

PUBLIC-PRIVATE PARTNERSHIP FOR LEAN SUSTAINABLE DEVELOPMENT IN CONSTRUCTION

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Abstract

Sustainability of construction projects has become a major issue facing decision-makers, developers, city and urban planners as well as designers worldwide. Construction projects are characterised with the excessive use of natural resources and consumption of energy, which have a crucial impact on the environment and future generations. This called for the construction industry to adopt the Lean principles as an approach to achieve sustainability objectives. Due to its achievement, partnership between public and private sectors turned into a strategic option to promote sustainability of construction projects. The increasing recognition and apparent success of lean principles called for focusing on utilising the knowledge and skills of project participants to develop sustainable construction through enhancing values and eliminating wastes. This paper aims to investigate the role of public-private partnership (PPP) in applying Lean principles as an approach for sustainable development in construction. A research methodology is developed to accomplish four objectives. Firstly, literature review is used to build a comprehensive background about the research topic including partnership, sustainable development and lean principles. Secondly, case studies are presented to explain the role of partnership in delivering sustainable construction projects. Thirdly, developing a framework to facilitate the creation and implementation of partnership between public and private sector towards lean sustainable development in construction. Finally, summarising research conclusions and recommendations for governmental authorities, construction professionals and further research. Research findings showed that creating a partnership between the public and private sectors could play a significant role towards achieving sustainability in construction through lean principles application.

Keywords: Construction, Framework, Lean Sustainable Development, Public-Private Partnership

INTRODUCTION

Despite the valuable contributions of the construction industry as a vehicle for improvement and a driver for achieving social and economic development strategies at national and international levels, it impacts the environment in a number of ways. The construction industry accounts for 40% of the total flow of raw materials into the global economy every year; 50% of the material resources taken from nature; 40% of energy consumption and 50% of total waste generated. It is a source for air pollution and water contamination; construction and demolition waste; inefficient consumption of natural resources and energy as well as habitat destruction. This called for the construction industry to be sustainable through saving the environment and using resources in a way that enables current generations to meet their needs without obstructing future generations from fulfilling their needs and achieving their objectives (Roodman and Lenssen, 1995; Anink et al., 1996; Earth Watch Institute, 2011). A number of techniques have been used to achieve sustainable construction including value management, risk management, total quality management, integrating clients in the decision-making process and constructability. In spite of the valuable contributions of these approaches, sophisticated stakeholders needs and projects' complexity in terms of innovation and sustainability, called for learning from other industries that made leaps of progress such as manufacturing which showed successful improvement in performance through developing the concept of Lean Production (LP). This concept promotes the elimination of waste and addition of value (Koskela, 1992; Latham, 1994; Egan, 1998; Othman, 2011a&b). In construction, the objectives of LP are achieved through meeting customer needs; changing organizational culture and improving people performance; standardising workplace; eliminating waste and continuous improvement. The diverse knowledge, skills and expertise of project stakeholders make it is essential for creating a partnership between public and private sectors towards applying lean principles as an approach for delivering sustainable construction projects. Government cannot deliver sustainable projects in green cities alone. It requires help, and the private sector has the capabilities to provide support. Kole (2004) stated that government has to involve local communities and private organisations with the public sector to improve sustainable development.

The Royal institute of chartered surveyors (RICS, 2004) indicated that despite the commitment of the private sector to sustainable development, it is clear that it is unlikely to be delivered without a partnership with government and the support of an appropriate fiscal and regulatory framework. Through public-private partnerships, partners attempt to create closer collaboration and commit themselves to improve performance (Wai, 2004). This paper aims to investigate the role of public-private partnership in applying Lean principles as an approach for sustainable development in construction.

RESEARCH METHODOLOGY

In order to achieve the above mentioned aim a research methodology consists of literature review and case studies have been developed to accomplish four objectives.

- Literature review is used to build a comprehensive background about the research topic including partnership, sustainable development and lean principles;
- Case studies of projects benefited from creating public-private partnership in delivering sustainable construction projects are presented;
- Developing an innovative framework to facilitate the creation and application of partnership between public and private sectors in construction;
- Outlining research conclusions and recommendations useful for public and private sectors in construction as well as further research.

PARTNERSHIP

Definitions and Background

The New Choice English Dictionary (1999) defined a partner as one of two or more persons jointly owning a business who share the risks and profits. Partnership in the field of construction has been defined in a number of ways. Korte (2003) defined partnership as the method of establishing good working relations and building trust between project stakeholders such as the owner, designer and contractor. It calls up the parties involved in a contract to form a relationship of teamwork, cooperation and good faith performance. The primary objectives involved in partnership include facilitating improved contract performance through enhanced communications, effective conflict management, and avoidance of disputes and litigation.

