UTILISING BUILDING INFORMATION MODELLING (BIM) FOR IMPLEMENTATION OF SUSTAINABLE RESORT DEVELOPMENT IN MALDIVES

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ABSTRACT
Ineffective collaboration within project participants during building process is causing poor implementation co-ordination for sustainable development of resort projects in the Maldives. Attainment of acceptable level of quality in the construction industry has long been a problem. Utilisation of (Building Information Modelling) BIM for implementation co-ordination during building process in Maldives and the implications on two selected projects was studied. The conditions (planning errors, design errors, amendments due to design errors, misinterpretation of drawings, use of 3D models, discontinuation of information, construction practicality, onsite errors, use of prefabrication, amendments due to construction errors and time extensions) identified from the projects were related to its phenomenon of the study to increase quality and productivity while decreasing cost and duration. BIM will improve implementation co-ordination by increasing construction productivity and prefabrication with less rework on site. Innovation in planning and implementation will contribute to make Maldives build a sustainable, eco-friendly construction industry. Effective collaboration will improve implementation co-ordination and integration through BIM during building process with innovative planning in the Maldives, hence improve construction industry and develop sustainable resort projects.

Keywords: *BIM, implementation co-ordination, sustainable development, construction*

1 INTRODUCTION

The main contributor any country's economy and infrastructure is the construction industry. However the industry faces many problems of high fragmentation, instability, low productivity, poor quality and lack of standards (Metri, 2005). As building projects gets larger and complex, clients are also demanding increasingly higher standards for their delivery.

There is an urgent need to integrate technology with innovative planning to minimise errors during construction process in the Maldives to plan towards sustainable buildings in the resorts. Such obstruction will cause cost overruns and exceeded time schedules due to conflicts and controversies concerning project design and implementation during construction. A case study consisting of two similar resort projects with the same bed capacity and star rating within the Ari atoll (Maldives) was undertaken for the purpose of study. The problems of managing concerns of implementation coordination and technological integration in developing sustainable resort projects in the Maldives were evaluated. Utilisation of Building Information

Modelling (BIM) for implementation coordination during building process in Maldives and the implications on two selected projects were evaluated.

Utilisation of BIM for co-ordination during building process in Maldives and the impact on the projects will be studied. The growing demand for 3D tools from the design and construction community to adopt the current industry has changed dramatically. Utilising building information modelling (BIM) on an actual project is a complex process that involves a well-co-ordinated attempt. It was found that BIM can have a significant impact on the execution of a project. One of the fundamental principles of BIM is the concept of continuously improving the building process and the relationship among the parties involved in the process (Azhar *et al.*, 2008a). The supplier, the processor and the customer is very important for the quality of work process and therefore for the quality of product itself (Arditi *et al.*, 1997). Project delivery in construction is highly dependent on the effectiveness of the team put together to implement the project. The organisational priorities for collaborative working will be considered together with project needs, users' requirements and technologies to develop a decision making framework that can facilitate the strategic planning and implementation of effective collaborative working policies and practices.

Sustainable development can significantly reduce adverse human impacts on the natural environment while simultaneously improving quality of life and economic wellbeing. BIM will increase construction productivity and prefabrication with less rework on site. Incorporation of technology with innovative planning to improve construction implementation will be focused in the study. To achieve sustainability through interaction, integration by identifying relationship between ecological and socio-economic systems will be the main contribution to the construction industry.

2 DEMOGRAPHY AND RESORT SETTINGS IN MALDIVES

Maldives situated in the Indian Ocean, consisting of 1196 coral islands is grouped in 26 geographical atolls. However, the government of Maldives grouped these atolls in 19 administrative divisions and these divisions are sub grouped in to 7 provinces under Decentralisation Act 2010. From 1196 islands 192 islands are inhabited and 101 islands are developed as resorts. In addition to this, there are 41 resort islands currently under construction to be developed and will come to operation within the period 2013-2015 as published in Tourism Year Book 2012 (Appendix A). The islands in the Maldives are low laying at an average height above sea level of 1 meter. Maldives have a population of 328,536 (2012) and today the number of tourist arrivals are more than 900,000 (2012). The people of the Maldives are 100% Muslims and speak in Dhivehi language. The local script of Maldives is known as Thaana.

