Green Construction Sector:
Buildings & Campuses

HIGHLIGHTS

Growth Forecast for Green Construction in India	Job potential for Green Construction sector	Occupational map for Green Construction sector

Preamble

Green issues have been gaining prominence for the past two decades. With the rising oil prices and phenomenon like global warming affecting us, it is imperative that we take a closer look at adapting and making our infrastructure resilient. The definition of "Green" is quite wide and wide spectrums of issues are subsumed within this umbrella. Some of the major issues that fall under the "Green", category are sustainability, environment, energy, water, waste minimization, etc. With initiatives like Kyoto Protocol, ISO 14000 and carbon credit system and now the Paris Agreement the adaptation of the "Green" philosophy is being regulated and incentivized. The major drivers behind adaptation of green are regulations; cost savings through reduction in energy costs and waste minimization; .promotion of corporate green image; and. corporate social responsibility.

> "*Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs*".
>
> *(Brundtland Report)*

India accounts for 2.4% of the world surface area, but supports around 17.5% of the world population. It houses the largest proportion of global poor (30%), about 1.77 million people are houseless and 4.9% of the population (aged 15 years and above) are unemployed. Around 24% of the global population without access to electricity (304 million), about 30% of the global population relying on solid biomass for cooking and 92 million without access to safe drinking water. With a HDI of 0.586 and global rank of 135, India has a lot to do to provide a dignified life to its population and meet their rightful aspirations. Almost all the macroeconomic models predict that anticipated needs in the future will be large. Rapid urbanization in the country will be one of the most dominant trends in the coming years. It is expected that about 40% of the population in 2030 would be urban as against 30% currently. (India's Intended Nationally Determined Contribution: working towards climate change)

As population expands and incomes grow, this shift will likely be realized alongside demographic changes that will exponentially increase the demand for urban amenities like housing, energy, transport, water, waste disposal. It is estimated that more than half of India of 2030 is yet to be built.

They account for approximately 30%of global energy consumption, and in turn generate around 20% of all energy-related greenhouse gas (GHG) emissions(Viola Polesello & Katie Johnson, Energy Efficient buildings for low-carbon cities, International center for climate governance,2016).The Demand for indirect & direct use of energy and water is very high throughout the construction, operation & maintenance phase of buildings. This calls for usage of alternate materials and technologies in the construction industry moving towards Green construction concepts and sustainable buildings.

CONTENTS

Executive Summary

Green Construction is a sustainable way of designing, constructing, operating & maintaining the Infrastructure. Waste reduction, energy efficiency, water conservation, enhanced indoor environment quality and environmentally preferable materials and eco-friendly transportation are some key components of Green construction. Green construction comprises of green buildings & green campuses.

"A Green Building is one which uses less water, improves energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building." as defined by IGBC (Indian Green Business Council). The concept of Green building globally has laid emphasis on energy efficiency and sustainability of building across its life cycle. (USGBC).

Green campus is a higher education community with optimum land use, environmental planning and resource management i.e., improving energy efficiency, conserving resources, enhancing environmental quality including habitat preservation, healthy living Environment, use of renewable energy and management of wastes, water recycling etc.

Under the IPCC's high growth scenario it is estimated that the total GHG emissions from the building sector will almost double to 15.6 billion metric tons CO2-e by 2030. The urban population growth trends estimate an increase in urban population in Indian to 590 million by 2030 creating a direct demand for new construction and Infrastructure in the country. The current scenario and growth forecast in population growth and the relative demand for construction, foresees a huge potential in the construction Industry. Construction in India is poised to become the world's third largest construction sector by 2018 (Global Construction Perspectives and Oxford Economics, 2013).

The building sector can play a very critical role in supporting India's commitment for Climate Change through encouraging Green building construction & Retrofitting existing buildings. In 2013-14, the residential sector & commercial sector consumed 22.5% and 8.7% of the total energy respectively (Central Statistics Office, 2015). They account for 30% of the total electricity consumption in India, out of which almost 72% is consumed by the residential sector. Buildings sector is responsible for roughly 12% of fresh water use, generation of an estimated wastewater of 22,900 million litres per day (MLD), most of which goes untreated to the very sources of water-rivers, streams and ocean. As per Central Pollution Control Board (CPCB, 2011) the current quantum of solid waste generated in India is around 62 million tonnes per annum out of which *25% accounts for construction industry.*

The Green Building movement has been accelerated through the various rating bodies like Indian Green Building Council (IGBC), Green Rating for Integrated Habitat Assessment (GRIHA) and LEED (Leadership in Energy & Environmental Design-U.S. Green building Council) in India.

The sector has also got boost through policies, missions and agreements which would impact green building sector. Some of them are the Paris agreement COP 22, National mission on sustainable Habitat, Smart Cities Mission (Ministry of Urban Development (2015), Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Energy Conservation Act, Energy conservation building Code (ECBC) and National Building Code (NBC) to name a few.

The GDP contribution of the construction sector is estimated to grow at a CAGR of 9.5-10 percent till 2022 in real terms (Human Resource & Skill Requirements in the Building, Construction and Real Estate Services Sector (2022); NSDC) As per estimates of Indian Green Building Council (IGBC) over 2 billion sq. ft. area of green building projects has been registered so far and is targeting to have 10 billion sq. ft. by 2022.

Experts in the green construction sector estimates that green buildings would be around 10% of total buildings in the country, 40% of the Green construction would fall under IGBC, 40% under USGBC, while 20% of green buildings would fall under GRIHA.Through Stakeholder consultation it was assumed that 100 persons would be required to construct per 1 lakh sq.ft. in 18 months and 20% of these jobs would require people with green knowledge. As per the above estimates the above growth scenario would lead to a job potential of 95.82 million by 2030.

The Growth of Green building sector will lead to an increased demand for green products, materials and technologies. This would create direct jobs in the Green building industry, along with a parallel indirect demand for

people required in manufacturing, research, certification & development of Green building products, materials and technologies.
According to the definition of sustainability of the Brundtland Report (2),"*Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs*".

A material can therefore be considered sustainable if its productions enables the sources from which it was made to be continue to be available for future generations and has lowest possible impact on human health and on the environment. A sustainable material is made usually from natural or recycled materials and its production requires small amount of energy. It makes limited use of non –renewable sources and has a low environmental impact. Usage of alternate building materials and products promotes conservation of dwindling non-renewable resources.

In addition, integrating green building materials into construction projects can help reduce the environmental impacts associated with the extraction, transportation, processing, fabrication, installation, reuse, recycling, and disposal of construction industry source materials. The manufacture of many of the materials used in buildings require the consumption of large amounts of energy derived from the fossil fuels and the displacement of mega-tons of earth during the course of mining.

From an innovation perspective, green or sustainable construction has gained increasing attention as an important aspect of sustainability. Green construction implies that the different stages of a construction process, including implementation, delivery of product, and to some extent maintenance of the building are of importance for green construction. From a business perspective there is a lot of scope for new/altered business models for the Green construction market.

The 'Building Sector' is the major source of demand for energy and materials that also produce by-product greenhouse gases (GHG). However, a low-cost and renewable resource for permanent construction could be based on alternate material like 'Bamboo'. Local economy can be promoted at all steps in the supply chain. Bamboo can even help the whole world by its remarkable CO2 sequestrating capacity. Bamboo has historically been used as a building material due to its inherent properties, being regenerating, biodegradable, with high tensile strength, and light weight.

The Building construction sector is linked to around 275 ancillary industries and hence it has a large scope for creating employment opportunities at large. The material industry has a huge employment scope in the Supply Chain of materials/products in the construction Industry.

This document focuses towards understanding the green construction sector and the related value chain. It also maps the occupations and related job roles in the green construction sector, which have been further classified into various NSQF levels.

Chapter 1

Introduction

Green Construction is a sustainable way of designing, constructing, operating & maintaining the Infrastructure. Waste reduction, energy efficiency, water conservation, enhanced indoor environment quality and environmentally preferable materials and eco-friendly transportation are some key components of Green construction.Green construction comprises of green buildings & green campuses.

Green Building

"A Green Building is one which uses less water, improves energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building." as defined by IGBC (Indian Green Business Council). The concept of Green building globally has laid emphasis on energy efficiency and sustainability of building across its life cycle.

Defining a Green Building

Green, or sustainable, building is the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition. **(US, Environmental Protection Agency)**

Green building is a holistic concept that starts with the understanding that the built environment can have profound effects, both positive and negative, on the natural environment, as well as the people who inhabit buildings every day. Green building is an effort to amplify the positive and mitigate the negative of these effects throughout the entire life cycle of a building. **(USGBC)**

Elements of Green Buildings

Green Buildings are infrastructure which brings together various expertise around processes, technologies and material in an environmental sensitive manner and impacting towards better life of inmates and the overall environment.

Major Elements of green buildings are:

Green Campus

Green campus is a higher education community with optimum land use, environmental planning and resource management i.e., improving energy efficiency, conserving resources, enhancing environmental quality including habitat preservation, healthy living Environment, use of renewable energy and management of wastes, water recycling etc. Green-Campus aims to make environmental awareness and action an intrinsic part of the life and ethos of a college.

In Green Campuses, the operation of the buildings, machines, equipment, tools and materials, as well the design of the buildings and the school grounds shall become environmentally and resource friendly. The green concepts and techniques in campuses (*viz.,* administrative campuses, convention centers, educational campuses, healthcare campuses, hospitality campuses, IT parks, Industrial parks, leisure & recreational campuses, military campuses, religious campuses, etc.) can help address National issues like water efficiency, energy efficiency and reduction in fossil fuel use in commuting, handling of consumer waste and conserving natural resources. Most importantly, these concepts can enhance occupant health, happiness and well-being.

The most important aspects are:

- Reduction of energy consumption,
- Reduction of water consumption and pollution,
- Reduction of waste generation and recycling,
- Control and safe handling of hazardous materials,
- Minimization of air pollution,
- Environmental friendly travelling and transport,
- Health and environmental friendly food and food services,
- Green landscaping & consideration of biodiversity
- Use materials with low embodied energy & source materials from radius of 500 miles-intent reduce transport intensity of materials.
- Mandate green campus to be off grid after due diligence based on acreage rain fall pattern agro-climatic condition.

Biomimicry's Cool Alternative: Eastgate Centre in Zimbabwe

The Eastgate Centre in Harare, Zimbabwe, typifies the best of green architecture and ecologically sensitive adaptation. The country's largest office and shopping complex is an architectural marvel in its use of biomimicry principles. The mid-rise building, designed by architect Mick Pearce in collaboration with Arup engineers, has no conventional air-conditioning or heating, yet stays regulated year round with dramatically less energy consumption using design methods inspired by indigenous Zimbabwean masonry and the self-cooling mounds of African termites!

The Eastgate Centre uses less than 10% of the energy of a conventional building its size. These efficiencies translate directly to a saving of $3.5 million alone.

