

# INTEGRATED SUPPLY CHAIN CONSTRUCTION ECOSYSTEM MANAGEMENT

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## ABSTRACT

Agenda 21 may be considered the most significant programme of action influencing environmental policy for the Australian development and construction industry. The industry has remained one of the most rapidly expanding sectors; yet, we have seen the gradual process of exhausting natural resources and irreversible environmental degradation. Even with the introduction of numerous new environmental policies, it remains questionable as to whether real improvements have occurred across the industry. Legislative mechanisms to direct on-site environmental management appear deficient; information flows between participants along the supply chain appear to impact upon environmental management performance; and industry fragmentation remains compounded by ill-defined external, non-contractual *supply chain influences* that directly impact on contractual systems. Limited research has considered construction supply chain theory and environmental management particularly in reference to policy. The literature highlighted a need to develop a supply chain model which seeks to integrate chain actors and government regulators through holistic information management. The model assumes that fundamental to industry change is statutory control to mandate construction environmental management plans. However, industry change and subsequent environmental management rely upon effective information dissemination. The next stage involves model refinement, investigating barriers and enablers to widespread diffusion of such an innovative integrated environmental management system.

## KEY WORDS

Supply chain integration, ecologically sustainable construction, environmental policy, environmental management

## INTRODUCTION

Ecologically Sustainable Development (ESD) is an attempt to meet the needs of the current generation ‘...while conserving ecosystems for the benefit of future generations...’ (EA, 1992). Principles of ESD were recognised approximately 17 years ago at an international level through Agenda 21, at the United Nations Conference on Environment and Development. At the Earth Summit, 176 signatory

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countries to Agenda 21, including Australia, acknowledged the global impact that human activity was having on the environment (EA, 1992).

The Agenda 21 programme may be considered the most significant event influencing environmental policy for the Australian development and construction industry. The industry has typically remained the most rapidly expanding sector (ABS, 2009); however, synonymous with development is the gradual process of exhausting natural resources and irreversible environmental degradation (Tam *et al.*, 2006). Typically the industry generated 32.4 million tonnes of solid waste in 2002-03, with 42% from the construction and demolition sector. This equates to approximately 13.6 million tonnes and positions the industry as the largest waste producing sector in Australia (ABS, 2009).

Within Australia, the commitment of the governmental hierarchy to ESD principles was evaluated immediately after Agenda 21. Subsequently, legislative policies were formulated and implemented across the tiers of government to reduce environmental degradation. However, the policies that emerged generate an extremely complex and confusing system, with little evidence of harmonisation between policy and practice throughout the supply chain. It remains questionable as to the real improvements that have occurred. Legislative mechanisms to direct on-site environmental management practice appear deficient; while, industry fragmentation is compounded by the ill-defined external, non-contractual *supply chain influences* which can directly impact on the contractual system. The question is raised as to whether Australia has a genuine commitment to principles of ESD. Rather, do we wish to portray an illusion of commitment to ESD, yet we really have a poor understanding of construction industry impacts, conflicting policy, insufficient regulatory control and lack of demarcation between regulatory agencies.

“as long as the water is murky, you can’t see what’s going on” (Correia, 2007).

## **NATIONAL STRATEGIES AND LEGISLATION**

Although Commonwealth, State and Territory Governments endorse ESD strategies, Local Government authorities (LGA) are not bound to conform (EA, 1992). Hence, this has enabled local strategy development that may be inconsistent, in conflict with governing policy or designed to conform to local development and political pressure.

The Commonwealth *Environment Protection and Biodiversity Conservation Act*, 1999 mandated State of Environment (SoE) reporting by all Australian States and Territories. SoE reporting demonstrates the policy dilemma, as apart from solid and hazardous waste, building and construction industry impacts are not clearly identified nor acknowledged through any indicator. There remains no ability to accurately assess target areas and industry impacts to ensure appropriate policy formulation.

## **STATE AND TERRITORY LEGISLATION AND POLICY**

Australia consists of 6 States and 2 Territories and for the purposes of brevity this paper will focus on the State of New South Wales (NSW) as it provides an effective example of current policy issues that confront the construction industry. Whereby, the State Government, Department of Planning (DoP) has described the system (refer Figure 1) as a confusing web of conflicting plans and instruments, complex, full of

unnecessary and complicated red tape and consisting of complicated planning instruments (DoP, 2007; DoP, 2009).