Former President Ibrahim Nasir (1968-1978), introduced tourism in the Maldives and the first resort Kurumba Village in Maldives was opened in 1972, since then the tourism in Maldives has flourished. The tourists who visit Maldives, arrives at Ibrahim Nasir International Airport (INIA), a separate island near Malé, the capital city which is reachable by boat in 10min. The tourists are usually transferred to the designated resorts by speed boats or sea planes. Sometimes the domestic flights are also used to transfer tourists from INIA to regional airports. However these tourists require boat transfer from regional airports to the resorts. Tourism in Maldives started with just two resorts, Kurumba Village and Bandos island resort. At the beginning of tourism the total bed capacity was 280 in two resort islands and currently it has grown to 22,120 beds in 101 resort islands (Appendix A).

Today the largest contributor to the economy of the Maldives is the tourism industry and the second largest is the construction industry (Appendix A). The construction industry plays a major role in the development of these resorts. The government of the Maldives has statutory bodies to regulate and monitor the construction and development of the resorts. However, there are no previous studies related to either construction or resort development in the Maldives found up to this date other than financial and statistical surveys.

3 BACKGROUND PROBLEM

Construction is a vital sector that contributes to the economies of all countries (Aouad *et al.*, 2010). This assertion is further strengthened by Kulatunga *et al.*, (2011), stating that, this industry holds the overall potential of the whole economy. However, in the Maldives tourism is the main contributor to its economy playing an important role in foreign currency income and generating employment opportunities in the country. The main attraction of the Maldives archipelago is the white sandy beaches and coral reefs surrounding the small islands that are built as resorts. Therefore, it is imperative to acknowledge the close attachment of the construction and tourism industry and their contribution to the country's economy.

Small island nations like Maldives is vulnerable to the climate change. The growing demand for sustainable buildings in the resorts has impacted on all aspects of the built environment. The use of prefabricated modular design systems in resort will make a dramatic change. Construction design and building process can contribute greatly to make Maldives build a sustainable, eco-friendly and green/lean construction industry.

Significance of innovation in planning, how it affects the quality of design and the end product by identifying changes and adjusting the schedule in the most efficient manner will benefit all parties involved in building process by BIM. Minimising errors from a well-co-ordinated interaction and achieving common objectives that could lead to significant decrease in capital cost. The evaluation process through BIM can help the design team for better interpretation of future buildings and realisation of their visions by utilising sophisticated programs like Autodesk Revit, 3ds Max and VR4Max (Ku *et al.*, 2008). The primary cause for the decline of construction productivity directly or indirectly involves poor management practice. Quality is part of productivity, hence the first step for the organisation to recognise the problems (Arditi *et al.*, 1997).

Understanding the complex process of producing a quality building which involves technical knowledge to create a set of specific instructions for the construction and where the production is the responsibility of contractors, they tend to perceive project as simple as possible for easy production. The sources of costs associated with the no achievement of quality include the costs of rework, correcting errors, reacting to customer complaints, having deficient project budgets due to poor planning, and missing deadlines (Culp, 1993).The resort developers in the Maldives still tend to use traditional construction methods such as coral masonry, where coral is taken from the island reef. This has a negative impact on the vulnerable environment and surrounding of the island.

Introduction of new materials and technologies will be incorporated during implementation and building process. Clients should move away from the usual practice of awarding tenders to the lowest price and advocate rewarding the best designers and suppliers who could provide the best service (Pheng *et al.*, 2004). The competitive pressures will lead to create supplier partnerships by choosing suppliers based on quality rather than price. Construction industry is in need for innovation in planning and implementation which allows the project team to identify the order of extent those different technological characteristics that have had on construction productivity (Mawdesley *et al.*, 2010). BIM has transformed the way buildings are designed, constructed and managed (Hardin, 2009; Azhar *et al.*, 2009).