(Inhabitat; Abigail Doan; 11/29/2012, Biomimetic Architecture: Green building in Zimbabwe)

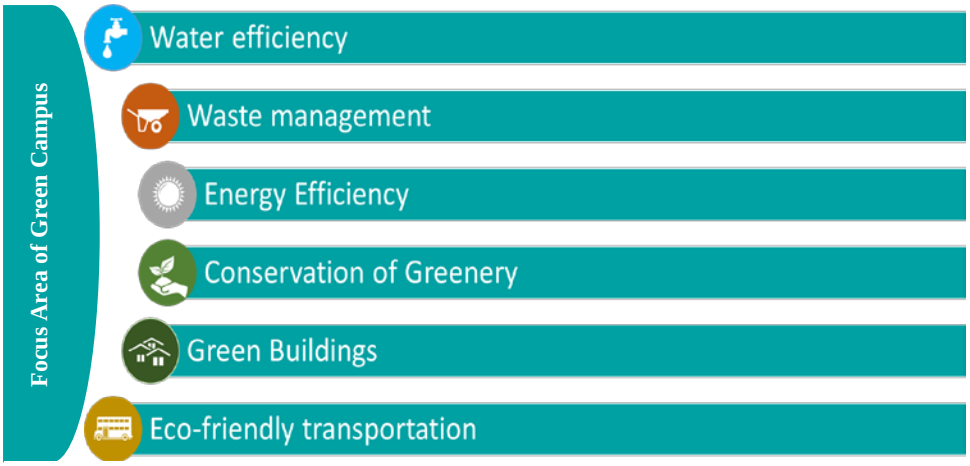


Figure 1: Focus Area of Green Campus

The main objective of the Green Campuses is to reduce the carbon foot-print and it can be done as illustrated in the Table below:

Activity	Output	Expected Outcome
Identification of energy sources and other relevant resources	Consumption is recorded and analyzed	Electricity consumption per college/per campus has been reduce
Identification of amount and type of waste produced	Waste is avoided, waste is recycled and waste is managed adequate	Amount of waste per college/per campus has been reduced
Campus should be 2/4 wheeler free, walking /cycling to be encouraged as part of joining rules.	Adequate sources of renewable energies are in practice	Electricity consumption per college/per campus has been reduced

In general, it makes more economic sense to integrate energy efficient measures and technologies at the early design stage of buildings, compared to retrofitting these buildings for more energy efficient later.

Nevertheless, due to the high number of existing buildings, especially in developed countries, a large amount of GHG emissions result from the inefficient operation of these buildings. In order to significantly reduce the sector's GHG emissions in a short time frame, retrofitting existing buildings to make them more energy efficient plays an important role.

The tremendous growth in economic activity across the globe is placing pressure on natural and environmental resources. Buildings account for more than 40% of global energy use, and approximately 30% of energy-related GHG emissions (Lucon et al. 2014; UNEP, 2014), however, energy use and emissions from buildings have the potential to decrease significantly if the existing best practices and technologies are widely diffused, simultaneously supporting the transition to low carbon cities.(Viola Polesello & Katie Johnson, Energy Efficient buildings for low-carbon cities, International center for climate governance,2016)

The International Energy Agency (IEA) and the Organization for Economic Co-operation and Development (OECD) project that by 2050, energy demand in the building sector will increase by 60%, which is a larger projected increase than is projected for the transport sector or industrial sector (IEA & OECD, 2010).

The LCA (Life-Cycle) approach reveals that *over 80 percent of greenhouse gas emissions take place during the operational phase* of buildings, when energy is used for heating, cooling, ventilation, lighting, appliances, and other applications. The IPCC identifies the main sources of GHG emissions associated with buildings as space heating, space cooling, water heating, artificial lighting and the use of appliances. In addition, buildings, with their use of insulation materials, and refrigeration, are also responsible for non-CO2 GHG emissions, including halo carbons (CFCs and HCFCs) and hydro-fluorocarbons (HFCs).

The Fourth Assessment Report of the IPCC, the Stern Review Report on the Economics of Climate Change, and the European Commission (2007) indicates the target to keep global warming to 2°C above pre-industrial levels, in order to potentially avoid some of the worst climate change impacts. Achieving this target requires global emissions to peak by 2015-2020, and to decline rapidly to 2050 and beyond.

Under the IPCC's high growth scenario it is estimated that the total GHG emissions from the building sector will almost double to 15.6 billion metric tons CO2-e by 2030.

Indian Context – Scope for Green Construction

The urban population growth trends estimate an increase in urban population in Indian to 590 million by 2030 creating a direct demand for new construction and Infrastructure in the country (TERI, Green Growth and Building Sector in India, 2015)

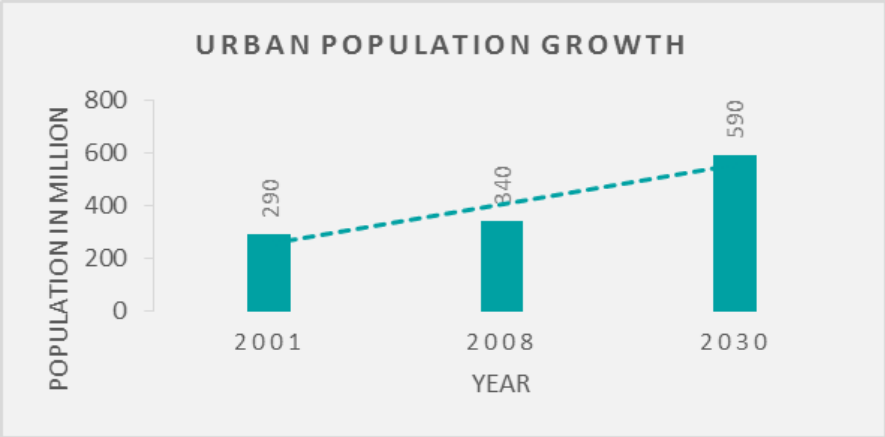


Figure 2: Urban Growth Trends of India

As per the NSDC report Human Resource & Skill Requirements in the Building, Construction and Real Estate Services Sector (2022), the GDP contribution of the construction sector is estimated to grow at a CAGR of 9.5-10 percent till 2022 in real terms.

The current scenario and growth forecast in population growth and the relative demand for construction, foresees a huge potential in the construction Industry. Construction in India is poised to become the world's third largest construction sector by 2018(Global Construction Perspectives and Oxford Economics, 2013).

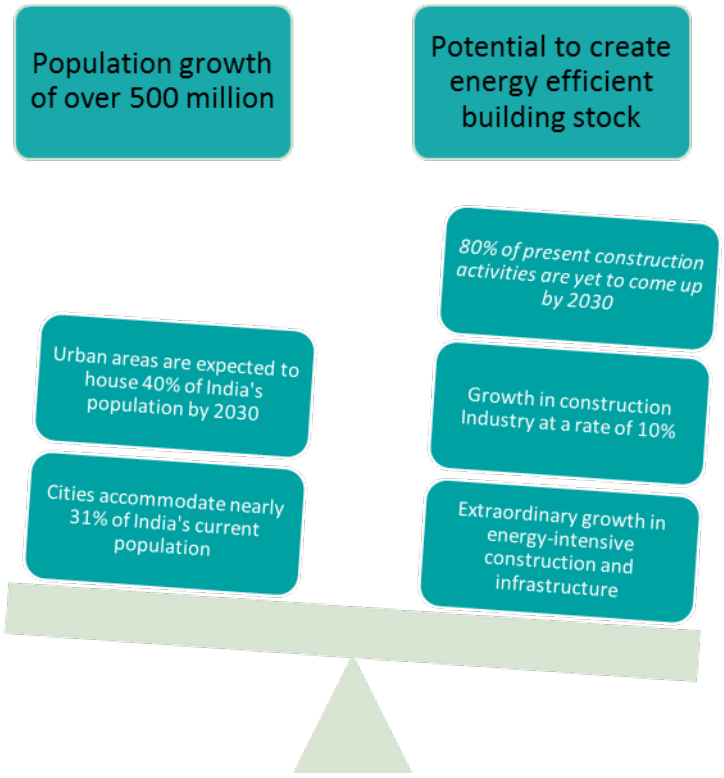


Figure 3: Depicting the current scenario & potential growth in the construction Industry

The building sector can play a very critical role in supporting India's commitment for Climate Change through encouraging Green building construction & Retrofitting existing buildings. The Construction sector is highly resource and energy intensive, and puts tremendous pressure on the natural resources. Environmental Impacts such as land degradation, waste generation and CO_2 emissions from transportation and production are proportional to the value of extraction and use of resources.

Annually the Indian Brick sector, generates - 66 million Tonnes of CO_2, Consumes-35-40 TCE (Tonnes of Coal Equivalent) of Coal and 350 million tons of Top Soil (Live-mint, 2015).Buildings sector was the second largest sector with regard to material consumption in 2007 , accounting for 20% of all material demand, growing by over one billion tonnes from 1997 (SERI,2012).The sector uses 40% of Indian Steel, 85% of paint production,65-70% of glass (Planning commission, 2012).

Energy and water consumption and waste generation are very important components of buildings. Some facts worth noticing have been described:

Energy	Buildings account for the second highest share of consumption after industries. In 2013-14, the residential sector & commercial sector consumed 22.5% and 8.7% of the total energy respectively (Central Statistics Office, 2015). They account for 30% of the total electricity consumption in India, out of which almost 72% is consumed by the residential sector (TERI, Green Growth and Building Sector in India, 2015).

Water	Buildings sector is responsible for roughly 12% of fresh water use, generation of an estimated wastewater of 22,900 million litres per day (MLD), most of which goes untreated to the very sources of water-rivers, streams and ocean. (TERI, Green Growth and Building Sector in India, 2015). There should be no outlet pipes for green buildings such building exist ITC green center, ZED in Bangalore.
Waste	As per Central Pollution Control Board (CPCB, 2011) the current quantum of solid waste generated in India is around 62 million tonnes per annum out of which *25% accounts for construction industry.*

The Union Ministry of Forests and Environment (MoEF) has confessed there is no systematic database on C&D waste. As per the estimates of Centre for Science and Environment (CSE), since 2005, India has newly constructed 5.75 billion m^2 of additional floor space with almost one billion m^2 in 2013 itself. If (according to the Technology Information, Forecasting and Assessment Council's, or TIFAC's, thumb rule) a new construction generates 40-60 kg of C&D waste per m^2, then taking an average of 50 kg per m^2, India must have generated 50 million ton (MT) of C&D waste in 2013. Over the last eight years, it would have produced 287 MT of this waste. This estimate only accounts for new construction. Demolition and renovation/repair-related waste of the older stock generates additional waste. The waste produced per m^2 of demolition is 10 times that generated during construction: as per TIFAC, 300-500 kg of waste per m^2. If it is assumed that five per cent of the existing building stock gets demolished and rebuilt completely annually, then about 288 MT more of C&D waste would have been generated in 2013 alone because of demolitions.

TIFAC also says building repair produces 40-50 kg per m^2 of waste. Assuming that one-third of the existing building stock underwent some sort of repair or renovation in 2013, India must have generated an average of 193 MT of C&D waste just from repair and renovation in that year.

