging students in thinking and learning about environmental issues that are more likely to impact beyond the bounds of the classroom which therefore potentially

reach a wider audience than the student population through the process of intergenerational influence [26].

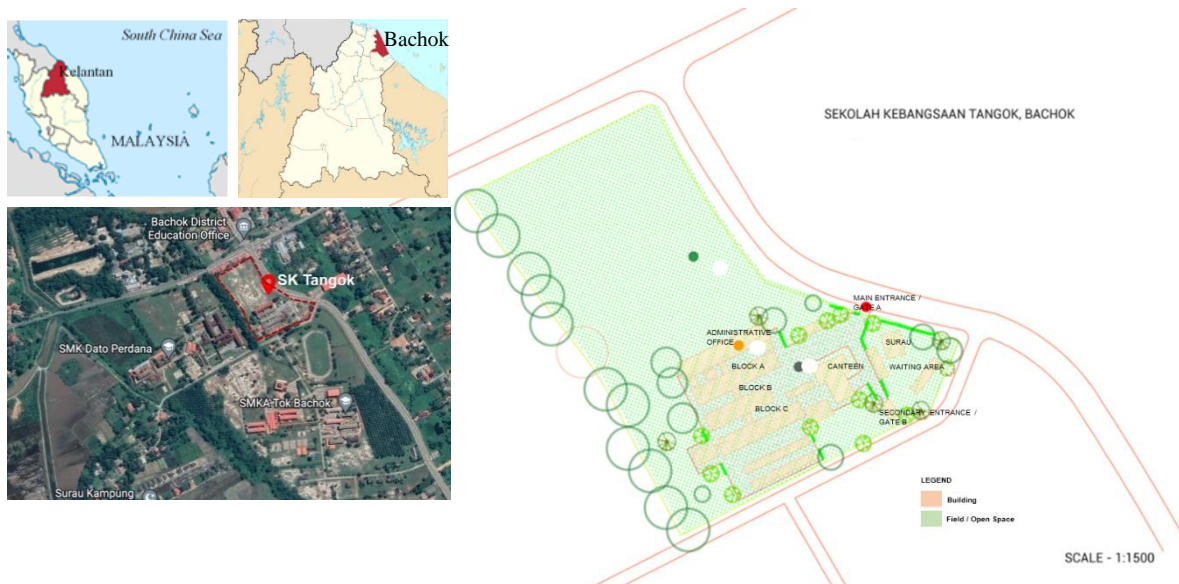


Figure 3. Location of Case Study Area at Sekolah Kebangsaan Tangok, Bachok, Kelantan

2.2 Methodological Framework of Structured Case Study Method

The methodological framework for the case study analysis details the process to guide a specific planning in executing the research process systematically, particularly in carrying out the case study research foreseen from the greening activities. The concept of structured case study represented in the methodological framework developed is elucidated by two main aspects, namely structured and case as exemplify from the work by [27] and translated in the field of built environment research as highlighted by [28]. Structure refers to the use of formal process model for constructing theory that involves three structural components; namely the conceptual framework, the research cycle and the literature-based scrutiny of theory built. Additionally, the case refers to case study design in which defining case to scientific inquiry through detailing the aspects or units that form the case. The delineated framework provides a flexible resource that is structured but not prescriptive, in the sense that it can accommodate the cyclical, iterative and participatory process of the case study work for delivering the final analysis at the end of the research. Figure 4 illustrates the methodological framework adopted in this research.