The Association of Project Management stated that partnership is a commitment between two or more organisations to achieve specific business objectives by maximising the effectiveness of each part's capability through cooperation. Partnership means trust, communication and sharing. Partnership is a process to establish productive working relationships among all parties on a project. While a contract establishes legal relationships and obligations, the partnership process establishes working relationships among the parties through a mutually developed formal strategy based on cooperation. It attempts to create an environment where joint problem solving prevents disputes and the parties truly work as a single team towards the goals of a successfully completed project and continuous improvement (APM, 2003). Partnership is an attempt to create closer collaboration in the construction industry, whereby clients, design consultants, contractors and supplier alike commit themselves to closer working relationship to improve buildability and performance, with the emphasis on collaboration, rather than confrontation (Wai, 2004). Public-Private Partnership brings public and private sectors together in long-term contracts. It is a long term relationship between the two sectors that has the purpose of producing public services or infrastructure.

Partnership Concept around the Globe

Partnership and the involvement of the private sector in delivering public services is not a new phenomenon. PPP in the form of Build Operate and Transfer (BOT) were used as early as 1858 for the construction of the Suez Canal (Cartlidge, 2006). In modern day construction industry, the concept of partnership was first used in the USA with Arizona State Highways and the US Army Corps of Engineers in 1980's. It was claimed that the use of partnership had resulted in some 9% reduction in cost and 8% improvement in time for completion in some projects. When partnership was first introduced to the UK and Australian construction industry, a non-contractual partnering approach was typically adopted as the first step, whereby parties entered into a partnering relationship after a traditional contract had been awarded through competitive tendering. Studies indicated that such arrangements could achieve cost savings of 2-10%, comparing with the expenditure of 1% or less used on facilitation and in managing the partnership process (Wai, 2004). Partnership in the UK is now becoming the norm in civil engineering contracts in both private and public sectors. Projects are performing much better in meeting their time, budget and quality objectives. Clients are happier and contractors have started to make money (Maxwell, 2004).

In response to the success with partnership in the UK construction industry, a more collaborative form of contracts such as the New Engineering Contract (NEC) had been developed embracing the concept of partnership and incorporating the “pain-share gain-share” contractual agreements. The use of this new form of contract is also gaining popularity in South Africa. In Hong Kong, the Hospital Authority and Mass Transit Railway Corporation (MTRC) were one of the first clients to embrace the concept of partnering in hospital projects in the mid 1990’s with some notable success. Partnership was also adopted by the MTRC in its Tseng Kwan O Extension project, which opened ahead of schedule with construction cost below budget. MTRC has attributed such success to the use of partnership (Wai, 2004). Spain embarked on its motorway program in the mid-1960s as the national budget was considered inadequate to meet the demands of a booming tourist industry. The solution adopted was to use the private sector financing. The new Spanish motorway companies were all private entities, although they were subjected to a high degree of state monitoring and control. The energy crisis of the 1970s led to the collapse of most PPP companies in Italy, Spain, and France. In France, the state had to intervene and take over some of the companies and assimilate them into the public system of infrastructure. A similar development in Spain in 1983 led to the collapse of three companies representing about 15% of the motorway sector. Changed economic conditions saw the reverse process in the 1980s. Today, PPP projects in Italy and Spain are profitable, with some of them traded and quoted on the local stock exchanges (Nyagwachi and Smallwood, 2007). In June 2003 the Association for Project Management Hong Kong (APM HK) published partnering guidelines for construction projects in Hong Kong. This document was prepared by the Association for Project Management Partnering Specific Interest Group (APM Partnering SIG). The APM Partnering SIG is an initiative of the APM HK to support best practice in partnership within the Hong Kong construction industry. Coates (2004) highlights the objectives of the APM Partnering SIG which are to:

- Promote the practice and development of partnership to all who can benefit.
- Educate, provide guidelines and tools for practitioners and facilitators of partnering.
- Measure performance, providing demonstration projects and evidence of success in partnership.
- Coordinate the activities of the APM Partnering SIG with initiatives taken by other bodies.

In the recent past, many countries have seen a tremendous increase in cooperation between the public and private sectors for the development and operation of infrastructure. Such PPP arrangements have been driven by limitations in public funds to cover desired investments and the need to leverage expertise from the private sector, in order to improve the quality and efficiency of public services (Grimsey and Lewis, 2004).

Benefits of Partnership

The benefits of partnership are as follows (Carmack, 1993; Climas and Kam, 2004; Erridge and Greer, 2002; Ysa, 2007; Zhang and Kunaraswamy, 2001; Zhang et al., 2002; Zhang, 2004a&b; Grimsey and Lewis, 2002; Li et al., 2010; Shen et al., 2006; Ball and Maginn, 2005; Hart, 2003; Ho, 2006; Norwood and Mansfield, 1999).