Thus, the total C&D waste generated in India just by buildings in one year — 2013 — amounts to a humungous 530 MT, 44 times higher than the official estimate. Imagine the scenario if the waste generated by infrastructure projects such as roads and dams is added. Not surprisingly, in India, if C&D waste is quantified, it will be more than all the other types of solid waste put together. The C&D waste has various constituents.

Constituent of waste that arises from construction industry in India is mentioned below.

Constituent	Quantity generated in Million Tonnes
Soil, Sand and Gravel	4.20 to 5.14
Bricks and Masonry	3.60 to 4.40
Concrete	2.40 to 3.67
Metals	0.60 to 0.73
Wood	0.25 to 0.30
Others	0.10 to 0.15

Source: Markandeya Raju Ponnada and Kameswari Construction and Demolition Waste Management – A Review International Journal of Advanced Science and Technology Vol.84 (2015)

The above numbers makes it important to think about the concept of designing a building to support waste reduction, reuse, adaptation and disassembly, and extend its useful life, providing economic and environmental benefits for builders, owners, occupants, and the communities. This practice can also avoid building removal altogether, and allows materials to be easily, cost-effectively and rapidly taken apart and directed for further reuse. By designing for adaptability, disassembly and reuse, design practitioners are finding new opportunities early in the design process to reduce environmental impacts, conserve resources, and reduce costs. In the vicinity of Delhi, Gurgaon Bangalore there are abandoned mines, C&D waste can also be used for filling such areas.

Some strategies to use when designing for adaptability, disassembly and reuse include:

- Developing an adaptation or disassembly plan with key information (e.g., as built drawings, materials, key components, structural properties and repair access and contact information).
- Using simple open-span structural systems and standard size, modular building components and assemblies.
- Using durable materials that are worth recovering for reuse and/or recycling.

- Minimizing the use of different types of materials and making connections visible and accessible.
- Using mechanical fasteners such as bolts, screws and nails instead of sealants and adhesives.
- Planning for the movement and safety of workers to allow for safe building adaptation, repair and disassembly
- Use of pre- fabricated materials to minimize waste generation from site.

The Ministry of Environment, Forest & Climate Change, notified the Construction and Demolition Waste Management Rules, 2016 on 29th March 2016, the rules very clearly have placed the responsibility of waste management on the waste generator (individual or others).

Certification & Rating of Green Buildings

The Green Building movement has been accelerated through the various rating systems in India. Majorly *Green rating* in India are undertaken by IGBC (Indian Green Building Council), GRIHA (Green Rating for Integrated Habitat Assessment and LEED-USGBC (Leadership in Energy & Environmental Design- U.S.Green Building Council).

IGBC, GRIHA & USGBC undertakes rating of green buildings across different categories as mentioned below:

Table1: Rating Categories under IGBC, GRIHA & USGBC

S.no	IGBC	GRIHA	USGBC
1	IGBC Green New Buildings	SVAGRIHA (for projects with built-up area less than 2500 sq. mtr.)	Green Building Design & Construction • LEED for New Construction • LEED for Core & Shell • LEED for Schools • LEED for Retail: New Construction and Major Renovations • LEED for Healthcare
2	IGBC Green Existing Buildings	GRIHA Rating (All buildings more than 2,500 sq. m, (except for industrial complexes)	Green Interior Design & Construction • LEED for Commercial Interiors • LEED for Retail: Commercial Interiors
3	IGBC Green Schools	GRIHA for Large Development (Total site area greater than or equal to 50 hectares)	Green Building Operations & Maintenance • LEED for Existing Buildings: Operations & Maintenance
4	IGBC Green Homes	GRIHA Prakriti (for Sustainable Schools)	Green Neighborhood Development • LEED for Neighborhood Development

5	IGBC Green Residential Society		Green Home Design and Construction
6	IGBC Green Interiors		
7	IGBC Green Healthcare rating		
8	IGBC Green SEZs		
9	IGBC Green Schools		
10	IGBC Green Data Center		
11	IGBC Green Factory Buildings		
12	IGBC Green Landscapes		
13	IGBC Green Campus		
14	IGBC Green Villages		
15	IGBC Green Townships		
16	IGBC Green Cities		
17	IGBC Green SEZs		

GRIHA is the national rating system adopted by the Ministry of New & Renewable Energy with a 1-5 star rating system. Another body for rating under the Ministry of Power is the Bureau of Energy Efficiency (BEE) which has developed its own rating system to enhance energy efficiency of appliances based on a 1 to 5 star scale rating 5 being most energy efficient and 1 being lowest.

Major categories of buildings for the purpose of rating are *New Buildings* & *Existing Buildings*. IGBC has laid down clear rating determinants and rating scale for both the categories.

Table 2: Rating determinants for evaluation under IGBC New & Existing buildings

Category	Sub Categories	Rating determinants	Rating Scale
IGBC Green New Buildings	a)Owner occupied buildings b)Tenant-occupied buildings Includes buildings like Office, IT parks, Banks , shopping malls, hotels, hospitals, airports, stadiums, colleges, universities, museums etc.	• Sustainable Architecture and Design • Site Selection and Planning • Water Conservation • Energy Efficiency • Building Materials and Resource • Indoor Environmental Quality • Innovation and Development	• Certified • Silver • Gold • Platinum • Super Platinum
IGBC Green Existing Buildings O&M	Includes all types of non-residential buildings including office buildings, IT Parks, BPOs, shopping malls, hotels, hospitals, airports, banks, etc.	• Site & Facility Management • Water Efficiency • Energy Efficiency • Health & Comfort • Innovation	• Certified • Silver • Gold • Platinum

Other categories of Green Buildings -Apart from New and existing buildings there are other categories of buildings like Schools, Homes, and Factory buildings .IGBC has developed Determinants and rating systems for each of these categories of buildings.

Table 3- Rating determinants for evaluation under few other Categories of Green Building

Building Type	Sub categories	Rating determinants & Certification*
IGBC Green Homes	a)Individual residential unit b) Multi-dwelling residential units - Gated communities. -High rise residential apartments. - Hostels, Service apartments, Resorts, Motels and Guest houses. Designed for both new & existing res	• Site Selection and Planning • Water Conservation • Energy Efficiency • Materials & Resources • Indoor Environmental Quality • Innovation & Design Process
IGBC Green Schools	Designed for both existing and new schools	• Site Selection & Planning • Sustainable Water Practices • Conserving & Harvesting Energy • Eco-Friendly School Material • Indoor Environment Quality • Health & Hygiene • Green Education & innovation
IGBC Green Factory Buildings	Exclusively for Industrial sector	• Site Selection and Planning • Water Conservation • Energy Conservation • Materials Conservation • Indoor Environmental Quality and Occupational Health • Innovation & Design Process
IGBC Green Villages	Designed for Villages	• Clean Village and Improved Lifestyle • Improved Drinking water and Sanitation facilities, • Adequate infrastructure for Education & Healthcare, • Reduced Potable water demand, • Effective • Solid waste management, • Ensure Power security through Clean Energy, • Local Economic Development • Digital Village Initiative.

* Certification levels for all these categories is Certified, Silver, Gold and Platinum.

Credit Rating for Green Buildings

IGBC has defined credit system against different determinants of Green Building across planning to construction stages. Some of these determinants are mandated and do not have credit linked to them while other determinants have credit ranging from 1 point to 15 points. There are total 100 credit, with highest credit points around Energy efficiency. The Credit points are largely same but there is a slight difference in credit rating system for owner occupied buildings (OOB) and tenant occupied buildings (TOB).

Determinants	Total Credit	Mandatory Requirements
Sustainable Architecture & Design	OOB-5 TOB-5	NA
Site Selection & Planning	OOB-14 TOB-14	1 Local Building regulations 2 Soil Erosion Control
Water Conservation	OOB-18 TOB-19	1 Rainwater harvesting, Roof & Non Roof 2 Water Efficient Plumbing Fixtures
Energy Efficiency	OOB-28 TOB-30	1 Ozone Depleting Substances 2 Minimum Energy Efficiency 3 Commissioning Plan for Building Equipment & Systems
Building Material & Resources	OOB-16 TOB-16	1 Segregation of waste ,post-occupancy
Indoor Environment Quality	OOB-12 TOB-9	1 Minimum Fresh Air Ventilation 2 Tobacco Smoke Control
Innovation & Development	OOB-7 TOB-7	NA

Policies, missions and agreements impacting on green building sector

Paris Agreement COP 22	India plans to reduce its carbon emission intensity, i.e. the emission per unit of GDP, by 33-35% from what it was in 2005, by 2030.India ratified the Paris Agreement on 2nd October 2016.
National Mission on Sustainable Habitat	The national mission on sustainable habitat approved by Prime minister is one of the eight missions under national climate change action plan. It aims to make cities sustainable through improvements in energy efficiency in buildings, management of solid waste & shift to public transport.
Smart Cities Mission (Ministry of Urban Development (2015)	In the approach of the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities.
Atal Mission for Rejuvenation and Urban Transformation (AMRUT)	The purpose of Atal Mission for Rejuvenation and Urban Transformation (AMRUT) is to (i) ensure that every household has access to a tap with assured supply of water and a sewerage connection; (ii) increase the amenity value of cities

	by developing greenery and well maintained open spaces (e.g. parks); and (iii) reduce pollution by switching to public transport or constructing facilities for non-motorized transport (e.g. walking and cycling).
Energy Conservation Act	The Energy Conservation Act (EC Act) was enacted in 2001 with the goal of reducing energy intensity of Indian economy. Bureau of Energy Efficiency (BEE) was set up as the statutory body on 1st March 2002 at the central level to facilitate the implementation of the EC Act. The Act provides regulatory mandate for: standards & labeling of equipment and appliances; energy conservation building codes for commercial buildings; and energy consumption norms for energy intensive industries.
Energy conservation building Code (ECBC)	The Energy conservation building Code (ECBC) is a standard for energy efficiency standards for design and construction for buildings of minimum conditioned area of 1000 Sq. mts and a connected demand of power of 500 KW or 600 KVA.To spur energy-saving building construction, the Bureau of Energy Efficiency (BEE) launched the Energy Conservation Building Code (ECBC) in 2007 and plans to make it mandatory nationally by 2017[1] Around 22 states are at various stages of mandating ECBC.2 Complementing the efforts of the government of India, the ECBC has been integrated in other rating & compliance systems being followed in the country such as EIA (Environmental Impact Assessment) for large area development under MoEF (Ministry of Environment & Forest), Green Rating for Integrated Habitat Assessment (GRIHA) rating system of ADARSH and Leadership in Energy & Environmental Design (LEED) rating system of the Indian Green Building Council (IGBC).[3]
Green Rating for Integrated Habitat Assessment (GRIHA)	GRIHA is the national rating system endorsed by the Ministry of New and Renewable Energy, GoI. According to an official circular released by the Ministry of New and Renewable Energy on 17th September 2009, all new buildings of central government / public sector undertakings shall comply with the mandatory guidelines and benchmarks of at least a GRIHA 3 star rating.
National Building Code (NBC)	The National Building Code of India (NBC), a comprehensive building Code, is a national instrument providing guidelines for regulating the building construction activities across the country. It serves as a Model Code for adoption by all agencies involved in building construction works, be they Public Works Departments, other government construction departments, local bodies or private construction agencies

