The contributions of environmental management systems towards project outcome: Case studies in Hong Kong

Anita M. M. Liu¹*, Wagner S. W. Lau¹ and Richard Fellows²

¹Department of Real Estate and Construction, The University of Hong Kong, Pokfulam, Hong Kong
²Department of Civil and Building Engineering, Loughborough University, Loughborough, UK

Abstract
Sustainable development has been promoted and pursued for many years within the environmental, economic and social domains, i.e., the triple bottom line. From such perspectives, sustainable construction integrates low-energy design with materials which have minimum environmental impact while maintaining ecological diversity. The sustainability concept is supported but not fully implemented in Hong Kong compared with countries such as the UK. This study proposes a sustainable construction model with three key factors, namely, government policy, contract procurement system and environment management system (EMS). In this study, the effects of EMS are tested through case studies of a sample of school development projects in Hong Kong. Performance comparisons between contractors with and without ISO 14001 certification are analysed. The results show that, in general, the implementation of EMS enhances the achievement of sustainable construction outcomes.

Keywords – Environmental management systems; sustainable construction; sustainable development

INTRODUCTION
Sustainability is becoming an ever more important and popular topic, especially in relation to construction projects. The overriding issue is encapsulated by González-Benito and González-Benito (2005), who state that “The current economic growth in developed countries entails high rates of consumption of natural resources that nature is unable to restore, and great amounts of residues that cannot be absorbed.”

Sustainable construction (SC) is regarded as the application of sustainable development (SD) in the construction industry. It is suggested that the construction industry is one of the major polluters during the construction process (ONS, 2011); the situation is more serious in Hong Kong due to its high density in population and buildings. Moreover, the number of employees in the construction sector accounts for a significant proportion in the total employment population in Hong Kong and the construction industry has always been a main contributor to the economy. Therefore, the environmental, social and economic sustainability of the construction industry must not be treated lightly.

The construction industry is criticized extensively for fragmentation in the industry’s organizational and operational processes which, allegedly, led to poor performance, dangerous activities and wastefulness. Construction projects embody vast quantities of energy and matter (as well as continuous and large inputs of resources) in the delivery of safe and functional construction outputs. The array of international standards developed by the International Organization for Standardization (ISO)
have been helpful in addressing performance improvements via benchmarking and certification approaches in areas such as construction health and safety. For organizations to secure certification under ISO 14000 – the series of standards relating to environmental performance – is becoming important for movement towards SD and ‘green’ performance. Various government departments and organizations have implemented environmental management systems (EMS) to satisfy such SD goals.

The research aim of this study was to examine the concept of sustainable construction in terms of the impact of EMS dictated by government policy and construction procurement systems in public projects. Through case studies of construction projects in Hong Kong, the development processes are examined to determine the impact of participants having certified environmental management systems (ISO 14001:1996; ISO 14001:2004) on project performance.

SUSTAINABLE DEVELOPMENT IN CONSTRUCTION

SUSTAINABILITY

Basiago (1995) suggests that sustainability can be ‘regarded as tantamount to a new philosophy, in which the principles of futurity, equity, global environmentalism and biodiversity must guide decision making.’ That is an inclusive concept which takes on varied meanings in different disciplines. The Oxford English Dictionary (2005) defines sustainable as Capable of being borne or endured; supportable, bearable … Capable of being maintained at a certain rate or level. However, to endure is to last. Hence, something is sustainable if it continues to exist, at the limit, forever (whatever that may be). Thus, the concept of limits, or boundary, becomes important. (See Fellows (2006) and Fellows and Liu (2008) who examined the various arguments for SD.)