- Creating and maintaining cooperation and trust between contractors and the project owners, which ensure the efficient, safe, timely and mutually beneficial completion of construction contracts.
- Delivering successful projects on time, within budget, as specified and with few significant claims.
- Improving partnership between the public sector and the private sector.
- Better risk management and clearer government policies.
- Revealed critical success factors and improved maturation of contract.
- More appropriate financial analysis.
- Enhancing communication, cooperation and team working between the contracting parties (Wai, 2004).
- Helping governments achieving sustainable development objectives of rural areas (Othman and Sirbadhoo, 2009) and developing affordable housing projects (Othman and Abdellatif, 2011).

Partnership Drawbacks

- Partnership may help to address some of the problems faced by the construction industry, but it is not a solution to all problems. For example, partnering has led several UK private and public sector clients to enter into strategic long-term arrangements, which helped to bring about a less adversarial environment and improved collaboration between the contracting parties.

However, such a procurement strategy tends to favour bigger contractors and suppliers (Wai, 2004). As a result, small and medium sized contractors and suppliers have alleged that they have been slowly driven out of the markets.

- The allegations are being investigated by the Office of Fair Trading in the UK. Partnership in the construction industry is leading to a dramatic cultural change amongst the parties involved. Maxwell (2004) stated that it was recognised by the strategic team, that behavioural change was going to be a challenge and needed a considerable amount of individual and team development. On-sing (2004) states that culture changes cannot occur overnight and it requires organizational and employees commitment.
- Maxwell (2004) further mentions that relationships with regulators and government departments are a general cause of frustration to project managers in delivering the programme/ partnership workshops, resulting in one of the major drawbacks to the partnership process.

SUSTAINABLE DEVELOPMENT

There are as many definitions and explanations of sustainable development. The World Commission on Environment and Development (1987) defined sustainable development as the development which meets the needs of the present without compromising the ability of future generations to meet their own needs. At its heart is the simple idea of ensuring a better quality of life for everyone, now and for generations to come. This means achieving four objectives simultaneously:

- Social progress which recognises the needs of everyone.
- Effective protection of the environment.
- Prudent use of natural resources.
- Maintenance of high and stable levels of economic growth and employment.

Sustainable development is a dynamic process which enables all people to realise their potential, and to improve their quality of life, in ways which simultaneously protect and enhance the Earth's life support systems (Walton, 2000).

The information gleaned from the various definitions above highlight a number of common characteristics and RICS (2004) mention that it seems that any sensible definition of sustainable development needs to at least recognise the following points:

- Development needs to occur within the limits of the long-term carrying capacity of the earth - that is the ability to balance the use and production of resources, deal with waste and provide environmental services such as a stable climate and fresh water in perpetuity.
- Development should be equitable, both between individuals within a given generation and across generations overtime.
- Development needs to take account of the relationships between the economic, the environmental and the social aspects.

It is important to remember that the term “sustainable development” represents an intellectual framework. As such, it does not in itself provide the solution to particular problems; rather it requires the application of a common set of principles to derive a most sustainable outcome. At its best, therefore, sustainable development enables the continuing resolution of conflicting priorities with the ultimate aim of balancing the economic, environmental and social credentials of a particular situation. As no two situations can ever be exactly the same, this intellectual process needs to be repeated time and time again. The key attributes of a sustainable built environment are:

- Public participation in the decision making process for flexible sustainable design.
- Effective and efficient use and re-use of land
- Efficient use of sustainable materials, energy and water in the production, manufacture and transportation of materials used in the construction, operation and management processes of buildings.
- Encouragement of diversity (i.e. mixed uses, different age groups, different ethnic groups and religions etc.).
- Promotion of local employment and economic development.
- Provision of healthy, safe and secure environments.
- Equitable access to facilities and services.
- Sufficient size, scale, density and the right layout to support basic amenities.
- Provision of public open spaces including some green spaces.

- A balance and mix of uses to support social, economic and environmental objectives (RICS, 2004).

LEAN PRINCIPLES

Concept Background

Lean principles are the set of “tools” that assist in maximizing client’s delivered value while eliminating waste. As waste is eliminated quality is improved, production time and cost are reduced. Toyota Motor Corporation, the founder of lean principles, identified seven types of wastes that have to be eliminated, they are:

Table 1: Toyota’s 7 Types of Waste (Source: Kotelnikov, 2001)

Overproduction	Producing items for which there is no order resulting in overstaffing, storage or transportation
Waiting	Workers idled watching a machine or waiting for material, equipment, approvals or directions
Unnecessary Transport	Moving work-in-process or inventory
Over or incorrect processing	Taking unneeded steps to achieve an outcome, inefficiencies due to poor tools or design; procuring to higher standard than required
Excess Inventory	Raw material, WIP or finished goods, increasing lead time, obsolescence, damaged goods, storage, transportation; also hides production and delivery problems
Unnecessary movement	Wasted employee motion – looking for, reaching for, stacking parts or tools. Walking is waste
Defects	Production of defective parts or correction. Repair, rework, Scrap and inspection

Organisations that adopt the lean concept define client’s value and develop the necessary plans and processes to achieve and continuously increase it. Through applying 5 principles, lean organisations approach these challenges:

1. **Value:** Specifying client’s value through accurate understanding and proper identification of client wants and only what the client wants.