Chapter 2

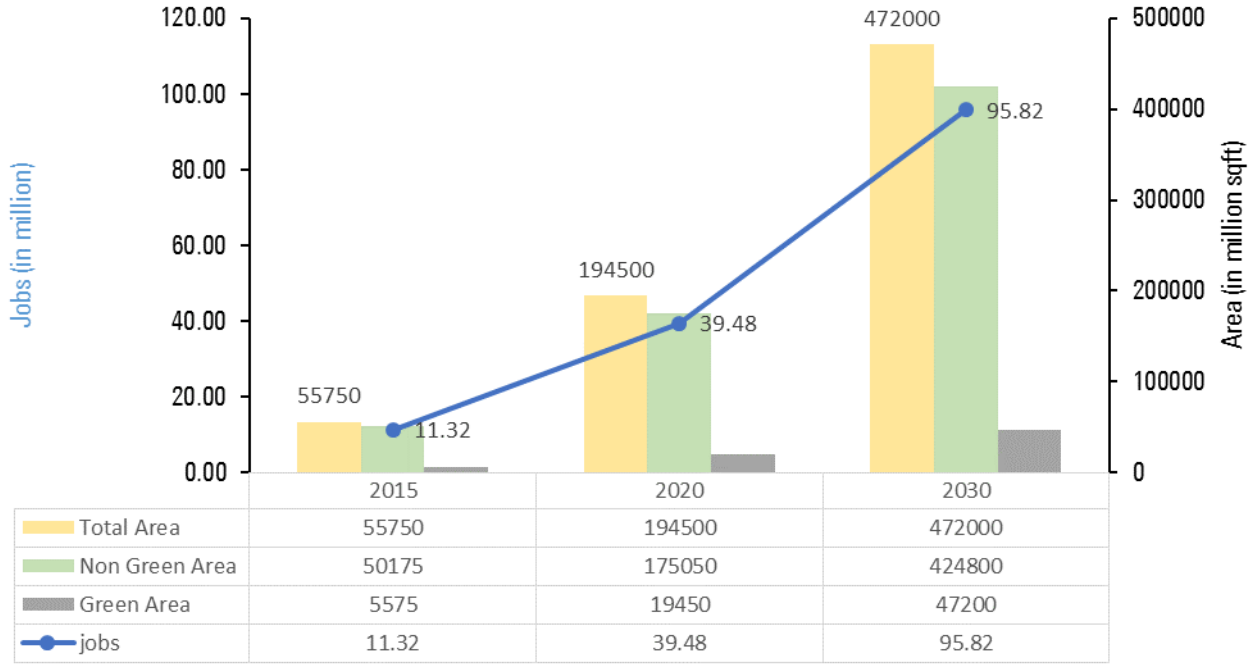
Growth Forecast & Job Estimates

As per a report of the Royal Institution of Chartered Surveyors (RICS), 4127 million m2 of real estate space (which includes residential, retail, offices, hotels, health care, and education sectors) is expected to be built in India between 2012 and 2020.

The movement of Green buildings started with 20,000 sq. ft. in 2004 and has grown exponentially, with an expected green building footprint of 15 million sq. ft. by end-2008.By the end of 2013 India had more than 1.28 billion sq.ft. of green building area (Devarshi Tathagat, Dr. Ramesh D. Dod, Role of Green Buildings in Sustainable Construction- Need, Challenges and Scope in the Indian Scenario ,IOSR-JMCE,2015,Volume 12)

As per estimates of Indian Green Building Council (IGBC) over 2 billion sq. ft. area of green building projects has been registered so far and is targeting to have 10 billion sq. ft. by 2022.(Indian Green Building Council targets 10 billion square feet green building area by 2022;Economic Times; Jun 18, 2014)

Experts in the green construction sector estimates that green buildings would be around 10% of total buildings in the country, 40% of the Green construction would fall under IGBC, 40% under USGBC, while 20% of green buildings would fall under GRIHA.Through Stakeholder consultation it was assumed that 100 persons would be required to construct per 1 lakh sq.ft in 18 months and 20% of these jobs would require people with green knowledge. Based on these inputs the sector growth forecast and its related job scenario by 2030 is depicted below.



	2015	2020	2030
Total Area	55750	194500	472000
Non Green Area	50175	175050	424800
Green Area	5575	19450	47200
jobs	11.32	39.48	95.82

Figure 4: Graphical representation of sector projections & job forecast

Chapter 3

Technologies

The Growth of Green building sector will lead to an increased demand for green products, materials and technologies. This would create direct jobs in the Green building industry, along with a parallel indirect demand for people required in manufacturing, research, certification & development of Green building products, materials and technologies. Use of building material made with construction debris CD - work towards 100% use of CD- the larger vision of making the city land fill site free. (sand is becoming a limiting factor for business in many parts of the world, as it cannot be extracted at the cost of the river eco system, since sand helps in recharging the underground well in the riverine belts).This significant growth will result in demand for high performance green building products & technologies.

Green building sector is driven by evolving technologies, innovative ideas, materials and research. Innovation with the concept of circular economy at the centre of idea & planning would play a critical role. Labor colony designed for assembly/disassembly- to encourage reuse – can be a small step towards circular economy.

Figure 5: Depicting Main areas of technology requirement for Green buildings

Innovations in the Green Construction Sector

Technologies

3D BIM Modeling - 3 D computer designs using Building Information Modelling (BIM) are seeing a new trend. BIM delivers benefits throughout the building project lifecycle. BIM is an acronym for Building Information Modelling. BIM describes the means by which everyone can understand a building through the use of a digital model which draws on a range of data assembled collaboratively, before during and after construction. Creating a digital Building Information Model enables those who interact with the building to optimize their actions, resulting in a greater whole life value for the asset.

Passive Solar and radiant Heating - where warm, sunlit air is diverted to heat a building or, during the summer months, used to draw in colder air for ventilation. Such passive solar designs are used in many high-efficiency buildings

Thermal Bridging- Efficient insulation material is becoming increasingly important throughout the construction industry. Heat transmission through walls tends to be passed directly through the building envelope, be it masonry, block or stud frame, to the internal fascia such as drywall. This process is known as "thermal bridging". Aerogel, a technology developed by NASA for cryogenic insulation, is considered one of the most effective thermal insulation materials and US spin-off Thermablok has adapted it using a proprietary aerogel in a fiberglass matrix.

One of the more striking examples of the clever incorporation of solar- and wind-power technology is the refurbished CIS tower in Manchester, England. It relies on a photovoltaic skin to generate up to 180 000 kWh of electricity per year and has two dozen wind turbines that produce about one tenth of its energy requirement.

Insulating concrete forms (ICFs), Structural insulated panels (SIPs) are another frequently used insulation option, partly because they can be integrated into a number of materials, including particle and gypsum board, sheet metal, plastics and foams. Unlike typical insulation that traps air in pockets, often between strands of fibrous material to resist the flow of heat, **phase-change materials (PCMs)** absorb or discharge heat as they change back and forth from a solid to liquid state. In a sense they "melt" and "freeze" at conditions close to room temperature and draw in or release heat in the process.

Vertical Gardens are also known as green walls or living wall, are self-sufficient vertical garden attached to exterior or interior walls of a building. They differ from green facades (ivy walls) as green walls have growing media supported on the face of the wall, while green facades have soil only at the base of the wall and support climbing plants on the face of the wall to create the green, or vegetated, facade. The plants receive water and nutrients from within the vertical support instead of from the ground.

Photovoltaic Glazing- Building integrated photovoltaic (BIPV) glazing can help buildings generate their own electricity, by turning the whole building envelope into a solar panel. Companies such as Polysolar provide transparent photovoltaic glass as a structural building material, forming windows, façades and roofs. Polysolar's technology is efficient at producing energy even on north-facing, vertical walls and its high performance at raised temperatures means it can be double glazed or insulated directly.

Kinetic Footfall - Kinetic energy is another technology under development. The technology that enables flooring to harness the energy of footsteps. It can be used indoors or outdoors in high traffic areas, and generates electricity from pedestrian footfall using an electromagnetic induction process and flywheel energy storage. The technology is best suited to transport hubs where a large flow of people will pass over it. The largest deployment the company has done so far is in a football pitch in Rio de Janeiro to help power the floodlights around the pitch. It also currently has a temporary installation outside London's Canary Wharf station powering street lights.

Kinetic Roads- Italian startup Underground Power is exploring the potential of kinetic energy in roadways. It has developed a technology called Lybra, a tyre-like rubber paving that converts the kinetic energy produced by moving vehicles into electrical energy. Developed in co-operation with the Polytechnic University of Milan, Lybra operates on the principle that a braking car dissipates kinetic energy. The cutting-edge technology is able to collect, convert this energy into electricity and pass it on to the electricity grid. In addition to improving road safety, the device upgrades and promotes sustainability of road traffic.

Modular Construction - Modular construction is increasingly popular where a building is constructed off-site using the same materials and designed to the same standards as conventional on-site construction. It limits environmental disruption, delivering components as and when needed, and turning construction into a logistics exercise. It also has strong sustainability benefits, from fewer vehicle movements to less waste.

Cloud Collaboration – It is a system allowing the remote sharing of data on a construction site in real time. It is predominantly a review tool for engineers and architects which digitizes the drawing review process on construction projects, and allows for better collaboration. The cloud-based collaboration tool is focused on the installation of everything from steel beams to light fittings. The system is used to add "snags", issues that happen during construction, on to pdfs, then users can mark or add notes through base stone. Trials have revealed possible cost-savings of around 60 per cent compared with traditional paper-based review methods.

Asset mapping - Asset mapping focuses on operational equipment, including heating and air conditioning, lighting and security systems, collecting data from serial numbers, firmware, engineering notes of when it was installed and by whom, and combines the data in one place. The system can show engineers in real time on a map where the equipment needs to be installed and, once the assets are connected to the real-time system using the internet of things, these can be monitored via the web, app, and other remote devices and systems. It helps customers build databases of asset performance, which can assist in proactive building maintenance, and also reduce building procurement and insurance costs.

Solar water heating -Solar water heating (SWH) is the conversion of sunlight into renewable energy for water heating using a solar thermal collector. Solar water heating systems comprise various technologies that are used worldwide increasingly.