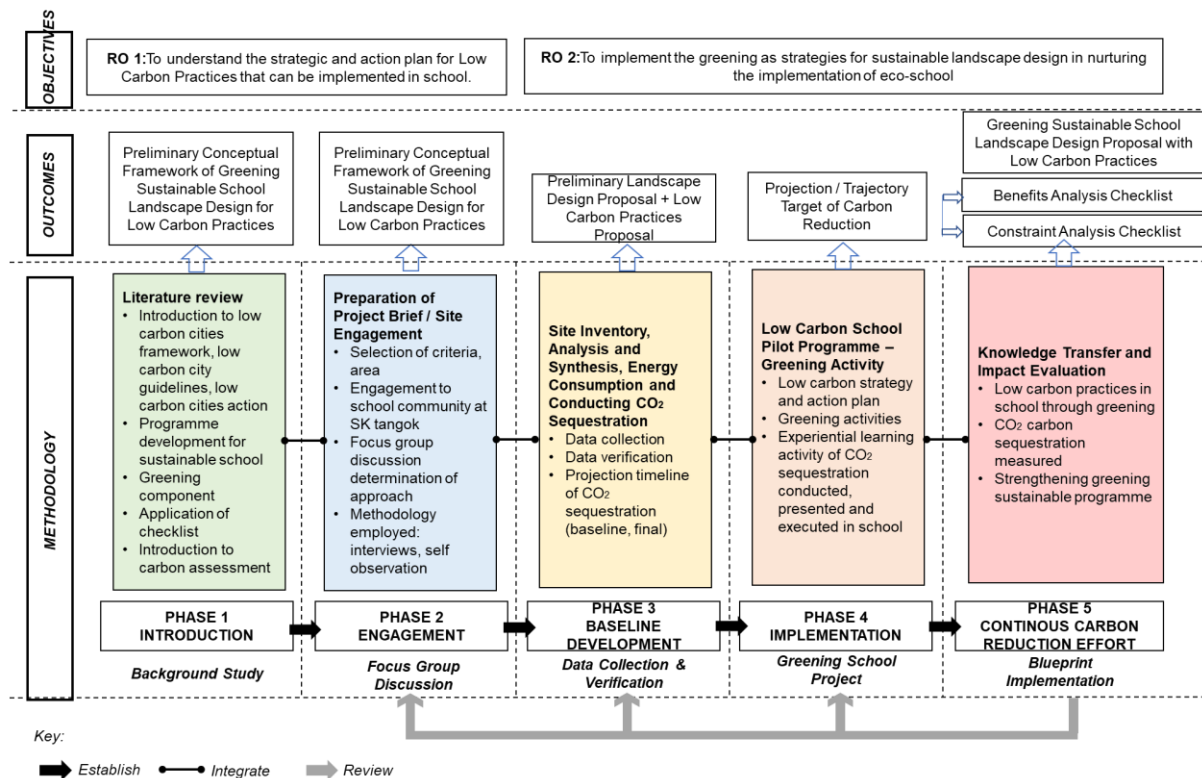


Figure 4. Methodological Framework of the research

3. Analysis

The discussions of the analysis synthesize the result from the mapping analysis based on the thematic spatial zoning delineated according to existing school compound areas that are available and potential to implement with the greening strategies.

3.1 Spatial Analysis

The spatial analysis was carried out through the process of thoughtful site inventory and analysis to determine the elements and conditions that will impact the ultimate use and design of the landscape at the school compound. Throu can improve the environment, can improve the environment, by creating new features based on the users' needs and keeping those features which are deemed useful and desirable.



Figure 5. Spatial Analysis of the Existing School Compound Area at Sekolah Kebangsaan Tangok, Bachok, Kelantan

Table 1. SWOT Analysis and Synthesis of School Compound Areas

	SWOT Analysis	Synthesis for Greening Strategies
Compound 1	Located adjacent to Main Hall, fully paved, several hardscape elements provided, multipurpose and active area.	Central focus for interactive playscape to accommodate the multipurpose use.
Compound 2	Located in the middle of Block A and B at the front area, some softscape elements provided with several planting species, no proper access, moderately used for pre-school activity.	Welcoming entry point connecting the administrative building and classrooms.
Compound 3	Located in the middle of Block A and B at the rear area, no proper used, entry point connecting row of classroom for pre-school, standard 1,2 and 3.	Strategic location for creation of natural green connection for outdoor learning, located in central area within two blocks, received least treatment.
Compound 4	Located in the middle of Block B and Block C at the front area, well-maintained of landscaped area with several softscape elements being	Transition point to serve as a transit green pocket space connecting Block B and C.

	planted, located next to active foyer for pupil's access	
Compound 5	Located in the middle of Block B and Block C at the rear area, provided with existing small gazebo, heavily used for pre-school activity.	Active space for playscape area dominated with hardscape elements themed.

4. Result and Discussion

4.1 Greening Low Carbon Sustainable Landscape Design in School

Design planning and development through greening strategies were developed according to spatial zoning at school compound areas. Four thematic designs based on the SWOT analysis were established that are greening for interactive design in compound 1, greening for green innovation design in compound 2 and 3 which are located adjacent to each other, greening for welcoming landscape design in compound 4 and greening for green play area in compound 5 that is next to pre-school building.



Figure 6. Greening for Low Carbon Sustainable Landscape Design Ideas according to Spatial Zoning

In addition, as a pilot case study, compound 3 was selected as beginning for greening activities conducted in Sekolah Kebangsaan Tangok. The greening voluntarily activities involve the multiple participation from school communities including teachers, pupils, parent's association as well as the participation of higher institution from Universiti Malaysia Kelantan that reflects the initiative of community engagement towards creating the awareness on environmental conservation and low carbon practice.