2. **Value Stream:** Understanding the value stream through identifying unnecessary and wasteful activities that should be eliminated; supporting value-adding activities that have to be reduced as far as possible; and finally client value-adding that should be continuously improved.
3. **Flow:** Improving the flow of work to be steady and without interruption from one value adding or supporting activity to the next. Flow of work considerably speeds the processing and every effort should be made to eliminate obstacles that prevent flow.
4. **Pull:** Adopting the pull strategy to react to client demand. In non-lean organisations work is pushed, in other words, the system produces outputs that are not required. Most lean services react to client demand and so pull the work through the system.
5. **Perfection:** based on the implementation of the four principles mentioned above, organisations should understand the system ever better and generate ideas for more improvement. A perfect process delivers just the right amount of value to the client. In a perfect process, every step is valuable-adding, capable (produces a good result every time), available (produces the desired output, not just the desired quality, every time), adequate (does not cause delay), flexible, and linked by continuous flow. If one of these factors fails some waste is produced.

Benefits and Methods of Lean Production

The application of a lean production system helps companies to achieve the following benefits:

- Reducing waste and inventory by 80%
- Reducing production cost, manufacturing cycle times and labour by 50% while maintaining or increasing output.
- Increasing capacity in current facilities by 50%.
- Achieving customer satisfaction, improving quality and increasing profits.
- Enhancing system flexibility towards reacting to changes in requirements.
- Creating better strategic focus and improving cash flow through increasing shipping and billing frequencies.

The most important methods used to attain lean production are: JIT, TQM, time based competition, concurrent engineering, process redesign (or reengineering), value based management, visual management, total productive maintenance and employee involvement (Kotelnikov, 2001).

Lean principles in construction

The adoption and implementation of lean principles in the construction industry entails a continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of construction project (Construction Industry Institute, 2011). Towards creating lean construction, a set of lean principles and best practices could be applied including: customer focus, culture/people, workplace standardisation, waste elimination and continuous improvement / built-in-quality. In spite of the fact that lean concepts have been brought to the construction industry in a number of countries such as Australia, Brazil, Denmark, Ecuador, Finland, Peru, UK, USA and Venezuela (Ballard and Howell, 2003), survey studies carried out in the UK by Common et al. (2000) concluded that the construction industry in general has been slow in taking lean concepts. Moving towards lean construction and have it as a system of thinking and behaviour requires a comprehensive commitment and involvement of the entire organisation as well as the provision and facilitation of sufficient resource needed (Hunting, 2010). Changing organisational culture, creating a conducive environment, explaining the benefits of lean principles and present successful projects as well as offering training programmes are essential for achieving lean principles in the construction process (Construction Industry Institute, 2011; Othman, 2011a).

Lean Project Delivery System (LPDS)

The Lean Construction Institute (LCI, 2011) developed a new and better way to design and build capital facilities. This new way is called the Lean Project Delivery System (LPDS). The new LPDS model consists of 13 modules, 9 organized in 4 interconnecting triads or phases extending from project definition to design to supply and assembly, plus 2 production control modules and the work structuring module, both conceived to extend through all project phases, and the post-occupancy evaluation module, which links the end of one project to the beginning of the next, see figure (1).

- The Project Definition phase consists of the modules of purposes, design criteria and design concept. This phase is managed by the project manager who is responsible to the client for the entire project, including both designing and building. The project manager may use traditional sources as inputs, such as architectural programming, but such inputs will be integrated with others, including post-occupancy evaluations.
- The Lean Design phase consists of the modules of design concept, process design and product design. It develops the conceptual design from the project definition, gained in the previous phase into process and product design, consistent with the design criteria produced in project definition phase.