The issues regarding SD have developed for more than 30 years. In the late 1960s and early 1970s, it was argued by many that economic growth directly caused environmental decline and could not be sustained forever. This argument and concern can be seen from the publication of Limits to Growth (Meadows, Meadows, Randers, & Behrens, 1972) and the initial Earth day on 22 April 1970. In the 1980s, the limits-to-growth model was replaced with the sustainable development model which seeks ways to make economic growth sustainable, mainly through technological change. In 1987, the Brundtland Commission brought the term ‘sustainable development’ into common use and defined it as ‘development which meets the needs of the present without compromising the ability of future generations to meet their needs’ (WCED, 1987), and this definition is the widely accepted classic definition. Other commentators also provide their own perspective of sustainable development (e.g. Berggren, 1999; Costanza & Daly, 1992, Giddings, Hopwood, & O’Brien, 2002; cf. Porritt, 1993; Steele, 1997; Chen & Chambers, 1999). The more recent impetus for SD includes the Earth Summit, Habitat I, Habitat II, the Kyoto Treaty and the Bonn Agreement, with relative focus on environment, city sustainability and reduction of greenhouse emission, respectively.

In biology, sustainability is associated with the protection of biodiversity; it concerns itself with the need to save natural capital on behalf of future generations. In economics, it is advocated to foster accounting for natural resources; it examines how markets, as conventionally conceived, fail to protect the environment. In sociology, it advances environmental justice in situations where some groups make decisions over the use of resources, thereby affecting other groups. In environmental ethics, it means, alternatively, preservation, conservation or sustainable use of natural resources; it probes the domain where humans ponder whether they are part of, or apart from, nature, and how this should guide moral choice. In planning, it is the process of urban revitalization where there is a pursuit of a design science to integrate urbanization and nature preservation. The Town and Country Planning Act, 1971 (a seminal piece of legislation) in UK defines ‘development’ as (ss 290(1) & 22(1)):

1 the carrying out of building operations, engineering operations, mining operations or other operations, in, on or under land;
2 the making of any other material change in the use of any buildings or other land.
Munasinghe (1993) provides a model of sustainable development in which economic, social and environmental variables interact to achieve dynamic equilibrium. The variables denote mechanisms to engender balance of individual disciplines’ concerns which must be brought into equilibrium via compatible levels of achievement.

These ‘sustainability’ criteria act as constraints on untoward forms of development. They are premised on the belief that humanity will only succeed in a cosmic sense if it finds a way to meet human needs, while at the same time maintaining the integrity of biological systems, accounting for the loss of natural resources from the economy, working social equity, regenerating human settlements and conserving natural capital... (Basiago, 1995).

Porritt (1993) criticizes the sustainable development principle of the World Commission on Environment and Development (1987) on the basis of its being ambiguous and so, open to a wide range of interpretations, many of which have proved to be contradictory. Further, he asserts that exponential economic growth, as has, largely, become the expectation, cannot be sustained indefinitely from a finite base of resources, no matter how ingenious human invention and technological innovation may be. Thus, he concludes that while sustainable development is possible, sustainable growth is not. Pollington (1999) also determines that there are a number of critical barriers facing Agenda 21 (1992) and its implementation. Most important among the barriers are diverse cultures (and their underpinning diverse value structures), and imperatives and preferences of (project) clients.

THE SITUATION IN HONG KONG
Hong Kong is one of the cities with very high population density and perhaps the most sustained pressures and initiatives for sustainability would come from the Hong Kong population. Ageing trend will have remarkable impact on a change in demand for housing in an ageing community. In addition, the construction industry constitutes major employment in Hong Kong (HKSAR, 2011), thus, the working environment and occupational health and safety have large impact on a large number of construction workers. Accidents and occupational injuries in the construction industry are very high compared to other industries (Labour Department, 2011).

Major effects of the construction industry upon the environment originate from energy consumption, carbon emission, construction waste, noise pollution, health and safety, land use, existing site dereliction, habitat destruction and use of natural resources, use of water resources/water discharges. In Hong Kong, the building industry gives rise to more than half of the electricity consumed during the construction process and the occupation stage. Air pollution is one of the two most serious types of pollution in Hong Kong and much research has been carried out which directly or indirectly relates to construction (e.g. Chen, Li, Wong, & Love, 2002). Rapid development in Hong Kong has contributed to a dramatic increase in the amount of construction and demolition (C&D) material, and this becomes a heavy burden to the landfill capacity of Hong Kong. Noise pollution from construction is a very serious problem due to the high-density environment. The SD and SC concepts have not been implemented comprehensively through land use and development controls and the government’s involvement is limited – although construction sites which fall into the ‘designated area’ shall undergo Environment Impact Assessment (EIA) according to the regulations set by the Environment Protection Department (EPD) of the Hong Kong government (EPD 2004).