Green Roofs - A green roof is a roof surface, flat or pitched, that is planted partially or completely with vegetation and a growing medium over a waterproof membrane. They may be 'extensive' and have a thin growing medium (up to 200mm deep) with 'groundcover' vegetation, or 'intensive' and have soil over 200mm deep supporting vegetation up to the size of trees.
Green roofs are an accepted part of modern building in Europe where some city and national governments have mandated their use. The Austrian city of Linz, for example, requires green roofs on all new residential and commercial buildings with rooftops larger than 100m^2, and German green roof building has been encouraged by the Federal Nature Protection Act, the Building Code and state-level nature protection statutes. Australian examples are less common but in 2007 a national organization was formed to promote green roofs, and Brisbane City Council included green roofs in its proposed action plan for dealing with climate change.

Apart from the above during the architecture & planning phase attention must also be given to other innovations like mini vegetable farms to reduce carbon miles of food- collateral benefit will reduce the heat ingress & reduce HVAC load and day light pipes for basement lighting.

Some other technologies are listed below:

	Technologies
1	Home irrigation technologies
2	Hybrid –HVAC System
3	Heat Recovery Wheels
4	Task Lighting
5	Small grey water treatment systems
6	Solar water heaters
7	Timer based controls for lawn sprinklers
8	Sensors, efficient lift management control
9	Dimmer controls for lighting, movement sensors for lighting

10	Eco-friendly chemicals
11	Daylight pipelines for basement parking
12	Night Lighting Systems
14	Vermi composting
15	Solar pumping
16	Energy star equipment
17	Heat pumps

Alternative Material & Products

According to the definition of sustainability of the Brundtland Report (2),"*Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs*".

A material can therefore be considered sustainable if its productions enables the sources from which it was made to be continue to be available for future generations and has lowest possible impact on human health and on the environment. A sustainable material is made usually from natural or recycled materials and its production requires small amount of energy. It makes limited use of non –renewable sources and has a low environmental impact.

Usage of alternate building materials and products promotes conservation of dwindling non-renewable resources. In addition, integrating green building materials into construction projects can help reduce the environmental impacts associated with the extraction, transportation, processing, fabrication, installation, reuse, recycling, and disposal of construction industry source materials. The manufacture of many of the materials used in buildings require the consumption of large amounts of energy derived from the fossil fuels and the displacement of mega-tons of earth during the course of mining.

Some of the Green building materials are – Fly ash bricks, Low VOC paints, reclaimed wood, roof top hi albedo reflective paint, building material made with construction Debris, Bamboo, Illustration on Bamboo (Source: Geeta Mehta, Amit Mehta, Bidhan Sharma; Selection of Materials for Green Construction: A Review; IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE); Volume 11, Issue 6 Ver. III (Nov- Dec. 2014)

Description of Alternate Materials for Green construction

Aerated Autoclaved Concrete Blocks - AAC is made with fine aggregates, cement, and an expansion agent that causes the fresh mixture to rise like bread dough. In fact, this type of concrete contains 80 percent air.

Fly ash bricks (FAB) -Fly Ash bricks are made of fly ash, lime, gypsum and sand. These can be extensively used in all building constructional activities similar to that of common burnt clay bricks. The fly ash bricks are comparatively lighter in weight and stronger than common clay bricks. Since fly ash is being accumulated as waste material in large quantity near thermal power plants and creating serious environmental pollution problems, its utilization as main raw material in the manufacture of bricks will not only create ample opportunities for its proper and useful disposal but also help in environmental pollution control to a greater extent in the surrounding areas of power plants.

Insulated glass unit (IGU) – IGU combines multiple glass panes into a single window system. Most IGUs are double glazed (two panes of glass) with three panes (triple glazing) or more becoming more common due to higher energy costs. The panes of glass in IGUs are separated by a spacer and a still layer of air or gas. Double glazed windows are an ideal energy efficient choice with the added benefit of minimizing noise. The sealed air gap between the two panes acts as an added layer of insulation. This added thermal resistance reduces the amount of heat escaping in winter and keeps your home at a more comfortable temperature. Double glazing has the reverse

effect in summer, preventing unwanted heat from coming into the home. This extra insulation lessens your reliance on artificial heaters and air conditioners and can ultimately reduce your energy costs.

Glass wool - Glass wool is a thermal insulation that consists of intertwined and flexible glass fibers, which causes it to "package" air, and consequently make good insulating materials. Glass wool can be used as filler or insulators in buildings, also for soundproofing.

Float Glass- Green Tinted Glass - Green tinted glass is a transparent float glass produced by adding an oxide of metals into raw materials in the float glass process, the most technologically advanced method in the world. Being manufactured by this process, green tinted glass can effectively absorb the heat while offering a green aesthetic appearance.Green glass can not only absorb the heat but also reflects the infrared up to approximately 40% which can lead to a dramatic reduction in energy costs. Its pleasing greenish color can reduce the transmission that results in unwanted glare and discomfort. Green glass reduces the transmission of ultraviolet light and subsequently minimizes the color fading to furniture and flooring.

High Albedo Roof Paints & Reflective materials – These paints act as an Insulation Coating, Its ability to reflect or resist heat on all roof surfaces such as RCC, Concrete, Metallic, Asbestos, GI, Galvalum sheets, Pre-Coated roof sheets and Poly-flex. These are eco-friendly, low VOC products which reduces roof temperature leading to low pressure on air conditioning hence reducing Energy consumption of the building.

Ferro cement - Ferro cement is a composite material comprising rich cement which is highly reinforced with continuous and small diameter steel rods and wires. It may be defined as a sophistically designed well-proportioned cement based compound in which optimum quantity of suitably sized steel sections are evenly dispersed for achieving remarkable homogeneity, ideal monolithic properties, excellent strength and absolute impermeability.

Bagasse particle board - Bagasse is the residual pulp from sugarcane after the juice has been extracted. A considerable amount of excess bagasse generated from sugar mills is left to rot or burnt as fuel for boilers. This by-product is now being used as a substitute for wood in particle boards that are light and low cost. Bagasse-based composites offer potential as the core material for laminated floors, replacing high-density and expensive wood fiberboard. As such, bagasse does not have enough strength and water resistance to be used on its own. However, if it is made into a laminated particle board with resin as a bonding agent and wax as dimensional stabilizer, then it can be used for laminated floor and furniture applications.

Bamboo –Bamboo has long been used as a traditional building material, and is achieving increasing popularity due to its potential for environmental sustainability. Bamboo in disaster-prone areas come from the lightness and flexibility of the material, which give it resilience to collapse and strong winds.

Abaca -Abaca is a banana like plant that is typically found in tropical countries. It is one of the many species of banana native to the Philippines, and is extensively grown in Borneo and Sumatra. This material can be used in houses in the form of woven cloth, place mats and curtains to small furniture such as center and side tables.

Coconut Products -Coconut is grown in tropical and subtropical countries and is considered to be one of the best eco-friendly products. The remarkable thing about this plant is the fact that almost every part of the palm can be used from leaves to its roots. It can be used to create household items such as curtains, wall decors. The coconut coir fibers are great source for making door mats, carpets, and rugs.

Corn - Corn is one such product that can be used after being discarded. The discarded corn husks can be used in furniture such as home décor. They are equally brilliant and elegant compared to bamboo, sea grass, and other natural materials. A company known as Corn Board Manufacturing, Inc. has developed a proprietary corn-based composite board that can be used instead of particle board, plywood or fiberboard for furniture and house construction.

Jute -Jute is one of the most consumed and produced vegetable fiber after cotton. Some of the uses of jute include jute rugs, curtains, sacks, rugs, chair upholstery and even linoleum backing. It is 100% biodegradable making it a great option for your house.

Bamboo – A Sustainable construction material

The 'Building Sector' is the major source of demand for energy and materials that also produce by-product greenhouse gases (GHG). However, a low-cost and renewable resource for permanent construction could be based on 'Bamboo'. In tropical regions, construction size bamboo reaches full strength already after 3-4 years. Growing on hill sides and along roads and fields it does not encroach on agricultural land either.

Local economy can be promoted at all steps in the supply chain. Bamboo can even help the whole world by its remarkable CO2 sequestrating capacity. Bamboo has historically been used as a building material due to its inherent properties, being regenerating, biodegradable, with high tensile strength, and light weight. However, despite its innumerable qualities one does not get to see bamboo as popular building material.

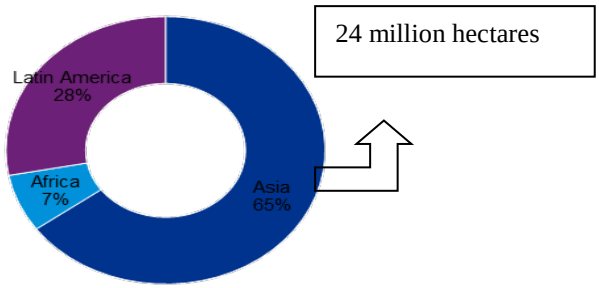
Worldwide Bamboo Resources

The global bamboo coverage worldwide is 36 million hectare that is 3. 2% of total forest area. Asia is the richest bamboo producer with about 24 million hectares of the total world bamboo resources. Five out of six countries have large extent of bamboo forests in Asia viz. India, China, Indonesia, Myanmar, and Vietnam.

Bamboo geographical zones

Source: Food and Agriculture Organization, 2005

Worldwide Distribution of Bamboo



In ***China***, bamboo has been used for different purposes like construction, as food and medicine for centuries and the modern bamboo industry has grown rapidly since the 1980s. By 1999, trade was estimated to be worth USD 4.5 billion, exponentially growing to an estimated USD 60 billion per year in 2015. Advances in technology has led to production of value-added products like pulp and paper, activated carbon for energy, flooring (construction material) and textiles. This diverstifation of products has seen China's domestic bamboo market alone reach a value of USD 32 billion, improving millions of people's livelihoods and generating over 7 million jobs.

Bamboo Industry in India

National Agriculture Forest and Bamboo Mission (NABM)

With a view to harness the potential of bamboo crop, Department of Agriculture & Cooperation (DAC), Ministry of Agriculture is implementing a 100% Centrally Sponsored Scheme called Mission for Integrated Development of Horticulture (MIDH) in which *National Bamboo Mission (NBM)* is being implemented as a sub scheme. National Bamboo Mission (NBM) commenced in 2006 was renamed as National Agriculture Forest and Bamboo Mission (NABM)

The Mission envisages promoting holistic growth of bamboo sector by adopting area-based, regionally differentiated strategy and to increase the area under bamboo cultivation and marketing. Under the Mission, steps have been taken to increase the availability of quality planting material by supporting the setting up of new

nurseries and strengthening of existing ones. To address forward integration, the Mission is taking steps to strengthen marketing of bamboo products, especially those of handicraft items.

The mission along with its limited resources has been implemented across 28 states in the country with the assistance of State Bamboo Missions. Since the initiation of mission, bamboo has been planted on 349864 hectare land and 1436 nurseries have been established to supply the quality saplings of bamboo.

Potential for Green Construction

Bamboo is a versatile material because of its high strength-to-weight ratio, easy workability and availability. Bamboo needs to be chemically treated due to their low natural durability. This strength and flexibility make it a potential alternative to steel (which requires more energy in production and manufacturing) in many applications.