Prefabrication and modular designs will lead to sustainable buildings, eco-friendly housing and green/lean construction. Prefabricated modular systems have greater energy efficiency, lower construction waste, faster construction time, and better structural stability, which results better long-term investment (Mawdesley *et al.*, 2010). The greater the capital investment in construction is, the less the amount of money remaining to operate and maintain the facilities and to spend on other things. The lower the amount spent on construction, the slower the development, the lower the quality of the facilities provided, the smaller the benefits and the smaller the opportunity for improvement (Mawdesley *et al.*, 2010). The main objective of sustainable buildings in Maldives is to avoid resource depletion, environmental impacts and create built environment that is comfortable, safe and productive. The existing practice of resort construction needs to change in order to acquire sustainable resort development.

The process of resort development in the Maldives begins from leasing of the island by the government. This is done by opening to a competitive bidding of proposal among developers, which includes the concept design. After evaluation of the proposals the resort are awarded to the best bidder. The construction of resort then completely relies on the developer.

The developer proceeds with detail designing of the resorts. The documents and drawings are prepared before selecting a contractor. Construction documents needed for tendering were prepared by the design firm hired by the developer. The design firm also act as a consultant during the design and construction of the project. In addition, the design firm represents the developer in dealing with the contractor and the government authorities. The detail design stage and construction take place separately. The operations and facility management commences at the last phase of the project. Figure 1 summarises the existing practice in the Maldives.

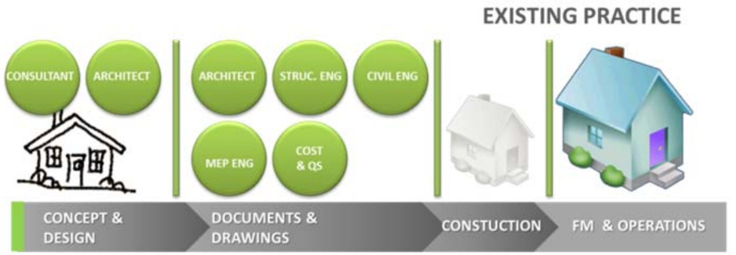

Figure 1: Existing conventional process of design and construction in the Maldives

From the early concept stage to operations and facility management involves different teams to execute the project and it requires coordination to minimise errors during project lifecycle. Since the researcher is a government official working in Construction Industry Development Section (CIDS) as a regulatory body it was realised that these problems can be addresses by policy interventions. However, the researcher needs to ascertain first, whether any new technology would be beneficial to another country who wants to adopt the technology. In this case, researcher is to determine whether it would make significant differences if Maldives were to adopt the BIM technology compared to its current traditional practice of construction approach.

4 UTILISATION OF BUILDING INFORMATION MODELLING

All buildings constructed are unique. Quality is seen as consisting of those product features which meet the personalised needs of the customers and thereby provide product satisfaction, supplemented with a provision of freedom from deficiencies (Sommerville *et al.*, 2000).

BIM in current form is capable of supporting the collaboration between various stakeholders by acting as an information backbone through the entire building lifecycle (Isikdag *et al.*, 2010). With BIM technology, an accurate virtual model of a building is digitally constructed to precise geometry and including relevant data needed for construction, fabrication and procurement activities required to realise the building (Eastman *et al.*, 2008). Sunesson, *et al.*, 2008, state that 3D/VR models in the evaluation process can help the design team for better realisation of their visions and the parties involved to enhance their need for information about the future building and how these models are well interpreted . Identifying the areas in which the knowledge can be improved with 3D and VR modelling, dealing with the issues from conceptual stage to execution on site. Allowing interacting with building designs, concepts and allows to view different perspectives.