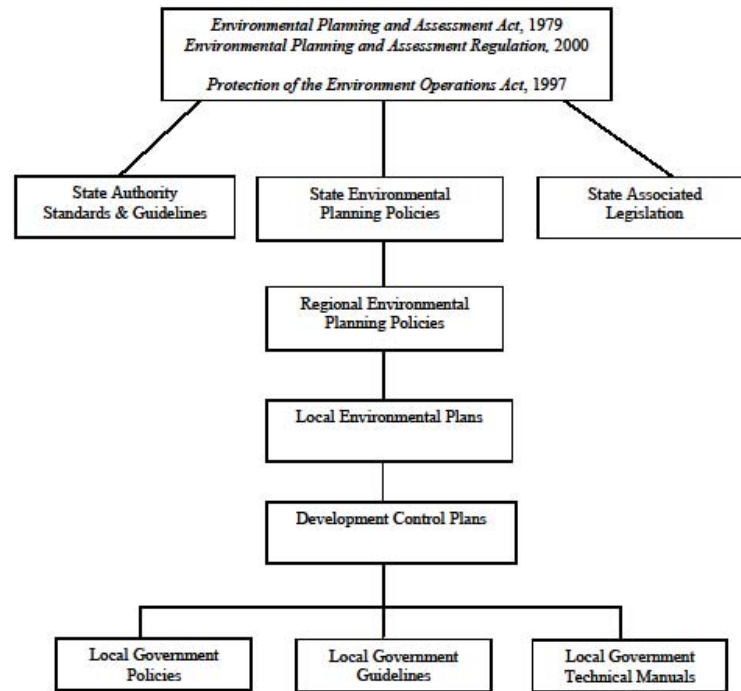


Figure 1: NSW Development Legislation and Policy Hierarchy

The gazettal of the NSW *Protection of the Environment Operations Act* [POEO], 1997 brought significant change to the industry. The NSW Environmental Protection Authority (EPA), now subsumed by the Department of Environment and Climate Change (DECC), came into effect with significant regulatory powers over large scale environmentally sensitive development activity (POEO, 1997). However, a review of EPA prosecutions with Land and Environment Court rulings indicate few proceedings for on-site construction practice environmental offences. Additionally, the DECC Annual Report 2007-08 (DECC, 2009) does not clearly distinguish prosecutions related to construction processes, demonstrating inadequate reporting mechanisms.

The primary Act governing development: the *Environmental Planning and Assessment Act* 1979 (EP&A Act), mandates submission of a ‘statement’ identifying potential environmental harm from proposed development. The Act prescribes areas to be evaluated by the consent authority: environmental, social and economic. Yet, content remain the discretion of the developer and scrutiny of assessor: subjectivity and political environment may regulate assessment. Industry emphasis is upon consent approval and dissemination of this consent information along the supply chain appears deficient.

Legislative impediments governing the industry have been acknowledged by the State and attempts made to reduce system complexity. However, a review of DoP documentation (DoP, 2009) has shown ‘reforms’ equate to additional legislation, policy and the introduction of Arbitrators, Regional Planning Panels and a Planning Assessment Commission: contributing to system complexity.

## **LOCAL POLICY**

Within NSW, regulatory documents, *inter alia*, Local Environmental Plan (LEP), Development Control Plan (DCP), Guidelines and Technical Manuals, may be developed by each LGA. LEP's identify development that is prohibited, permissible with and without consent for various 'land use zones' (EP&A Act, 1979); yet, negate inclusion of on-site construction controls. Interestingly, the DoP 2007 discussion paper identified across the 152 NSW LGA's, there remains in circulation over 3,000 land use zones, 1,700 development definitions and 5,500 planning instruments (LEP's): a myriad of mandatory policy and foundation for industry fragmentation.

Under the umbrella of the LEP, the DCP provides specific development detail. Previously, LGA's were not restricted in the number of DCP's developed. However, a recent policy amendment, attempted to streamline DCP documentation through a limitation of one DCP per LGA (EP&A Act, 1979). Regrettably, the focus on a single DCP for most LGA's has become an amalgamation of all previous DCP's. Therefore the new DCP may become an extremely lengthy document with a myriad of Elements avoiding the streamline approach.

## **STRATEGY AND LEGISLATION ADMINISTRATION**

Nationally, there is an overwhelming amount of legislation and policy that has been introduced to address principles of ESD and regulate the extremely complex and fragmented construction industry. Effectiveness of legislation is dependent upon successive links throughout the supply chain to enable information dissemination, implementation and practice. With a complex and fragmented construction network, involving multiple internal and external stakeholders, it is likely that legislative information remains unknown, confused or misplaced along the system. It is improbable that all construction supply chain stakeholders would have the knowledge and understanding of all applicable environmental legislation, in conjunction with the technical standards and policy associated with their individual professional domain.