It can be used in different ways in the construction sector for example roof structure as *purlins, rafters and reapers, for flooring, doors and windows, walling, ceiling, man-hole covers* etc.

Bamboo's potential for environmental sustainability is apparent across many areas. As a natural material, the process of preparing bamboo for construction has minimal environmental impacts, and when used locally, bamboo construction can lower carbon emissions related to transportation.

The Energy Balance of Bamboo also makes it a highly potential material for construction. Energy Balance is the energy required to produce a unit of building material with a certain level of load bearing capacity.

Energy Balance of various building materials in MJ/m^3 per N/mm^2

Material	MJ/m^3 per N/mm^2
Concrete	240
Steel	1500
Wood	80
Bamboo	30

Source: Bamboo as a low cost and green alternative for reinforcement in light weight concrete, SAITM – RSEA 2013

Other advantages of using Bamboo

- 35% higher oxygen emission into the atmosphere than equivalent stands of trees;
- Acts as a Sequestration agent: Certain Bamboo species have been known to sequester as much as 12 T of CO_2 per hectare;
- Unlike wood, bamboo (a member of the grass family) regenerates very quickly;
- Bamboo can be harvested every three to six years for construction purposes (depending on the species);
- Bamboo has a tensile strength of 28,000 lb. per square inch, versus 23,000 lb. per square inch for mild steel, making it among the world's best natural engineering materials;
- It is an essential component of earthquake resistant construction.

Current status and Scope

India is the second largest country in the world after China in terms of bamboo resources (Forest Survey of India [FSI], 2011). *Worldwide, India occupies 37.8% of the total bamboo forest area. Twenty Percent of its overall forest area is of bamboo.* In India there are 125 indigenous and 11 exotic species of bamboo belonging to 23 genera (FSI, 2011). 13% forest area is comprised of bamboo in India. The table below reflects the distribution of Bamboo across India.

States/Region	Area (%) (2011)
North- East	31
Madhya Pradesh	9
Maharashtra	8
Orissa	8
Andhra Pradesh	6
Karnataka	6

Others	32
Total	100

Table 4: Bamboo Distribution in India

66% of the total production in India (160077 hectares) is in forest area while the rest of the production of 81410 is in non-forest area. (Department of Agriculture and Co-operation, Ministry of Agriculture source:http://agricoop.nic.in/Admin_Agricoop/Uploaded_File/midhPPT4.pdf)

The world market for bamboo has been valued at Rs.50000 crore (US$ 10 billion) in 2001 and is expected to grow to Rs. 100,000 crore (US$ 20 billion) by 2015. India, China and Myanmar together have about 198 lakh ha of bamboo reserves - 80 percent of the world's bamboo forests. Of this, India's share is about 45 percent. However, its share in global market is only 4.5 per cent. On the other hand, China alone has captured 50 per cent of the World market, exporting as much as 20 million tonnes of varied products a year. India, almost 20 years behind China in commercial production, produces only 3.5 million tonnes of bamboo a year.

Projected Demand & Supply

- Country's bamboo economy is expected to grow by over 15% to touch Rs.26, 000 crore by 2015.
- Bamboo can replace the projected import of timber to the tune of Rs.30, 000 crore in the next 20 years i.e. 2025.
- The market size for bamboo plywood is expected to grow to Rs. 500 crore in 2015 from Rs.200 crore in 2001.
- It has been estimated that the total market size of bamboo flooring materials will rise to Rs.1, 950 crore by 2015 from the current Rs.200 crore.

(Source: Sangeeta Prasad Mehra & L.K Mehra: Bamboo Cultivation-Potential and Prospects)

- The current demand of bamboo for various purposes is estimated at 26.69 million tones as against the supply of 13.47 million tons (Tripathi, Thakur, and Bhuyan, 2008).
- Of the 13.47 million tons of bamboo, 3.4 billion are currently being consumed for scaffolding alone all over India (Rain Forest Research Institute, 2008).

Growth Projections of Bamboo Industry

The estimation of the potential size of the industry by 2015 is Rs.260 billion. It has been estimated that the Bamboo Industry is estimated to grow at a CAGR of 15-20 % (Aniket Baksy; The Bamboo Industry in India: Supply Chain Structure, Challenges & Recommendations)

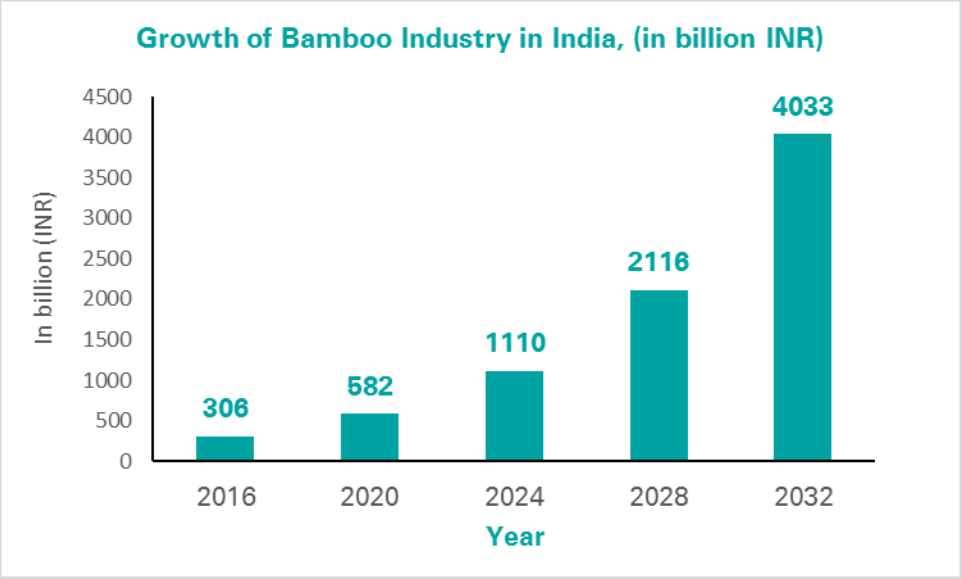
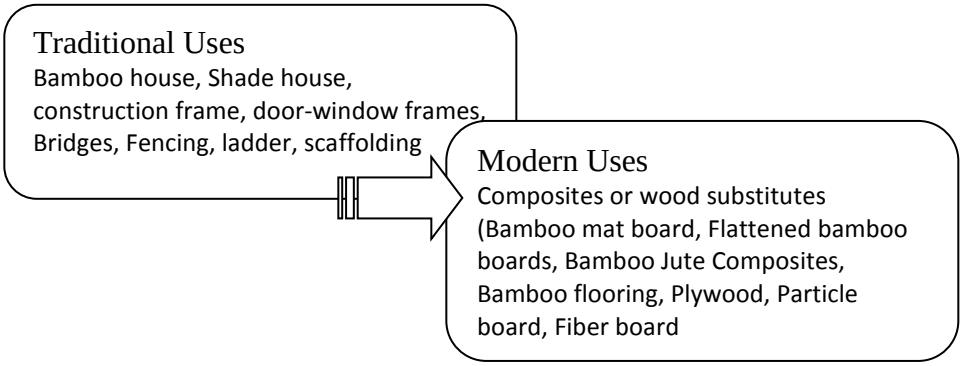


Figure 6 – Growth of Bamboo Industry in India

The above graph represents estimated size of the Bamboo Industry by 2015 with an AGR of 17.5 % (Source: Centre for Civil Society; The bamboo Industry in India, Researching Reality Internship 2013)

There is huge scope in utilization of Bamboo in the construction industry with support of traditional and modern technologies.



Rating Credit for Alternate Material use in Green Construction

IGBC Green Home provides *four points for the use of rapidly renewable building material* in the building. In GRIHA under its *Criterion 16* (Reduce volume, weight, and construction time by adopting efficient technologies such as pre-cast systems) and *Criterion 17* (Use low-energy material in interiors) professionals can gain *4 points in each by using low-energy materials/efficient technologies* in structural and non-structural applications or in interiors in each of the three categories of interiors (internal partitions, paneling/false ceiling/interior wood finishes/in-built furniture door/window frames, recycle old furniture to reduce burden on forest flooring).

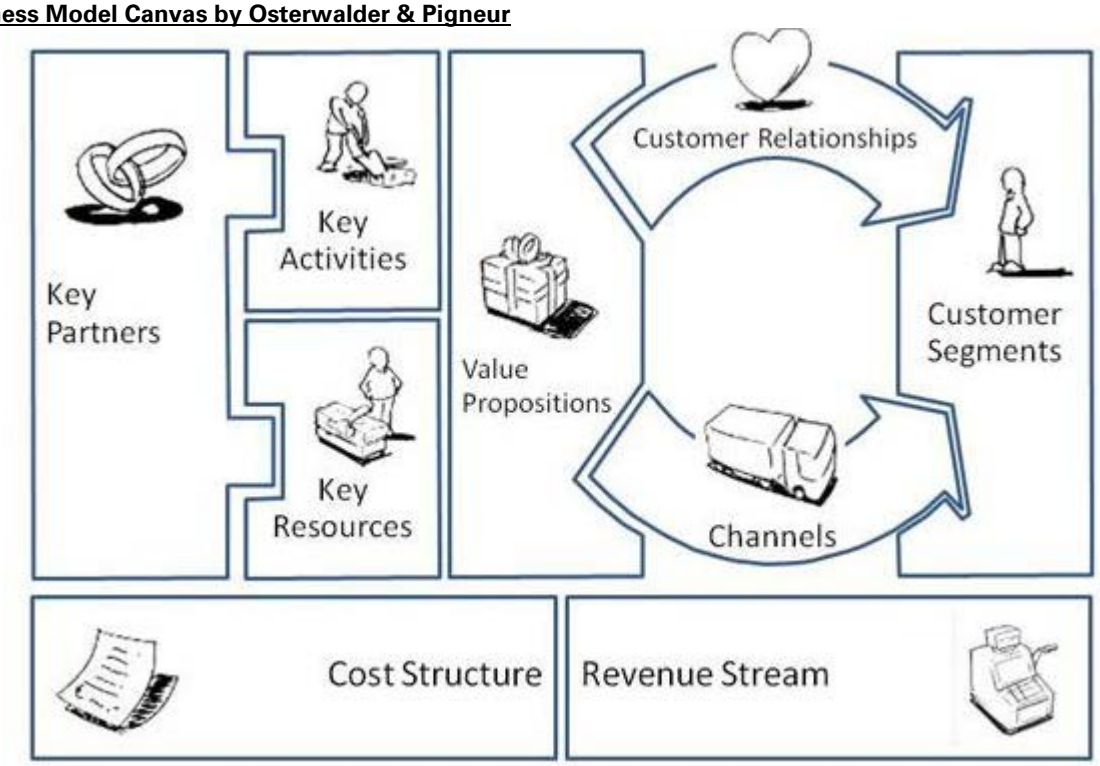
Chapter 4

Business Opportunities

From an innovation perspective, green or sustainable construction has gained increasing attention as an important aspect of sustainability. Green construction implies that the different stages of a construction process, including implementation, delivery of product, and to some extent maintenance of the building are of importance for green construction. From a business perspective there is a lot of scope for new/altered business models for the Green construction market.