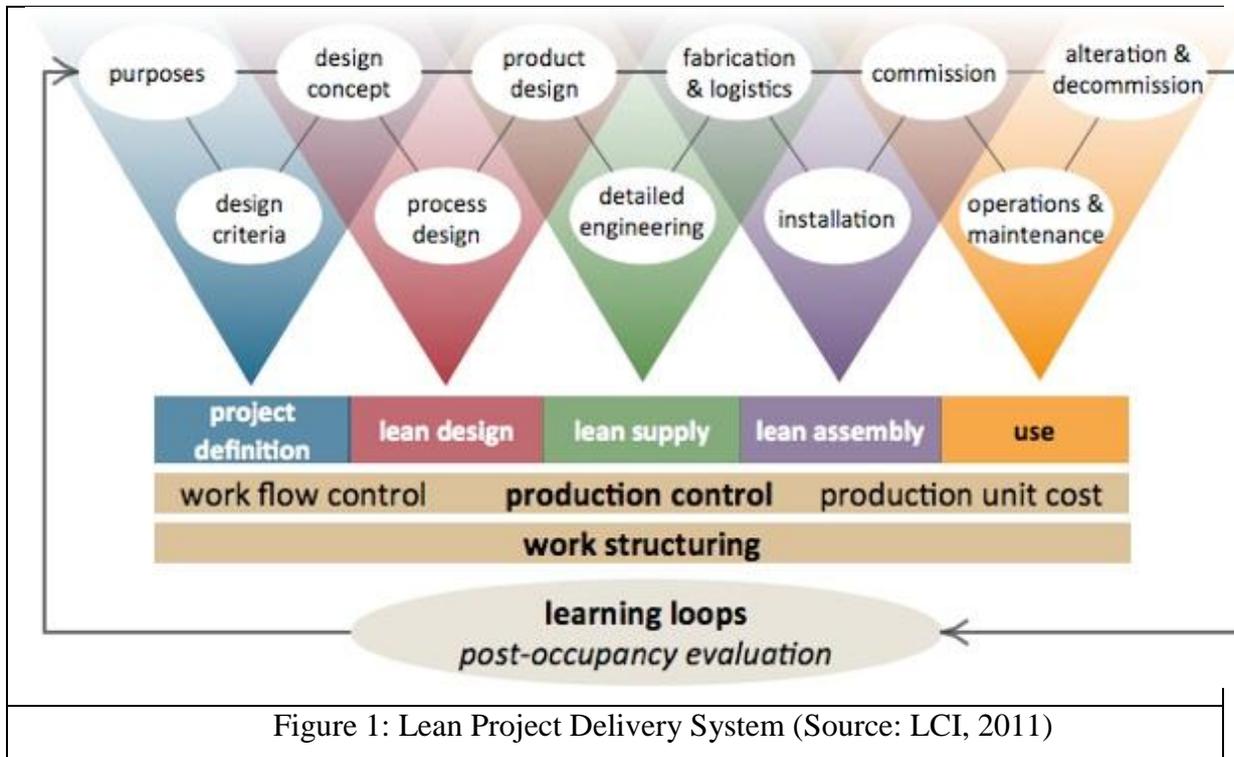


Figure 1: Lean Project Delivery System (Source: LCI, 2011)

- The Lean Supply consists of the modules of product design, detailed engineering and fabrication and logistics. The lean supply phase consists of detailed engineering of the product design produced in the lean design phase, then fabrication or purchasing of components and materials, and the logistics management of deliveries and inventories.

- The Lean Assembly consists of the modules of fabrication and logistics, installation and commission. Lean Assembly begins with the first delivery of tools, labour, materials or components to the site and ends when the keys are turned over to the client. A key issue is coordination of deliveries to ensure soundness of assignments while sizing buffers to residual variability.

The Production Control consists of the modules of commission, operation and maintenance, alternation and decommission. Within this phase commissioning and operating the delivered product is carried out. In addition, maintenance and conducting alternation to meet users' needs are implemented. Finally as the project was initiated it will be terminated.

The Work Structuring is a term created by LCI to indicate the development of operation and process design in alignment with product design, the structure of supply chains, the allocation of resources, and design-for-assembly efforts. The purpose of work structuring is to make work flow more reliable and quick while delivering value to the customer.

Essential features of LPDS include:

- Projects are structured and managed as value generation processes and downstream stakeholders are involved in planning and design through cross functional teams.
- Project control is responsible for execution as opposed to reliance on after-the-fact variance detection.
- Optimization efforts are focused on making work flow reliable as opposed to improving productivity.
- Pull techniques are used to govern the flow of materials and information through networks of cooperating specialists.
- Capacity and inventory buffers are used to absorb variability
- Feedback loops are incorporated at every level, dedicated to rapid system adjustment; i.e., learning.

CASE STUDIES OF PROJECTS BENEFITED FROM PARTNERSHIP IN DELIVERING SUSTAINABLE CONSTRUCTION

Case Study (1) - Tunstall Western Bypass, UK

A high-risk £12m project for the construction of the Tunstall Western Bypass was completed ten weeks ahead of programme, within budget and to the agreed high quality, as a result of the development of a partnering approach between client, consultant and contractor (see figure 2). The challenge was to create an environment in which a combined team of staff from client, consultant and contractor worked together on and off site to anticipate and resolve problems quickly and effectively. Actions taken at the start of the project included (Bennett and Peace, 2006):

- The client adopted an approach of open communication so tenderers were well informed and the brief was clear.
- When the contract was signed, a two-day team-building workshop was held for the entire project team. The workshop focused on changing old adversarial working practices and introduced a new approach of openness and cooperation.



Figure 2: Tunstall Western Bypass, UK (Source: Bennett and Peace, 2006)

The key benefits were:

- The project was completed under budget and ahead of schedule.

- Claims potentially as high as £6m if a traditional approach had been used were prevented by risk management and joint problem solving.
- The final cost was reduced by £800,000 through joint value management and value engineering.
- The client's budgetary control and contractor's cash flow were improved by dispute-avoidance procedures.
- All the concerns of local traders and residents were resolved quickly. Final accounts were agreed within a few weeks of completing the construction work.