With minimal regulatory on-site controls and prosecutions, insufficient enforcement may potentially reflect industry fragmentation. In effect, there is an apparent need for legislative mechanisms that facilitate information dissemination throughout the supply chain. Without appropriate dissemination methods, on-site environmental management and the ability to achieve principles of ESD remain limited.

An integrated supply chain construction ecosystem management model may induce lean construction practice. Such a model would introduce mandatory on-site construction controls: construction environmental management plans, through legislation and simultaneously employ mechanisms to direct implementation, monitoring and regulatory enforcement: distribution of information throughout the construction supply chain.

## **SUSTAINABLE CONSTRUCTION LITERATURE**

Shen and Tam (2002) provide a succinct summation regarding the reality of construction practice upon the environment 'Construction is not by nature an

environmentally friendly activity’. Throughout the literature sustainable construction (SC) has been used extensively; however, it is aligned with a myriad of definitions that evoke an array of conclusions (Du Plessis, 2007; Kaatz *et al.*, 2006). The definition by Kibert (1994) forms a nebulous or broad-spectrum statement, not uncommon throughout the literature: ‘the creation and operation of a healthy built environment based on ecological principles and resource efficiency’. Although such definitions demonstrate ESD appreciation, they may fall under criticism due to generalisation and uncertainty of direction. Matar *et al.* (2008) provide a more operational definition, where “sustainable construction is an emerging field of science that aims at incorporating the general sustainable development concepts into conventional construction practices”.

A literature review of sustainable construction in relation to on-site construction practice identified five dominant themes we have categorised as:

- Environmental Assessment and Evaluation Systems;
- Environmental Construction Design and Operation;
- Construction Waste Management;
- Policy and Environmental Management Planning; and
- Supply Chain Management.

#### **ENVIRONMENTAL ASSESSMENT AND EVALUATION SYSTEMS**

The literature has shown that environmental assessment (EA) and evaluation systems were introduced in an attempt to analyse and improve industry impacts and promote sustainability principles (Cole, 1999). EA, a legislative component of the NSW development approval process, involves the identification and mitigation of project impacts. Yet, it is interesting to note that the literature shows building assessment as a separate entity (see Kaatz *et al.*, 2006).

Although evaluation tools may contend with construction activities, the review has generated discussion around ‘green assessment’ (i.e. building performance against environmental criteria) and ‘sustainable assessment’ (i.e. holistic project assessment: environmental, social and economic) (Cole, 1999; Kaatz *et al.*, 2006). Research has identified assessment methods are generally voluntary mechanisms to promote sustainable practice (Cole, 1999). However, voluntary implementation has not appeared sufficient to induce necessary change.

#### **ENVIRONMENTAL CONSTRUCTION DESIGN AND OPERATION**

SC researchers who we have categorised in this field have typically been associated with the ‘green building’ phenomenon. Researchers in this area investigate more specific technical design issues which are then manifest in the operation phase of the asset, for example, energy efficient structures to reduce energy consumption and water reducing strategies to reduce water consumption during post-construction operation (Barnett, 2000; San-Jose *et al.*, 2007). Primarily, the literature indicates that good design at the pre-construction phase will have beneficial environmental effects at the post-construction phase. A review of the research into this domain has identified a dearth of information surrounding on-site construction practice. Where

the green building phenomenon does not appropriately consider construction impacts, it may be argued that it cannot support the claim of being a sustainable process.

### **CONSTRUCTION WASTE MANAGEMENT**

There is a plethora of literature on waste management in relation to on-site construction environmental impacts with themes including policy formulation, evaluation tools, minimisation and recycling. Predominantly, the literature evaluates construction waste by-products, reduction through improved operational design, possible elimination and disposal upon production (see Delay *et al.*, 2006; Kharrufa, 2006). Policy regulation and economic incentives are often utilised for waste management. Importantly, some form of regulation has generally preceded or run in conjunction with an economic incentive programme (see Begum *et al.*, 2006; Duran *et al.*, 2006) and this highlights statutory legislation as an initiator of industry change. To “enforce” appropriate environmental on-site construction practice, legislation may be the mechanism to drive sound practice.

### **POLICY and ENVIRONMENTAL MANAGEMENT PLANNING**

The literature review has shown policy regulation has the ability to significantly influence industry (see Karuthia, 2005; Shi *et al.*, 2007). Interestingly, regulatory enforcement has been a mechanism by which to assess policy effectiveness (Shi *et al.*, 2007). Shamshack and Ward, (2007) provided support for enforcement, stating that ‘enforcement significantly increases over-compliance’. Furthermore, enforcement involving economic disadvantage has been shown as a precursor to industry change (Earnhart, 2004; Shi *et al.*, 2008).