<table>
<tr><th colspan="3">Business opportunity –Areas of Innovation</th></tr>
<tr><td colspan="2">Green technology</td><td rowspan="3">Manufacturing of Green Building Materials</td></tr>
<tr><td colspan="2">Green engineering</td></tr>
<tr><td rowspan="2">Research & Development</td><td></td></tr>
<tr><td>Transportation from Source to Site</td><td rowspan="2">Renewable Energy Solutions</td></tr>
<tr><td colspan="2">Warehousing</td></tr>
<tr><td colspan="2">Deconstruction building Materials</td><td></td></tr>
<tr><td>Solid & Liquid Waste discharge/collection</td><td colspan="2">Recycling professionals</td></tr>
</table>

Business Model Canvas by Osterwalder & Pigneur



The above illustration has been taken from **Report on the successful business models for** Nearly Zero Energy Building Renovation (**NZEBR)**

One Stop Shop

There is a huge potential for energy efficiency improvement in single-family houses, and it is usually most cost efficient to realize the actions in connection to other renovations that would have been conducted for other reasons, e.g. to improve functionality or overall aesthetics of the building . The single-family house owner is however seldom expert in energy efficiency, and nowadays the renovation market for single-family houses is very fragmented and handicraft dominated. The house owner would benefit from a service that offers the optimal solution for his/her house based on a thorough analysis on the needs of the house owner family and the condition of the house. There was also a need from the service providers' side, to be able to provide high-quality service and to gain long-standing customers. New builders may put a dash board in all new houses so that owners can easily see consumption of energy/water & regulate use of the same .Raise cost of water to bring frugality in use of water. Taps/showers to have flow rates clearly indicated so that people buy on basis of water frugality flow rate. There was a lack of business models to offer such a solution on the market, and therefore an ideal model was developed in a SuccessFamilies and One-Stop-Shop projects in Finland. Below is the description of the business model.

K-Rauta & Rautia business model

<table>
<tr><td colspan="2">Key partners
▪Hardware store chain(service provider)
▪Product and material suppliers (insulation, heat pumps, heating systems, ventilation systems, fireplaces, windows, doors, lamps, all other building materials)
▪Renovation service providers: planning, installations, renovations, energy surveys, heat camera inspections ,Bank</td><td colspan="2">Value proposition
▪One-stop-shop to offer all kinds of renovation services
▪Fixed price offer, minimum surprises of extra costs
▪Different ways of buying: all installed, partly installed, just products. Flexible project schedules, etc.
▪All other building and housing material products and services also from same vendor.
▪Flexible funding, frequent customer benefits
▪Easy access energy saving renovation services under one roof and getting all from one trusted vendor, nationwide</td></tr>
<tr><td colspan="3">Key activities
▪Marketing
▪Selling all products which are needed in house renovations: insulation, heat pumps, heating systems, ventilation systems, fireplaces, windows, doors, lamps, all other building materials
▪Selling (in cooperation with company customers) most of services which are needed in house renovations: planning, installations, renovations, energy certificate, heat camera inspections
▪Flexible financing services
▪Energy surveys
▪Solutions are sold in easy and understandable packages/modules
▪Energy saving renovation service centers inside the stores</td><td>Key resources
▪Two well-known brands
▪Distribution network
▪Customer database through Kesko group
▪Large variety of products available through stores</td></tr>
<tr><td>Channels
▪Active sales out from stores</td><td>Customer relationship
▪Dedicated personal assistance</td><td>Customer segments
▪People renovating their houses</td></tr>
<tr><td colspan="2">Cost structure
▪Material and product costs
▪Labour costs (salaries & overheads)
▪Marketing costs
▪Travel costs
▪Subcontracting of the renovation work</td><td colspan="2">Revenue stream
▪Payment from customers from the services and products purchased
Commission from product suppliers</td></tr>
</table>

Construction & Demolition Waste Management – Connecting generators & recyclers

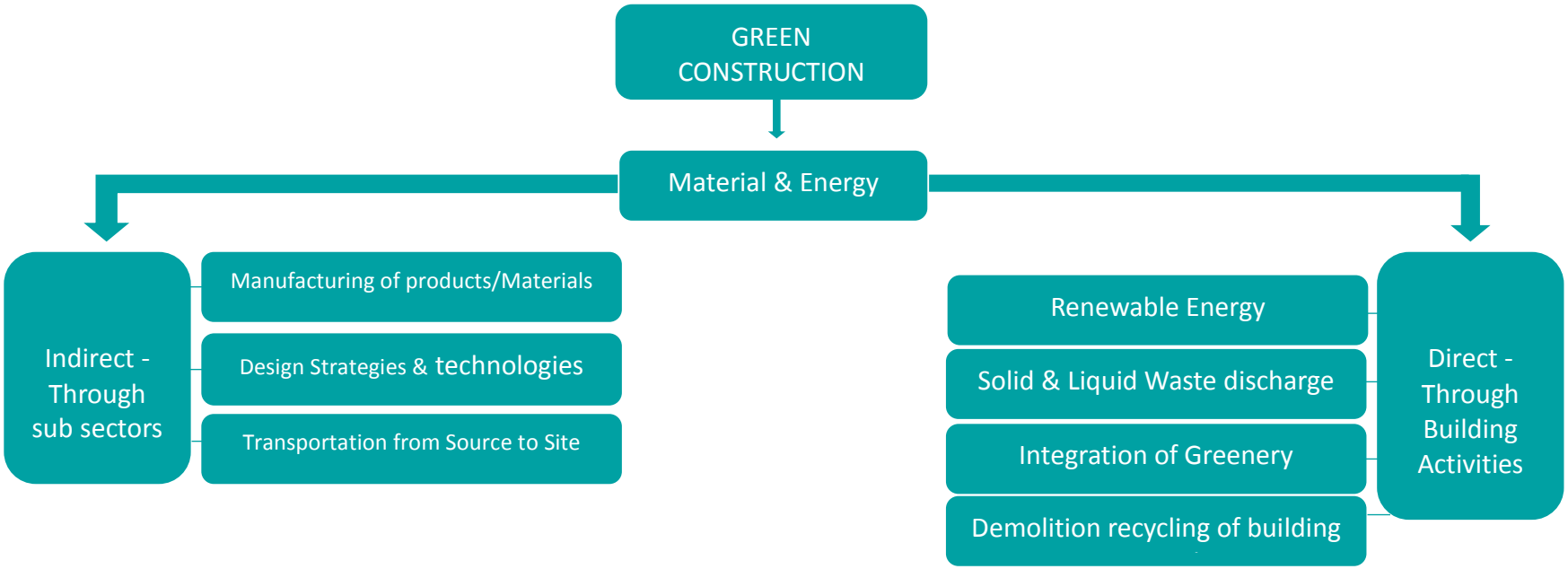
As per the recent 2016 notification by Ministry of Environment, Forest & Climate Change, the responsibility of waste management is entirely on the waste generation. In the case of Green construction the C&D waste generator is the developer and hence there is a huge market clearly have placed the responsibility of waste management on the waste generator (individual or others).

Market Potential

India produces 10 to 15 million tonnes of Construction & Demolition waste annually. (Source –Waste Management World ,11/2/2014)

<table>
<tr><td colspan="2">Key partners
▪Municipal corporations
▪Developers
▪Construction</td><td colspan="2">Value proposition
▪Complete management of C&D waste generated by the waste generators
▪Construction & Deconstruction waste assessment.
▪Collection of C&D Waste
▪Transportation of C&D waste from site to C&D management center.
▪Development of App for easy accessibility and being consumer friendly</td></tr>
<tr><td colspan="3">Key activities
▪Marketing
▪Mapping waste generators & Recyclers
▪Developing end to end solution from waste assessment to waste disposal at the C&D recycling site.
▪Logistics planning and management
▪Solutions are sold in easy and understandable packages/modules
▪Energy efficient transportation of waste (Solar, Electric) etc.
▪Regional distribution of Network for collection & transportation</td><td>Key resources
▪Client database
▪Access to recyclers
▪Raw material supply to recyclers
▪Smooth disposal of waste
▪Support in compliance of C&D rules for waste generators</td></tr>
<tr><td>Channels
▪Active sales</td><td>Customer relationship
▪Dedicated personal assistance</td><td>Customer segments
▪Developers
▪Recyclers
▪MCD</td></tr>
<tr><td colspan="2">Cost structure
▪Infrastructure cost
▪Machinery cost
▪Logistics
▪Labor costs (salaries & overheads)
▪Marketing costs
▪Transportation cost</td><td colspan="2">Revenue stream
▪Payment from developers
▪Payment from recyclers for providing raw material
▪Subsidy from government (for business supporting environmental Rules)</td></tr>
</table>

Mapping Business Opportunity potentials within Green Construction Sector



Material – Supply Chain

The Building construction sector is linked to around 275 ancillary industries and hence it has a large scope for creating employment opportunities at large. The material industry has a huge employment scope in the Supply Chain of materials/products in the construction Industry.