This case study shows that the partnering approach adopted helped achieving lean principle objectives in construction. Project partners managed to accomplish the following:

- Eliminate waste of time and money that occur in many construction projects.
- Achieve culture change by creation of a team (client, consultant and contractor) that works together on and off site. Also, by performing a team building workshop for all team members before beginning of work.
- Attain a customer focus by being a main member of the project team on which work is done on and off site.
- Continuous improvement is expected as the better the communication of the team members, the better results.

Case Study (2) - Wastewater treatment plant, Plymouth, UK

In August 1996, client South West Water appointed three partners, contractor Morgan Est. Water Division Civil Engineering, designer Mouchel and process manager Degremont, to refurbish a wastewater treatment plant in Plymouth within a tight schedule and budget (see figure 3). The partners worked as an integrated team and, by June 1999, achieved their cost and programme goals, enabling South West Water to meet tough new legal requirements. On the appointment of the three main partners, a series of workshops was organized, all facilitated by an external consultant. Milestone workshops for interim progress reviews and planning were held on site at varying intervals during the construction period of 18 months. Participants included project manager, site managers, subagents, section engineers and key subcontractors' representatives. They invited staff who operated the wastewater treatment plant to the workshops.

As end users, they contributed much to the development of the project. All subcontractors were involved early in the design process, in order to harness their expertise and make them feel part of the team. Specific meetings were scheduled to draw on their specialist inputs and ideas. Key benefits from the partnering approach included (Bennett and Peace, 2006):



Figure 3: Wastewater Treatment Plant, Plymouth, UK (Bennett and Peace, 2006)

- More certainty in maintaining programme and budget.
- Improved buildability as a result of close relation between the client, designer and contractors.
- The opportunity to apply value management principles continuously as a team.
- The outturn cost of civil works was approximately £100,000 below the target cost.
- Successful minimization of waste (e.g. concrete waste reduced to 1.5%).
- Reduced reworking by doing work 'right first time'.
- No claims submitted by construction firms or their subcontractors working under the partnering agreement.

The partners managed to accomplish the following:

- Eliminate waste of time and money that occur in many construction projects.
- Achieve culture change by creation of a team from the three main partners and by performing workshops for all team members, subcontractors and staff members.

- Attain a customer focus by being a main member of the project team on which work is done on and off site.
- Improved buildability as a result of the open communication between the three main partners.

DISCUSSION

Literature review and case studies showed that delivering sustainable construction projects is a multi-stakeholder process which calls for a wide range of partnership within and between communities, business, industries, and all levels of government. Sophisticated client requirements, project complexity, technology advancement, contractual arrangement as well as the need to achieve sustainability goals necessitate a more extensive collaboration and partnership among project stakeholders, especially public and private sectors. Creating a public-private partnership is paramount for successful application of lean principles. Application of these principles at the different stages of the project life cycle will help minimising waste, maximising resource usage, specifying renewable/recyclable resources, protecting the natural environment, creating a healthy, nontoxic environment and pursuing quality in creating the built environment. The main challenge is how to develop and portray the public-private partnership as well as how it could be activated towards sustainable development in construction. In addition, the strategies that help project partners applying the lean principles at project, organizational and governmental levels need to be investigated. To answer these questions, the following section presents a public-private partnership framework developed by the authors and set the strategic that facilitate and ensure its successful application in construction.

PUBLIC-PRIVATE PARTNERSHIP FRAMEWORK FOR LEAN SUSTAINABLE DEVELOPMENT IN CONSTRUCTION

Background and rationale

A framework is a structure that describes the concepts, methods and technologies required to complete a product process and/or design (EDMS, 2007). The Public-Private Partnership Framework for Lean Sustainable Development in Construction (PPP-LSDC) (hereinafter referred to as “the Framework” or the “PPP-LSDC”) is a proposed framework developed by

this research to facilitate the creation and implementation of partnership between the public and private sectors as an approach for applying Lean principles in delivering sustainable construction projects. . The rationale of the framework stems from the findings gained from literature review and case studies and the increasing call for saving the environment and using natural resources efficiently as well as the necessity to assist government in delivering sustainable construction projects. This could be achieved through creating a partnership with the private sector which has the professional knowledge, capacity and expertise to provide government with the assistance required (Vaughn, 1993). This perspective is supported by a number of initiatives and authors such as Integrated Sustainable Rural Development Strategy (ISRDS, 2000) which agreed with this view and highlighted the importance of private sectors involvement in rural areas development. In addition, Sirbadhoo and Othman (2008) supported this approach by underlined the dominant role of project management firms in the construction industry and the significance of utilising their unique management skills and expertise to help government authorities accomplishing their initiatives for sustainable development.

