In a linear economy, recyclable materials are not directed into the production process, and it causes long-run issues from the perspective of sustainability (Curran and Williams 2012). Hence, authors have declared, zero waste can be implemented with the rejection of one-way linear method and using a circular closed-loop system. Elgizawy et al. (2016) have further elaborated that the cradle-to-cradle approach should be used for the efficient use of materials. Figure 1 presents the linear and circular resource flow.

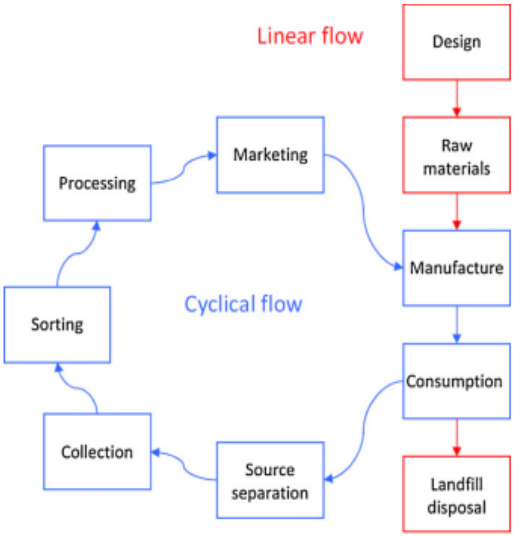

Figure 1 : Linear and circular resource flow
Source : Curran and Williams (2012)

Curran and Williams (2012) have defined zero waste as a whole-system approach that aims to 'eliminate' rather than 'manage' waste. Further, all discarded materials that are designed to become resources for others to use are also defined as zero waste (ZWIA 2015). Zaman and Lehmann (2011) defined zero waste as the recovery of all resources from waste materials, and the zero waste challenges the traditional waste management system within which, at the end of the product life, is considered as waste (Zaman 2014). The author states waste is transformed into a resource through zero waste and redirected to the production process holistic zero waste management systems. Further, the author explained zero waste management get created as a result of design integration and waste management philosophies. The implementation of zero waste promotes high recycling levels, valuation of resources that are generated from waste, prevention of waste, and changes in behaviors (Pietzsch et al. 2017). Table 2 shows the development of the zero waste concept over the past years.

Table 2. : Key milestones of zero waste concept development
Source : Zaman (2015)

Year	Country	Milestones/Events
1970	USA	The term "Zero Waste" was coined by Paul Palmer
1986	USA	The National Coalition against Mass Burn Incineration was formed
1988	USA	Seattle introduced the Pay-As-You-Throw (PAYT) system
1989	USA	The California Integrated Waste Management Act was passed to achieve 25% waste diversion from landfills by 1995 and 50% by 2000
1990	Sweden	Thomas Lindhqvist introduced "Extended Producer Responsibility"
1995	Australia	Canberra passed the "No Waste by 2010" bill
1997	New Zealand USA	• The Zero Waste New Zealand Trust was established • The California Resource Recovery Association (CRRA) organized conference on zero waste
1998	USA	Zero waste was included as guiding principles in North Carolina, Seattle, Washington, and DC

1999	USA	The CRRA organized zero waste conferences in San Francisco
2000	USA	The Global Alliance for Incinerator Alternatives were formed
2001	USA	Grass Roots Recycling Network published "A Citizen's Agenda for Zero Waste"
2002	New Zealand USA	• The book Cradle to Cradle was published • Zero Waste International Alliance was established • The first ZW summit was held in NEW Zealand
2004	Australia USA	• ZWIA gives a working definition for zero waste • GRRN adopts ZW business principles • Zero Waste SA was established in South Australia
2008	USA	The Sierra Club adopted a zero waste producer responsibility policy
2012	USA	• The documentary film Trashed premiered at the Cannes Film Festival • The Zero Waste Business Council was established in the USA

To remove the environmental threats caused as a result of human consumption and unsustainable behaviors, product design, and waste management principles are considered within the zero waste philosophy (Zaman 2014). The authors emphasized, to extend the lifecycle of the product in a zero waste product design, products are designed in a way they can either be reused or repaired. The authors also stated that pollution of the natural environment is avoided through the zero waste management process, as waste is recycled and recovered. Moreover, zero waste encourages the diversion of waste from incineration and landfills (Curran and Williams 2012). Figure 2 illustrates the historical development of waste management up to zero waste system.

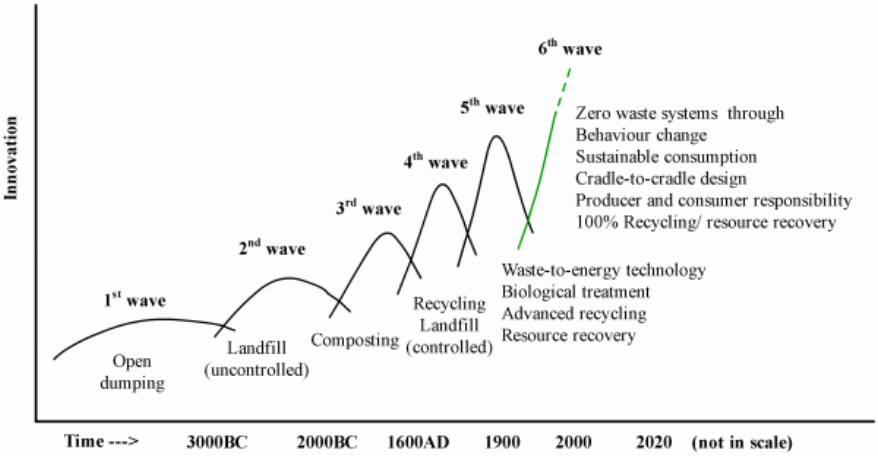

Figure 2 : Schematic waves of innovation management system
Source : Zaman and Lehmann (2011)