4.2 Greening Low Carbon Sustainable Landscape Design in School

The greening strategy is line with the policy context of developing Low Carbon Cities 2030 (LCC2030) in Malaysia as documented in the LCCF. These outlined frameworks aiming to realize the vision of Low Carbon Cities Master Plan 2021 (LCCMP). At a state level, the formulation and achieving the LCCMP vision in Malaysia are guided with Low Carbon City Planning Guidelines envisioned by PLAN Malaysia. At the school level, preliminary work to produce an action plan for low carbon can be developed which involves the element of exploratory on carbon quantification that need to be investigated, researched, learned and integrated into the learning system as part of the EE. Given the extensive applicability of LCCF, several interpretations in planning for urban greenery and improving air quality in school can be implemented by maximising the greenery through collaborative process of community engagement as vital component to reduce CO₂ emissions and increasing carbon absorption from land energy footprint [29]. Figure 7 suggested the integrated framework for low carbon practice which highlighted the three components, that are the trajectory of low carbon target, benefit analysis matrix and constraint analysis that can be implemented in school in tracking the level of CO₂ emissions and sequestration.

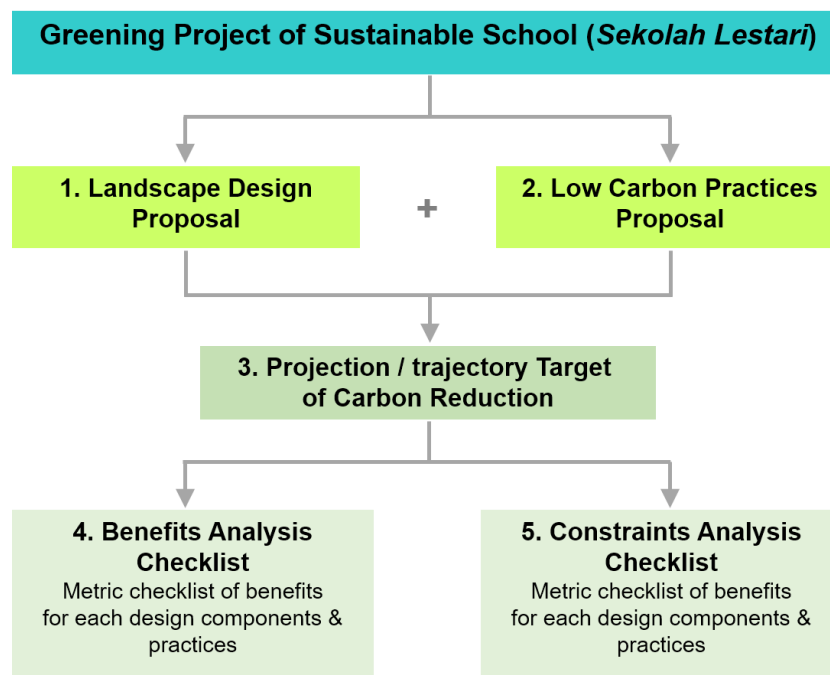


Figure 7. Integrated Three Components of Trajectory Low Carbon Target, Benefit Analysis Matrix and Constraint Analysis Matrix

5. Conclusion

As a conclusion, the study has set out to establish the underlying mechanism of the planning initiatives which enable the inclusion of how low carbon practice action plan can be conducted in school. The case study selection conducted in school compound of Sekolah Kebangsaan Tangok in Bachok, Kelantan testify the integration of theory and practice of sustainable low carbon in school community with environmental education. Such integration draws on the attention to contextual knowledge of CO₂ emissions and sequestration as one of the most important factors in implementation and execution of greening components as one of the measures for sustainable school programme. It has also been suggested that school environmental programmes can potentially reach a wider audience than the student population through the process of intergenerational influence. The discussion of findings concentrated on greening strategies and effort being conducted in school as well as the establishment of low carbon framework from three components, that are the trajectory of low carbon target, benefit analysis matrix and constraint analysis that can be implemented in school to track the level of CO₂ emissions and sequestration.

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Acknowledgement

The authors would like to acknowledge the financial contribution and support from the internal grant award of Universiti Malaysia Kelantan (UMK) Community Impact Research Grant (UMK-COM) R/COM/A1200/01869A/001/2021/00988.