The Aim and Contents of the Framework

The PPP-LSDC is an innovative business improvement tool designed to facilitate the creation and implementation of partnership between project stakeholders (public and private sectors in particular) towards lean sustainable development in construction. The frame consists of two sections: technical sections and managerial section. The technical section aims to apply the concepts of lean towards achieving sustainability objectives with regard to environment, society and economy, while the managerial section aims to develop the procedures and provide the resources needed to ensure the successful implementation of public-private partnership (see figure 4).

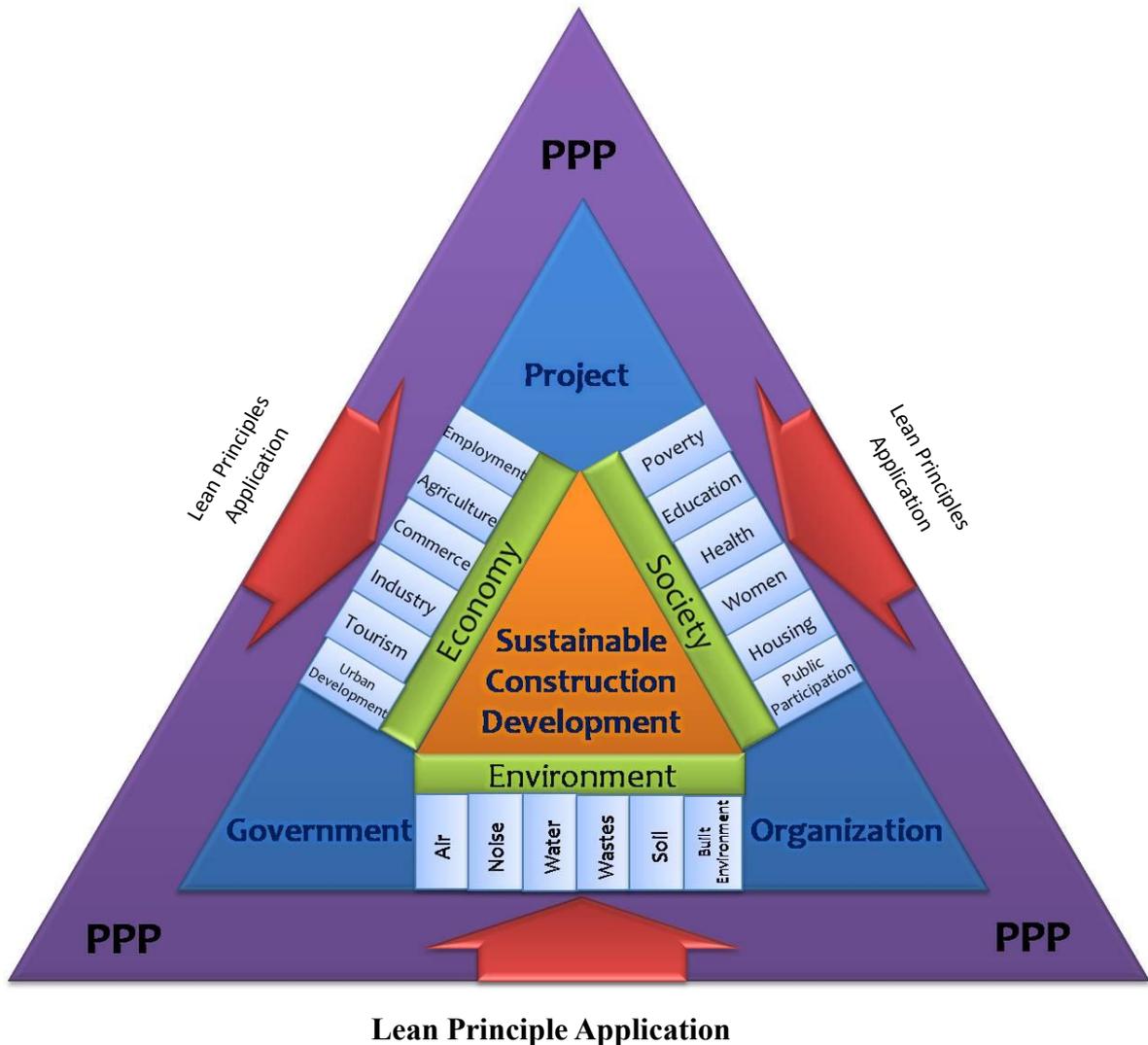


Figure 4: The Public-Private Partnership Framework for Lean Sustainable Development in Construction (PPP-LSDC) (Source: Developed by the Authors)

The Technical Section of the framework

The technical section consists of the three sectors of sustainable development, namely environment, society and economy, see figure (5). In order to reach the sustainability objective, lean principles have to be applied in each of the three levels.