In 1997, the Study on Sustainable Development for the 21st Century in Hong Kong (SUSDEV 21) was commissioned by the Government of Hong Kong SAR. The Study came up with a working definition for SD in Hong Kong, guiding principles and sustainability indicators and, in particular, a Sustainability Development System with a computer-aided sustainability evaluation tool and recommendations on institutional arrangements. However, the SUSDEV 21 was criticized for its orientation, limitation and immaturity (Barron and Steinbrecher 1999). Further development took place, including setting up of the Green Manager Scheme, environmental auditing, the Hong Kong Building
Environmental Assessment Method (HK-BEAM), the Environmental Impact Assessment Ordinance, environmental permit system etc. and establishing consultancy/advisory services provided by the Hong Kong Productivity Council, Green Buildings Council and various other environmental bodies.

RESEARCH RATIONALE
The sustainable development practices consider developments in terms of a triangle of categories (economic, social and environmental), each of which constitutes a focus in its own right. Given the concept of ‘development’ in the context of the built environment, construction constitutes the sub-system which is concerned with the provision of the built environment through design and physical realization processes. Clearly, the processes in operation are an important constituent of the design and its realization – those must also accord with the principles of sustainability. For instance, re-using and recycling of construction demolition wastes are suggested by Golton (1997) and RICS (2011) as effective ways to diminish the impact of construction on the environment. Thus, sustainable construction means integrating low energy design with materials to yield minimum environmental impact (Edwards, 1999) as well as providing sustainable economic growth and quality of life (Steele, 1997) in terms of adopting sound building economics in the provision of quality building products. The understanding or interpretation of sustainability of building and construction has undergone changes over the years (Sjostrom & Bakens, 1999). SC is seen as a way for the construction industry to respond to SD. Insights and views about SC are also provided by researchers such as Kohler (1999), Bourdeau (1999) and Du Plessis (2005).

Arguably, sustainable development can be analysed in terms of economic and social sustainability as well as environmental. However, the salient underpinning is that neither economic nor social variables can be sustainable unless the energy and other resource aspects of sustainability are present, for example, protection of the environment, prudent use of natural resources (DETR, 1999) and management of waste (Steele, 1997) – which suggests that only environmental sustainability matters as any other facets depend upon that. Policies and regulations lay out guidance for performance requirements and judging ‘what is good’. Thus, it is postulated that the projects which are completed by contractors whose EMS have obtained certification would have better sustainable construction performance measures.

ENVIRONMENTAL MANAGEMENT SYSTEMS
Since it is insufficient for the responsibility of sustainable development to rest with participants in the market place – because they are subject to imposed performance imperatives (e.g., Hutton, 1996) and therefore induced to behave opportunistically (Dietrich, 1994; Williamson & Maston, 1999), means for securing sustainable development fall into two categories, voluntary and mandatory. In both categories, government policy has an important role to play. The government may influence voluntary actions and legislate mandatory requirements. The means within the voluntary category may (commonly) be coupled with market-oriented incentives, such as ISO 14001 (environmental management system) certification, LEED (Leadership in Energy and Environmental Design) Green Building Rating System (US Green Building Council, 2006), GBTool assessment (Green Building Council Australia, 2006), HK-BEAM assessment (HK-BEAM Society, 2006) and Hong Kong’s planning incentives for incorporation of ‘green’ provisions in buildings, which carry sales incentives, including implications of ‘corporate social responsibility’ (see Carroll, 1979; McWilliams & Siegel, 2000; Wood, 1991), to compensate for the costs incurred. The mandatory category comprises obligatory management and assessments of designs and construction activities such as the Environmental Impact Assessment Ordinance, 1997 in Hong Kong (in force, 1998) (Government of Hong Kong, 1997) but such management measures are subject to well-known problems of institutionalized control, for example, legislation, performance standards, reliability of assessments, policing of compliance and transgressions.