Health and safety issues can also be effectively tackled. The integration of 3D/VR models will have an impact on architectural profession and the involvement of different professionals in the urban construction process shows that it provides a better window to the general public to understand the construction planning process. Building Information Modeling (BIM) is an innovative technology that has transformed the way buildings are designed, constructed and managed (Hardin, 2009; Azhar *et al.*, 2009). It provides a framework that combines visualisation and parametric modelling that allows simultaneously consider the interdependent processes of planning, analysis, design and construction (Casey, 2008; Azhar *et al.*, 2008b). BIM is a shared knowledge about the information for decisions making during its lifecycle (Kumar *et al.*, 2009). The construction analysis module reads from an external database of available equipment and labour, and formulas for the duration calculation. However there are certain factors that can affect the planning process by the 3D generated model and order.

Knowledge representation was initially followed by a computational approach to research how far this approach can go to produce a reliable planning (Vries and Harink, 2007). The complexity of construction projects makes construction planning a particularly difficult task for project managers due to the need to foresee and visualise possible future events. Virtual prototyping offers an improved method through the visualisation of construction activities by computer simulation. This enables a range of 'what-if' questions to be asked and their implications on the total project to be investigated (Li *et al.*, 2008). The successful implementation of complex-shaped buildings within feasible time and budget limits has brought attention to the potential of computer-aided design and manufacturing technologies (CAD/CAM).

From two-dimensional (2D) paper-based representations to three-dimensional (3D) geometric representations in building information models (BIM), architects and engineers have streamlined 'inner' design team co-ordination and collaboration. It was found that BIM (3D and 4D modelling) can have a significant impact on the execution of a project (Ku *et al.*, 2008). A building information model carries all information related to the building, including its physical and functional characteristics and project life cycle information, in a series of "smart objects" (Azrah *et al*. 2008a). However quality teams are necessary for successful utilisation of BIM in construction process. Training for integration of BIM should be executed through well planned team structure. The ultimate goal of the team approach is to get everyone involved including contractors, designers, suppliers, stakeholders and owner to be part of the process and BIM for effective co-ordination or communication during the building process.

4.1 Co-ordination with Building Information Modelling

BIM is one holistic documentation process beneficial for operational visualisation, and construction application such as estimating, scheduling and design co-ordination (Kumar *et al.*, 2009). Gibson, (2000) stated that, a negative attitude to a construction project by stakeholders can severely obstruct its implementation. Such obstruction will cause cost overruns and exceeded time schedules due to conflicts and controversies concerning project design and implementation. A project stakeholder is a person or group of people who have a vested interest in the success of a project and the environment within which the project operates. The implication is that a stakeholder is any individual or group with the power to be a threat or a benefit. Thus, project management must be able to analyse the various demands presented by stakeholders so that communication between them is facilitated.

BIM models are created, to scale, in 3D and all major systems can be visually checked for interferences by all project participants in a single data base (Figure 2). This process can verify that piping does not intersect with steel beams, ducts or walls (Azhar *et al.*, 2008). Hence, the dilemma for the project management is to balance the use of resources with the appropriate strategy towards each individual stakeholder group (Olander *et al.*, 2005). For the construction industry to survive the current turbulence in the economic atmosphere, it has the option of integrating new initiatives to march the uncertainties. Programme management is seen as an efficient vehicle to successfully deliver the improvements and changes (Shehu and Akintoye, 2010). The changes made in this Model are automatically coordinated throughout the project, which eliminate the coordination mistakes, improve overall quality of the work (Kumar *et al.*, 2009).

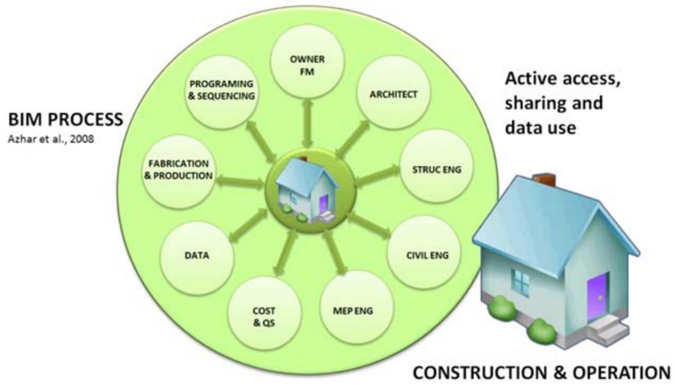

Figure 2: BIM process (Azhar *et al.*, 2008a)