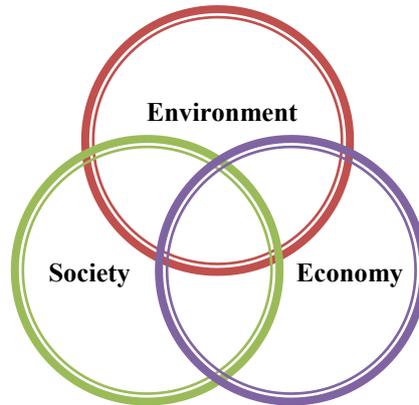


Figure 5: Technical Levels of the Framework (Source: Developed by the Authors)

Environmental Level

By applying lean principles in construction at the environmental level, it allows to maintain a good air quality, low noise impact from the construction project on its surrounding, efficiency in water consumption, elimination of wastes and continuous improvement of the surrounding built environment.

Economical Level

Lean principles aim at reducing production cost and manufacturing cycle times while maintaining or increasing output, which have a positive impact on the construction industry. The continuous improvement of the industry and therefore the economy provides more employment opportunities and an enhanced tourism and urban development.

Social Level

During the schematic phase of a construction project, lean principles aim at achieving customer satisfaction. The design process should put in consideration health factor and the educational level of the surrounding community. In housing projects it's really important to be customer focused in order to satisfy their specific needs. Another factor that should be put in consideration is public participation. Giving the public a role in the decision process gives efficient solutions that result in the elimination of waste in money and time.

The Managerial Section of the framework

This section consisted from three levels, namely project level, organisational level and governmental level (see figure 6).

At the Governmental Level

- Adopting partnership with the private sector and lean concepts as a strategic driver and fundamental vehicle for achieving national social and economic development programmes.
- Developing a set of legislations that promotes the creation and application of partnership between the public and the private sectors as well as benefiting from the diverse knowledge, expertise and skills of partners towards adopting lean principles as an approach for delivering sustainable development in construction.



Figure 6: Managerial Levels of the Framework

(Source: Developed by the Authors)

- Enforcing lean concept as a strategic option for sustainable development when planning new development projects by means of building codes, regulations, voluntary actions, incentives and fiscal instrument.
- Sponsoring seminars, conferences and workshops for escalating the awareness and educating the construction professionals in the governmental and private sectors of the importance and benefits of public private partnership and lean principles to reach the objectives of sustainable development.

- Reducing the governmental fees of issuing building permits and related certifications if developers and construction professionals went into partnership and incorporated lean principles in projects beyond the minimum standard.
- Encouraging national industries to produce lean and sustainable products to facilitate including them in development projects and reduce the cost of importing these materials from abroad.

At the Organisational level

- Including “partnership with government authorities” and incorporating “lean concepts in development projects” as a strategic element in the organisation vision, mission, objectives and strategies.
- Gaining senior management support and accordingly providing all facilities needed to ensure the successful creation and implementation of PPP and Lean principles. This could include for instance conducting training programmes, creating conducive working environment, establishing rewarding systems for doing well projects, educating clients and updating IT support facilities.
- Promoting the collaboration with construction companies and supply chains that are in partnership with government and adopt lean concept in doing their business.

At the Project level

- Developing and maintaining conducive environment that support cooperation and trust between project partners. This will help building shared vision, resolving conflicts, making proper and informative decisions.
- Encouraging team working and having open communications between the contracting partners, which will help reducing project waste and maximizing delivered value.
- Appointing project team members who are aware with and willing to cooperate and apply lean principles for sustainable development in construction. Alternatively, Invest in training and provide employees with necessary knowledge and skills for partnership and lean principles application and do not think that training is expensive or could be ignored.
- Selecting the team leader carefully and establishing the team norms, roles, and effective communication systems as early as possible.

- Establishing an appropriate motivation technique that stimulate and encourage project partners to increase their productivity towards delivering lean sustainable development in construction.

CONCLUSIONS AND RECOMMENDATIONS

The increasing awareness of saving the environment and using natural resources in an efficient way that enables current generations to achieve their objectives without compromising future generations from achieve their own objectives, called for the construction industry to think lean. Through adding value and eliminating waste, lean principles plays a pivotal role towards achieving sustainability in construction. The benefits of this approach could be facilitated and maximized through utilizing the diverse knowledge, skills and expertise of project participants by creating partnership between public and private sectors. Towards putting this partnership in a practical way, a two-section framework, namely technical and managerial has been developed by this research. The technical section focuses on applying the lean principles to achieve the three different aspects of environment, society and economy. The managerial section aims to set the rules end establish the grounds that facilitate the creation of PPP and ensure its application at project, organisation and government levels. The research comes to the following recommendations:

- Government authorities are advised to encourage creating partnership with the private sector, having political commitment towards applying lean principles and providing all resources as well as establishing regulations that ensuring the success of the public-private partnership.
- Construction professionals are encouraged to create partnership with government authorities, use lean products, gain top management support and invest in the human resources towards improving the skills needed to deliver sustainable development in construction.
- Researchers are directed towards identifying the causes that hinder the creation of partnership between the public and private sectors as well as lean principles application and develop overcoming strategies.

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