In practice, EMS are not about managing the environment but do concern managing the impacts
which organizations and their activities (outputs and processes) have on the environment. The best known EMS is the ISO 14000 series, the first version of which was published in 1996. Essentially, an EMS comprises management principles, tools and procedures which, when followed properly, enable an organization to recognize, measure and monitor (with a view to reducing) the impacts that its activities have on the environment. As such impacts are externalities for the organization, independent, periodic certification by an independent, qualified expert is a pragmatic essential. Many of the issues in establishing managerial systems, especially those commonly perceived to be oriented towards externalities, are well known. Yip (1994) notes the problems usually encountered in environmental management in relation to construction are:

1. different nature of environment from cost, time and quality;
2. little environmental concern at early stages of projects;
3. dominance of results-oriented policies;
4. ‘traditional’ culture and attitudes;
5. costs of environmental management;
6. misunderstanding of the value of the environment.

Typical incentives for organizations to obtain certification are to secure (opportunities for) more orders, to facilitate compliance with legislation and for greater efficiency/cost reduction through improvement of internal systems (such as via synergy as with quality, safety and environmental protection systems). Such incentives are necessary to commercially overcome the costs of establishing and operating the system.

Hence, the research focuses on a specific type of project (secondary schools) with defined procurement system boundary and government policy requirements to investigate the impact of EMS on SC outcomes.

CASE STUDIES IN HONG KONG

Exploratory case studies of projects executed under the school improvement programme (SIP) of the Hong Kong government are undertaken to examine whether major measures regarding environmental performance have increased (changed) as a result of contractors’ having a certified EMS. The School Improvement Programme (SIP) of projects is selected due to its size, commonality among constituent projects, commonality of project organization, a single client (Architectural Services Department (ASD) of the Hong Kong government; has EMS certification) and availability of data. Phase 4 and the Final Phase of SIP include 474 school projects divided into 90 building contracts each containing 2–7 schools. Of the 29 contractors involved, 3 have a certified EMS and they executed 15 of the SIP contracts. To facilitate comparison, the 3 contractors with EMS and three other similar contractors are selected for study. The selection of SIP projects has many advantages for comparison in terms of having defined project scope, similar contract duration, less economic fluctuation than normal projects, standard forms of government building contract and regulated governmental tendering process and procedures. In addition, the project client, ASD, who has already obtained EMS certificate would facilitate the implementation of EMS through contract documentation.

A questionnaire was developed to obtain quantitative data relating to performance measurements indicative of sustainable construction – the content of the questionnaire is derived from scrutiny of environmental performance indicators employed in various countries (e.g. KPI Working Group, 2000). The questionnaire includes the following performance measures relating to SC outcomes (see Table 2 and the Appendix): construction cost; cost predictability; time predictability; construction and demolition (C&D) materials; C&D waste; electricity consumption; water consumption; accident rate, defects.
The results of SC outcome for projects carried out by the two groups of contractors (with EMS and those without EMS) are compared. The mean value of both groups with respect to each SC outcome for both groups will be compared by $t$-test. Responses from the contracting firms are shown in Table 1 where five of the six contractors respond to the questionnaire. The results are summarized in Table 2.

In summary, eight of the nine performance measures in Table 2 reveal that the implementation of EMS encourages better sustainable construction outcome. The $t$-tests results of the differences between the two groups of contractors are significant at 95% level. The implementation of EMS can reduce construction cost; this reduction may come from saving in energy, recycling of resources and reducing occupational accidents etc. EMS includes a risk management element that may have helped to increase cost predictability. It also suggests that implementation of EMS can achieve much better environmental sustainability in terms of reduction in C&D materials, electricity consumption, water consumption, accident rate and defects. This is achieved by recycling and reusing effort and the commitment on waste management policy of contractors. Also, the environmental audit carried out by both internal and external auditors helps the contractors in focusing on their environmental commitment. The better safety and quality measures revealed by the results in Table 2 shows that better site management and working environment of the EMS contractors enhance performance.

However, the result shows that time predictability of the contractors with EMS is lower than those without EMS. A later interview conducted with contractors implementing EMS reveals some possible reasons. It is suggested that site cleanliness and tidying-up are required by EMS, but workers in Hong Kong have not adapted to this new ‘environmental’ culture and led to time inefficiency. Also, some practical requirements of EMS can result in time loss, such as idle time for preparation works.