However, the implementation of any new system or change initiatives has always been a challenging task; some of these challenges can be faced during the implementation or at practice stage. Due to the lack of clarity surrounding programme management in the construction industry, the understanding of these major challenges remains vague (Shehu *et al.*, 2010). The methods by which small firms overcome the disadvantages of their size to implement innovation on construction projects are found that such methods include working with advanced clients, prioritising relationship-building strategies and using patents to protect intellectual property. Key obstacles to innovation implementation by small firms on construction projects are found to be bias in the allocation of government business assistance and regulatory inefficiencies under federal systems of government (Manley, 2008).

Therefore the answer to the construction industry's continuing problems is said to lie in building a stronger innovation culture to improve the rate and quality of innovation across the construction system, particularly given increasing client demands for integrated services (Hartmann, 2006). BIM is a different approach of thinking about goals, organisations, processes, and people to ensure that the right things are done right the first time. Implementing BIM is a major organisational change that requires a transformation in the culture, process, strategic priorities, beliefs, etc. of an organisation (Motwani, 2001).

Collaborative working is considered by many to be essential if design and construction teams are to consider the whole lifecycle of the construction process (Shelbourn, M., Bouchlaghem, N.M., Anumba, C., and Carrillo, P. 2007). Much of the recent work undertaken on collaborative working has focused on the delivery of technological solutions with a focus on web (extranets), CAD (visualisation), and knowledge management technologies. Visualisation allows stakeholders to view detailed and often complicated sets of information in a format that is easily recognisable. Particularly give clients and end-users the ability to see the finished facility before onsite activities begin. This means that changes (from the client or conflict resolution) can be made earlier in the process (Caneparo, 2001; Sriprasert and Dawood, 2005; Whyte, 2005). It combines technology with the people and business aspects of collaborative working to provide an approach which can enable stakeholders in a project to benefit fully from having a collaborative working approach to their projects.

The negative side of a construction project can be deterioration of the physical environment for the affected stakeholders (Olander, 2002). It is worthy of note that although many of the respondents described their organisations as working towards collaborative and strategic partnerships with their supply chains, there is actually little evidence of this actually being achieved (Shelbourn *et al.*, 2007). The innovation in organisation wanting to utilise BIM would include consideration to be given to the following: customer focus, continuous improvement, leadership, employee involvement, teamwork, customer–supplier relationship, and process improvement.

4.2 Planning towards Sustainability with BIM

In order to pursue sustainability in the construction industry, existing development-focused construction activities must be transformed via a new paradigm focusing on sustainable development through the adoption of sustainable policies by the government and the development and dissemination of sustainable construction technologies (Tae and Shin, 2009). Shen, L., Tam, V.W.Y., Tam, L., and Ji, Y. (2010) state that, the importance of incorporating sustainable development principles in conducting project feasibility study is not effectively understood by project stakeholders. Since TQM is a customer oriented organisation to maximise customer satisfaction rather than internal efficiency, considering the next person in line who uses his output (Pheng, 2004). To enhance the effectiveness of internal efficiency in construction projects utilisation of BIM tool will establish a strong co-ordination. Sustaining environmental viability is the subject of discussion for our global community today, and transition of architectural building construction toward a sustainable industry for the sake of preserving our Earth's environment is now a critical necessity.

The governmental and commercial organisations that successfully innovate in sustainability go through eight consecutive stages of interorganisational innovation, and perform twenty-two interaction patterns that are part of these stages (Bossink, 2007). Recognising the innovative nature of green niches at the policy level could lead to new approaches to governance of bottom-up community action for sustainable development (Seyfang, 2009). With reference to construction business, sustainability is about achieving a win–win outcome for contributing to the improved environment and the advanced society, and at the same time for gaining competitive advantages and economic benefits for construction industry. Innovation in planning will maximise organisational output where BIM maximises construction productivity by minimising errors and identifying problems prior to construction process. Sustainability concerns the interactions, integrations and significant relationships among ecological, social, and economic systems (Shen *et al.*, 2010).