Recently the United Kingdom introduced the Site Waste Management Plans Regulations 2008 that demonstrate support for formulation and implementation of plans to control construction environmental impacts. Plans concern estimating types and generated waste estimates, with management measures. However, the Regulations apply to projects with an estimated cost of £300,000 and above. Projects under this threshold are not affected by the Regulations (OPSI, 2009); therefore, environmental impacts from smaller projects may be considered negligible. The potential for significant industry improvement may be questioned with the emphasis upon plan preparation rather than mechanisms to execute enforcement.

Self-regulation has received attention within the literature as a mechanism to drive industry change and encourage environmental management practice. Many environmental management systems (e.g. ISO series) exist that guide organisations in the planning and adoption of environmentally sensitive operations. However, researchers have tended to investigate the benefits of system implementation in terms of reduced operating costs and enhanced corporate image (Ofori, 200) with limited emphasis upon on-site construction environmental practice.

The literature review identified the importance of statutory policy to initiate change, particularly with the introduction of enforcement processes. Enforcement identifies the importance of the regulator: a direct impact upon the entire construction supply chain, including on-site construction operations. The literature highlighted a need to develop a supply chain model to integrate chain actors and government regulators through holistic information flow management.

## **SUPPLY CHAIN MANAGEMENT**

The literature has shown that harmonisation between supply chain operations and corporate strategy can produce significant advantage in fiscal management, quality and performance (Cox and Townsend, 1998; Johnson and Leenders, 2006). Research into the construction supply chain is moving out of its infancy phase; yet, the industry has not fully embraced the potential implications with this style of management. The construction supply chain is extremely complex and subject to constant change (London, 2004) and in an attempt to improve the industry a primary driver has been economic advantage: with little emphasis upon how it may be used to achieve environmental protection.

To understand the complexities and relationships specific to construction, that make supply chains unique, the ability to view the “entire” construction supply chain is necessary (London, 2004). In this respect, the literature has not really paid enough attention to external influences upon the industry and how they impact upon information delivery of environmental policy. The construction supply chain has been defined as “a complex web of information systems, operational activities and management techniques that exist amongst entities that maintain relationships of varying strengths with one another” (Wang, 2007). The most salient attribute of this definition lies with the term “entities”. Within this interpretation there is no specific limitation to those involved within the supply chain and it has the potential to move beyond the current view as an expression restricted to suppliers and customer. The interpretation enables introduction of external entities with no contractual relationship yet maintain powerful influence over successful supply chain operations.

Performance and interaction of entities and their ability to accept change, are crucial to effective operational activities. Notwithstanding the foregoing, there remains one central theme to successful supply chain operations: information transfer. The underlying need maintain effective communication channels is considered a fundamental principal to direct change (Ling, 2003; London., 2004; Wang, 2007) and this applies to the construction supply chain. However, flow of policy information, both upwards and downwards, throughout the construction supply chain related to environmental impact control is not clearly understood.

Fragmentation is identified throughout the development process, particularly in terms of information transfer. Understanding complexities of the construction supply chain, external influences and policy interaction will enable identification of barriers and enablers to policy formulation and implementation to reduce disharmony and achieve outcomes. Understanding the construction supply chain in its entirety, including relationships between on-site construction practices and environmental impacts, may influence knowledge and understanding of how we can achieve ESD principles.

## **IMPLICATIONS AND FUTURE RESEARCH**

Literature reviewed indicates a significant amount of research into SC; however, there is a perceptible lack of research relating to construction supply chain theory and environmental management in the context of policy and information flow. Industry fragmentation and poor information transfer may be significant causes of inefficiencies in the supply chain relating to on-site environmental controls. However,

knowledge about the external non-contractual supply chain system relationship remains inadequate. The potential value and effectiveness of construction environmental planning for on-site operations is not apparent. In this respect, the following research questions have been posed:

- Research Question 1: *“To what extent does government policy support construction environmental management”*
- Research Question 2: *“How does information flow impact integrated construction environmental management performance within the supply chain system?”*

Information is required on legislative information transfer and impact along the construction supply chain relating to on-site environmental management. The research involves development of a model that will seek to integrate chain actors through holistic information flow management. The model will assume that fundamental to industry change is the implementation of statutory controls to mandate construction environmental management plans. However, industry change and subsequent environmental management rely upon an effective information dissemination system. Examination of the interactions between all stakeholders, against the barriers and enablers to successful information dissemination will provide the understanding of how process change can be implemented. Additionally, an ability to reduce system fragmentation will enable mechanisms to drive information from the initial design and approval stage through to the on-site construction phase and improve construction environmental performance.

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