**DISCUSSION**

Government policies and legislation lay out objectives and performance requirements. However, to be effective, the objectives must relate to the underpinning issues and be translated into realizable standards for performance, given the current technologies, practices and cultural factors. A consequence of the need for (political) pragmatism is that, in Hong Kong, as everywhere else, what are termed sustainable policies and laws are, in reality, unsustainable although they are ‘green’ (see, e.g., Cole, 1999). ‘Green’ policies, laws etc. are those which require/encourage actions in the direction of sustainability but do not achieve sustainability, in many cases they fall far short of sustainability; they include pollution reduction and decreasing energy and resource consumption. Those laws constitute the minimum performance standards for compliance which, through profit-seeking, opportunistic behaviour etc., usually are treated as maxima too.

Common industry practices do little to exacerbate the situation. In Hong Kong, traditional (fragmented, design-tender-construct) procurement dominates (as in the five case study projects). Such arrangements are not conducive to improving constructability and so, tend to be wasteful. Poor constructability leads to waste of materials and to longer durations wherein production resources are idle; variations (from various causes) may require re-working (reducing motivation), cause delay, inefficient ordering and operations etc. Further, the competitive bidding system is not conducive to teamwork – in fact, quite the reverse – and so, fosters individualistic, opportunistic behaviour through claim pursuance and disputes (see, e.g. Rooke, Seymour, & Fellows, 2003, 2004).

Results of the case studies endorse the achievement of ISO14001 certification by the main contractor to secure more ‘green’ performance.

<table>
<thead>
<tr>
<th>Contractor</th>
<th>EMS</th>
<th>SIP phase</th>
<th>Number of projects (number of tender packages)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISO 14001</td>
<td>IV/final</td>
<td>10(2)</td>
</tr>
<tr>
<td>2</td>
<td>ISO 14001</td>
<td>IV</td>
<td>1(1)</td>
</tr>
<tr>
<td>3</td>
<td>ISO 14001</td>
<td>IV</td>
<td>6(1)</td>
</tr>
<tr>
<td>4</td>
<td>None</td>
<td>IV/final</td>
<td>10(3)</td>
</tr>
<tr>
<td>5</td>
<td>None</td>
<td>Final</td>
<td>4(1)</td>
</tr>
</tbody>
</table>

EMS: environmental management system; SIP: school improvement programme.
Further the performance on such projects is better in terms of two of the project management criteria – both cost and quality. However, the notable exception is time performance. The per cent difference in construction times for projects are shown in Table 2, which denotes comparability between the two sets of projects – those with and without EMS.

As true sustainability concerns many aspects of projects which are externalities to the (main) participants, their internalization, which is what sustainability requires, involves ethics and relates to culture – in particular the ways in which people relate to nature, the time horizons and relationships to others (people and other life forms) adopted in decision making. The ethical nature of sustainability decisions and actions, from global to individual, are obvious as they concern the consequences for all others as well as self. Thus, while horizontal collectivism (high concern for in-group others) tends to be strong, especially in collectivist national cultures, vertical collectivism (high concern for the collectivity) tends to be weak(er) (Triandis, 1995). That indicates that significant problems are likely in pursuit of sustainability, especially through voluntary means – as witnessed by the reluctance of the USA to endorse global policies for environmental protection.

In their investigation of organizations’ motivations to implement environmental management in Spain, particularly through ISO 14001 certification, González-Benito and González-Benito (2005), following Bansal and Roth (2000), examine ethical, competitive and relational motivations.