5 RESEARCH METHODOLOGY

In order to tackle the problem identified in this study a single, explanatory case study was conducted to understand the phenomenon since this allows investigating real life events (Yin, 2003). Case study can be seen to satisfy the three tenets of the qualitative method: describing, understanding, and explaining. According to Yin (2003), the case study strategy is useful when question are being asked about current events, where the investigator has no control, on the data collection environment.

A comparative case study is performed in this research, which undertakes two resort development projects in the Maldives. Data was gathered from interview, documents and direct observation for reliability and accuracy of the data. However the analysis was done by generalisation and pattern-matching. Yin (1994), pointed out that generalisation of results, from either single or multiple case-study, is made to theory and in complex and multivariate cases, the analysis can make use of pattern-matching techniques (figure 3).

During the study eleven conditions (planning errors, design errors, amendments due to design errors, misinterpretation of drawings, use of 3D models, discontinuation of information, construction practicality, onsite errors, use of prefabrication, amendments due to construction errors and time extensions for construction) identified from the projects were related to its phenomenon of the study to increase quality and productivity while decreasing cost and duration. The contractual and procurement method must be carefully planned and selected to accomplish project objectives. BIM will improve implementation coordination by increasing construction productivity and prefabrication with less rework on site. Better coordination to minimise errors in design, construction and management of the projects with BIM accounts for the improvement to the project lifecycle of the project to build a sustainable and eco-friendly construction industry.

6 CONCLUSION

In order to pursue sustainability in the construction industry, existing development-focused construction activities must be transformed via a new paradigm. Construction industry must realise that results of implementing BIM will take ample time. Since it is long-term achievement rather than short-term objective, the industry should develop a culture that will support innovation in planning. Recognising the innovative nature of green construction at the policy level could lead to new approaches to governance of bottom-up community action for sustainable development. Also the TQM aimed at sustainability, are modelled as interorganisational innovation processes. In parallel with green technology and techniques, the involvement by the stakeholders should be the most important factor for the preparation of green specifications.