In the schematic waves of the innovative waste management system, open dumping is the first wave still practiced in low-income countries; uncontrolled landfills are considered as the second wave while composting is the third wave (Zaman and Lehmann 2011). The authors stated the fourth wave focuses on recycling and controlled landfill, whereas the fifth wave focuses on waste-to-energy technologies such as incineration, pyrolysis-gasification, and plasma arc. Finally, the sixth wave of innovation focuses on sustainable waste management system through zero waste, and include the recovery of resources from waste, sustainable resource consumption, and cradle-to-cradle closed-loop design systems.

3.3. Zero Waste Strategies

Effective strategies are a need for implementing the zero waste concept (Zaman 2014). Zero waste system comprises four levels, i.e., design, manufacturing, application, and recycling and disposal (Song et al. 2015). According to Curran

and Williams (2012), different strategies can be followed to implement zero waste in the construction industry. Out of the identified strategies, the authors have selected Eco-design, Industrial Symbiosis, Closed-loop supply chain management, Innovative technology, Product stewardship, Life cycle assessment, and Environmental Management System as the key strategies to implement the zero waste concept.

- **Industrial Symbiosis (IS)**

Industrial Symbiosis is identified as a part of industrial ecology concept (Curran and Williams 2012). Yazan et al. (2016) have stated that more attention is paid towards the waste reduction in the production economies. The authors further reported IS has forced to provide waste as a primary resource to other companies, which will ultimately reduce the adverse environmental impacts near industrial areas.

- **Life Cycle Assessment (LCA)**

Measurement of impacts throughout the entire life cycle, starting from the raw material extraction up to end disposal of the product helps to identify the environmental effects of the product, and also to have sustainable production and consumption patterns (Curran and Williams 2012).

- **Eco-Design**

Eco-design could be defined as, starting from the origin of the product, thinking about the entire life cycle and environmental impact reduction, throughout the product life (Vallet et al. 2015). As per Bhamra (2004), Eco-design is defined as the integration and balancing of the existing design practice considering cost, quality, and functionality. In order to manage ecological issues related to the types of C&D waste, the client and design team awareness is needed (Ball 2002). Also, sustainable construction techniques and materials are required for the eco-friendly construction industry (Torgal and Jalali 2012), and in the ecosystem, waste is designed out of the system to achieve real waste reduction (Curran and Williams 2012).

- **Closed-Loop Supply Chain Management**

According to Krikke et al. (2004), closed-loop supply chains comprise of reverse and forward supply chain. Authors elaborate that loops can be closed through reusing the whole product, components, or materials. Moreover, Morana and Seuring (2011) stated that closed-loop supply chain deals throughout the product lifecycle. The supply chain of the construction industry could be explained under four roles as focus on the impacts of the supply chain on on-site activities, focus on the supply chain and to reduce costs in logistics, lead-time, and inventory, focus on transferring activities from the site to earlier stages of the supply chain, and finally, focus on the integrated management and improvement of the supply chain and the site production (Vrijhoef and Koskela 2000).

- **Product Stewardship / Extended Producer Responsibility (EPR)**

Management of impacts of a product throughout the life cycle of the product until the disposal is identified as the product stewardship (Zaman and Lehmann 2011). Further, authors have elaborated, once the consumer stops using the product, the producer has to take back the product in product stewardship. According to Zaman and Lehmann (2011), EPR is also identified as a product stewardship principle and take-back principle. Authors have stated that in the innovative packaging and product design, EPR is a vital tool to reduce waste generation in the production process, and EPR takes responsibility for each action and work. EPR is a strategy used in the recycling process (Chavan 2014). Accordingly, through the EPR, the manufacturer is responsible for the entire lifecycle of the product, and the manufacturer is liable for the take-back, recycle, and final disposal. EPR model comprises of four responsibilities as informative, physical, financial, and liability (Manomaivibool 2008), and EPR is an important tool to reduce and avoid major waste volumes during the production process of the product (Lindhqvist 2000).

- **Environmental Management System (EMS)**

EMS helps to achieve environmental obligations and performance goals by identifying problems and solving the problem with the systematic management of environmental activities of the organization, and the plans, schedules,

implementation, and monitoring of events take place to improve the environmental performance through EMS (Curran and Williams 2012).

4.0. Conclusion

C&D waste is a persuasive issue that needs to be addressed since the construction industry is considered a leading contributor to solid waste generation. C&D waste comprises of rubble, sand, cement, timber, plastic, brick, concrete, tile, aluminum, steel, paper, and cardboard. The generated C&D waste triggers health, environmental, and social and economic issues, and hence, strategies such as the 3R concept, WMD, waste reduction at source, waste hierarchy, and zero waste are being followed.

Zero waste concept is considered one of the idealistic methods to manage the generated C&D waste as a resource. In order to adopt zero waste concept, strategies such as eco-design, innovative technology, product stewardship, life cycle assessment, and industrial symbiosis are being followed. Development of a framework for adopting zero waste in the construction industry will be the final outcome of this research project.

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