### TABLE 2 Sustainable construction performance measures

| Sustainable construction performance measures | Mean value (standard deviation) | Difference |   |
|-----------------------------------------------|---------------------------------|------------|
|                                               | No EMS                          | With EMS   |   |
| Construction cost ($/M²)                      | 12,961.98 (3158.90)             | 10,550.90 (1616.78) | 2141.08 | 16.87 |
| Cost predictability (%)                       | 10.00 (8.167)                   | 4.206 (4.307) | 5.794 | 57.94 |
| Time predictability – building (%)            | 8.33 (4.608)                    | 14.82 (7.969) | −6.49 | −77.94 |
| Time predictability – piling (%)              | 7.26 (11.567)                   | 11.35 (22.951) | −4.09 | −56.34 |
| C&D materials (M³/100 M²)                     | 28.7 (17.33)                    | 14.86 (24.27) | 13.84 | 48.22 |
| C&D waste (tonnes/100 M²)                     | 16.01 (17.42)                   | 5.86 (9.94) | 10.15 | 63.40 |
| Electricity consumption ($/M²)                | 69.08 (96.04)                   | 7.16 (4.18) | 61.92 | 89.64 |
| Water consumption – building ($/M²)           | 6.84 (5.18)                     | 2.25 (1.54) | 4.59 | 67.11 |
| Water consumption – piling ($/M)              | 25.35 (23.29)                   | 7.67 (5.73) | 17.68 | 69.74 |
| Accident rate (no. of accidents/100,000 hours)| 11.52 (27.499)                  | 9.01 (12.086) | 2.51 | 21.79 |
| Defects (no./project)                         | 0.0669 (0.0837)                 | 0.0132 (0.0056) | 0.0537 | 80.27 |

EMS: environmental management system; C&D: construction and demolition.

All results are statistically significant at 95% confidence interval. Price data are adjusted to a constant base using the Building Works Tender Price Index, issued by the Architectural Services Department.
Ethical motivations relate to perceptions of ecological responsibility, competitive motivations concern seeking competitive advantage over others, and relational motivations involve desires for better relations with stakeholders and desires for legitimacy. They find that initiation of the process is driven by ethical and commercial motivations whereas actual certification is in response to ethical and competitive, especially operational (costs and productivity) motivations. The Environmental Impact Assessment Ordinance in Hong Kong came in force in 1998 and the certification of contractors can be seen as part of the initiation process prompted by the government. However, there are sectoral differences – different industries vary a lot in their interest in ISO14001, and, further, company size is a significant, positive variable – larger companies are much more interested in ISO14001 than small companies. The sectoral difference, in terms of company size, is evident in this research as the contractors which have obtained EMS are the relatively large companies.

**CONCLUSIONS**

In Hong Kong, despite much recent debate and attention to green issues, sustainability and environmental protection, very few organizations, particularly within the construction industry, have obtained ISO14001 certification. Further, despite extensive discussion on relational contracting, and partnering in particular, (including advocacy by major, government-sponsored reports, such as the ‘Tang’ report, 2001 – Construction Industry Review Committee (Hong Kong), 2001), the traditional procurement approach, firmly grounded in price competition, is dominant, especially in the public sector. Such a context for operation is hardly conducive to the internalization of externalities as necessary for sustainability. Indeed, it is evident that the environmental protection law is deficient in scope of coverage and extent of movement towards sustainability.

The results of the case studies are encouraging in confirming that ISO 14001 certification of contractors (working for an ISO14001-certified public agency client) does yield significant benefits in cost and quality performance for project management performance and for project performance measures relating to moves towards sustainability. Although the results relating to indicators of time performance are not so clear, they do suggest that there may be no time performance detriment due to the additional tasks (sorting of waste, proper disposal etc.) required under ISO 14001 certification.

**APPENDIX: SUSTAINABLE CONSTRUCTION PERFORMANCE MEASURES**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Formula</th>
</tr>
</thead>
</table>
| Cost predictability     | \[
| Final contract sum – Original contract sum \times 100\% \over Original contract sum \]
| Time predictability     | \[
| Actual construction period – Original contract period \times 100\% \over Original contract period \]
| C&D materials           | \[
| C&D materials (tonnes) \over Total CFA (100 M²) \]
| C&D waste              | \[
| C&D waste (M³) \over Total CFA (100 M²) \]
| Electricity consumption | \[
| Electricity consumption (GJ) \over Total CFA \]
| Water consumption       | \[
| Water consumption (M³) \over Total CFA \]
| Defects                 | \[
| Defects (no.) \over Total CFA \]  

**REFERENCES**