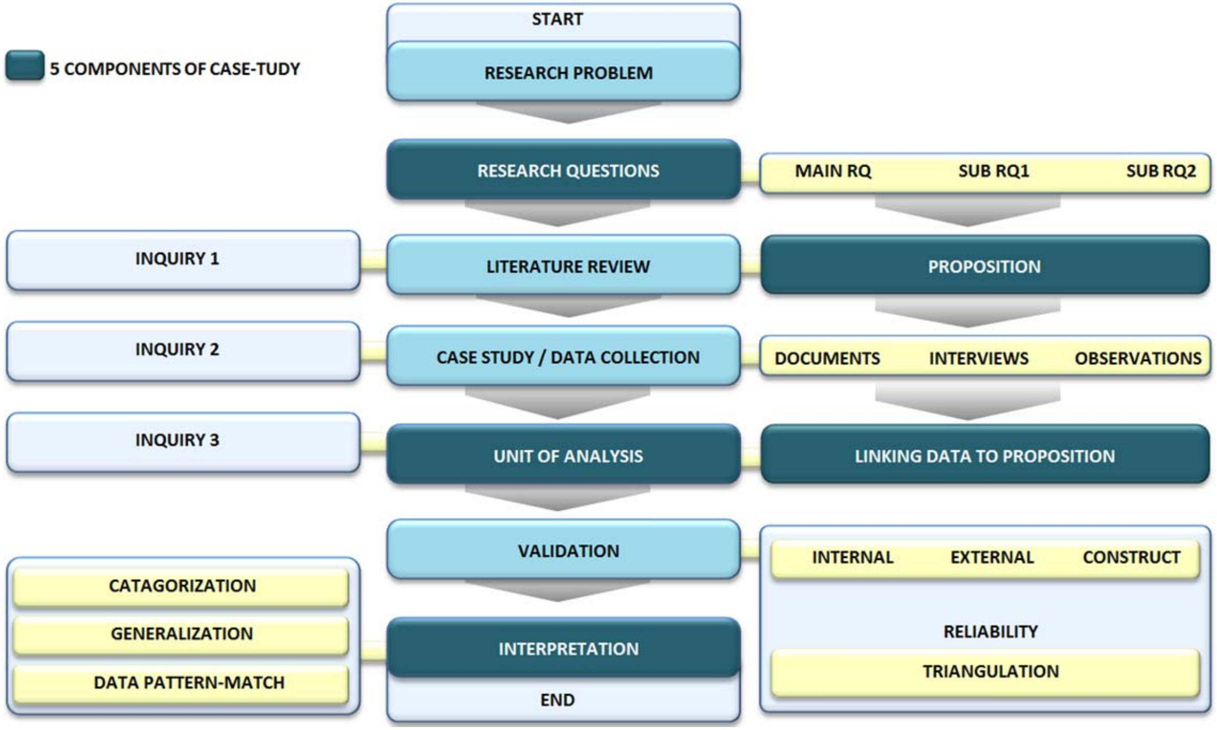

Figure 3: Conceptual Eagle Research Design Workflow of the research (adapted from Ibrahim 2011)

This study supports that the deployment of BIM will bring sustainable developments with project sponsor satisfaction together with economic and environmental benefits. Figure 4 illustrates that the innovation in planning through effective coordination and integrating technology with BIM are vital for sustainable developments. The researcher witnessed that improving implementation coordination is crucial to achieve project sponsor satisfaction and sustainable development. Hence the study would like to propose the need to utilize BIM for implementation coordination by integrating changes in technology to establish sustainable resort developments in the Maldives. It is via new paradigm in design, construction and management of projects by BIM which is precise and accurate for effective coordination that produces sustainable projects.

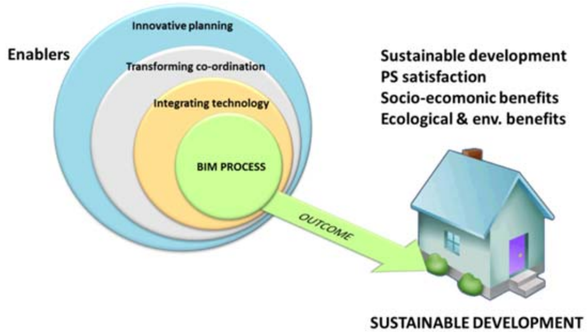

Figure4: Enablers for sustainable development

The researcher suggests that the integration of BIM should occur from early conceptual stage, since it includes all information related to project lifecycle. This includes planning, designing, construction and facility operations (Figure 5). Effective collaboration will improve implementation coordination and integration through BIM during building process with innovative planning in the Maldives, hence improve construction industry and develop sustainable resort projects. Achieving sustainability through coordination and integration by BIM and identifying relationship between ecological and socio-economic systems will be the main contribution to the construction industry in Maldives.

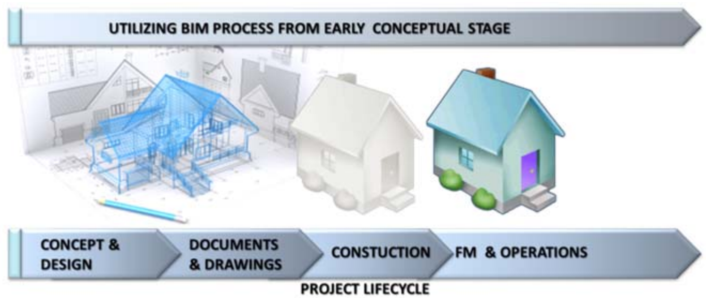

Figure 5: Project lifecycle of a sustainable construction project

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