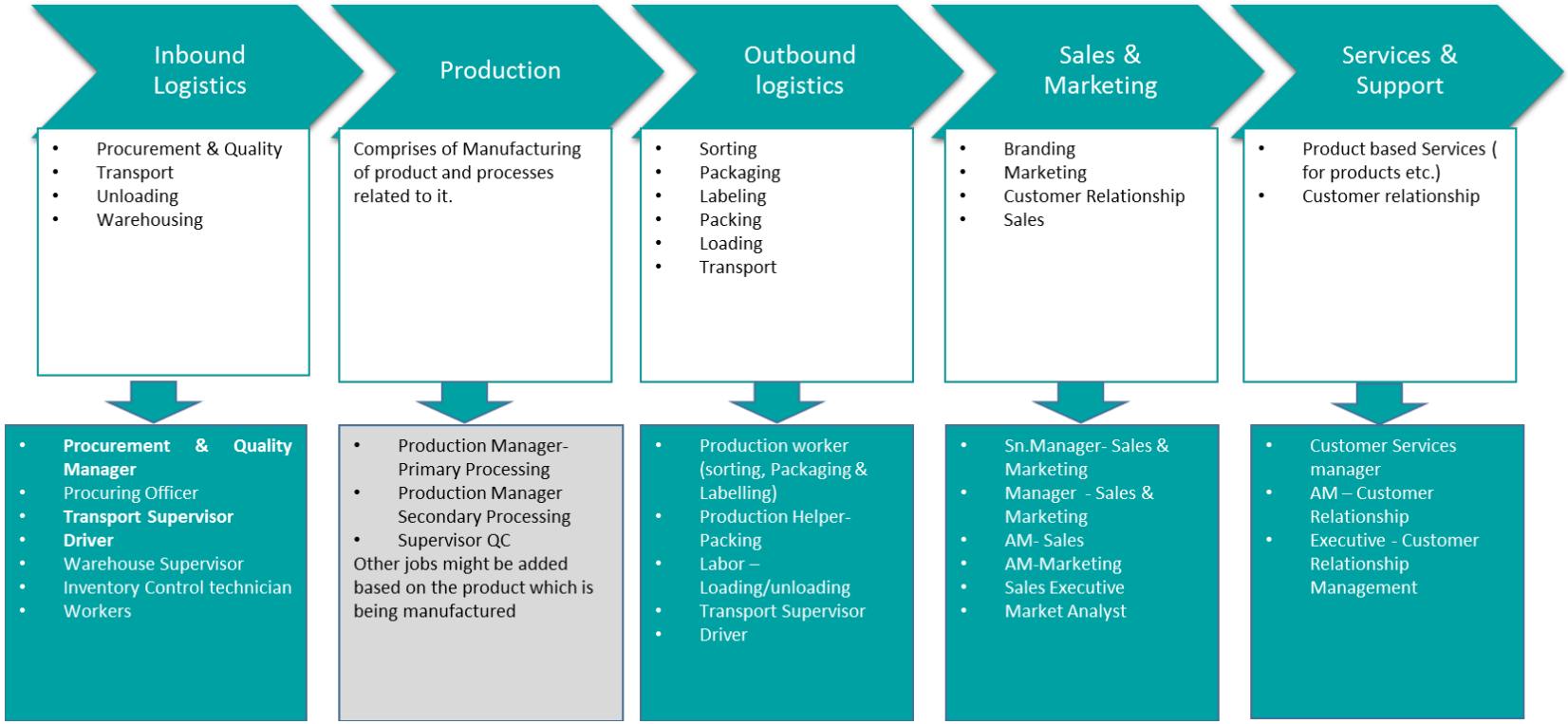


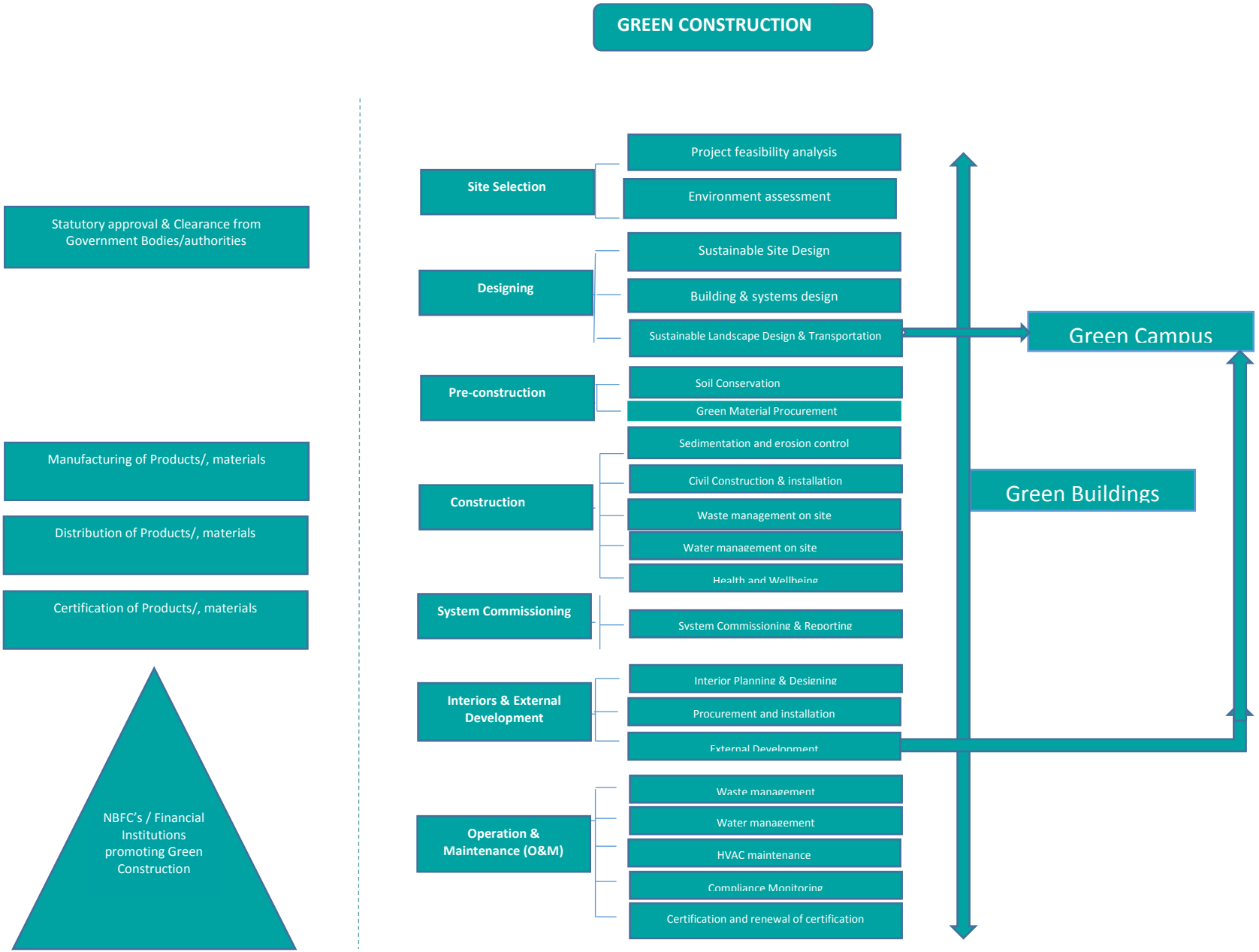
Figure 7: Depicting the Value Chain for Material Supply for Green Construction.

The above table reflects the Value Chain in Supply chain for material manufacturers. There is a huge scope of jobs around these processes which are listed above. Since the production processes would vary from product to product, the job roles for same have not been included in details. These Jobs are also reflected in the occupational mapping that we have developed for the sector.

Chapter 5

Process Flow

Green Constructions are largely classified into New & Existing Green Buildings & Green Campuses. New Green Buildings mainly comprise of 6 steps starting from site selection to Operation & Maintenance. On the other hand the focus of Green Existing buildings is on Operation & maintenance aspects of existing buildings.



Chapter 6

Occupational Mapping

Table 4: Occupational Job roles			
Stage	**Steps**	**Key Activities**	**Job Roles**
Stage 1: **Site Selection**	[1A] Project feasibility analysis	Land Authorization assessment Environmental clearance (EIA Reporting) Site Investigation Resource and need assessment Topographic survey/Hydrology Survey	Project Manager Architect Environmental Consultant Structural Engineer Land Surveyors
	[1B] Environment assessment	Environment assessment including tree Survey (Identify the habitats and/or species that exist within an area at the time of the survey. This would cover biotic and abiotic factors like plants, animals, soil, sunlight etc.)	
	[2A] Sustainable Site Design	Site sediment and erosion control planning (Based on hydrology Survey, soil survey, topography survey, vegetation survey) *Energy efficient Site planning (on-site renewable energy planning (Applicable for Green Campuses) Top soil protection planning Plan to be developed for soil conservation at site. *Sustainable Transportation Planning (Planning needs to focus on pedestrian networks, bicycles lanes network, access to sustainable transportation and Sustainable shades on campus.) -(Applicable for Green Campuses)	Environmental Consultant Green Building Consultant Landscape architect Architect Structural Engineer
	[2B] Building & systems design	Energy Design (Designing building envelope (wall, roof, glass) and HVAC systems and components along with its performance and cost. *Energy designing for On-site renewable energy	MEP Specialist Green Building Consultant Structural Engineer Fenestration Designer Project manager

Stage 2: Designing		Lighting design (artificial & natural lighting –Day & Night lighting) Passive architectural design (Earth, solar, wind) as per climatic condition of the area (Designing of buildings using natural sources of heating, cooling and ventilation by strategic planning on orientation of building, window design, sun shades, building insulation, and Earth air tunnel) Designing energy-efficient lighting and HVAC systems in homes/buildings. Façade Designing Building Information System Modeling	
	[2C] Sustainable Landscape Design	Water Efficient Landscaping Plan Heat Island Effect Management plan Lighting Design Strategies- Night Lighting Water efficient landscape designing Urban Greening/Forestry Transportation & Traffic planning	Electrical Engineer Architect Green building consultant Landscape Architect Plumbing Specialist
Stage 3: Pre-construction	[3A] Soil Conservation	Application of erosion control measures Sedimentation collection systems Drainage system development Transplantation & management of existing site feature (tree, water bodies/mounds etc.) Maintenance of maximum plant cover on the soil surface	Green Building Consultant Environmental Consultant Landscape Architect Architect Project manger
	[3B] Green Material/ Product – Supply Chain	Inbound Logistics- Procurement & Quality ,Transport ,Unloading Warehousing Outbound Logistics – Sorting ,Packaging ,Labeling,Packing,Loading Transport Sales & Marketing – Branding, Marketing ,Customer Relationship Sales	Green building Consultant Project manager Procurement & Quality control Manager Marketing & Finance Executive CRM Transport Supervisor Driver Warehouse Supervisor Inventory Control technician

		Services & Support - Product based Services ,Customer relationship	Workers Production worker (sorting, Packaging & Labelling) Production Helper- Packing Labor – Loading/unloading Sn.Manager- Sales & Marketing Manager - Sales & Marketing AM- Sales AM-Marketing Sales Executive Market Analyst Customer Services manager AM – Customer Relationship Executive- Customer Relationship Management
	[3C]Manufacturing of green products/ material	Production of products Processing of green material	Production Workers Processing supervisors Quality Assessment & Quality control Expert
	[3D] Financial Support	Financial support through Banks to support Green construction Financing.	Technical Head - Green Construction Financing Technical Manager - Green Construction Financing Credit Head Credit underwriters Lawyer - Green Constructions Financing
	[4A] Sedimentation and erosion control	Construction and installing erosion control systems Onsite inspection of soil erosion and sedimentation	Architect Landscape architect Project Manager
	[4B] Waste management on site	Segregation of waste – Manual separation, Screening and conveyor picking, size reduction & mechanical separation. Disposal of waste	Project manager Green Building Consultant Helpers on Construction site

Stage 4: **Construction**			
	[4C] Water management on site	Construction of Water treatment plant On-site waste water treatment Rainwater harvesting structure	Project manager Green Building Consultant Structural engineer
	[4D] Civil Construction & installation	Excavation Foundation Framing Interior Rough-in (HVAC, Electrical, plumbing etc.) Flooring , Roofing Insulation of Roofs, walls , ceilings Installations of Solar Panels ,wind turbines Installation of HVAC system Plumbing Air quality monitoring on site Inspection	Architect Structural Engineer Contractor Construction Manager (Contractor side) Project Manager (Developers side) Site Supervisor Construction worker Mechanical Engineer Electrical Engineer MEP Specialist Mason Plumber Welder Fenestration Designer Project manager
	[4E] Health and Wellbeing of construction workers	Sprinkling Safety Hazard equipment's like masks, boots etc. Adequate Housing for construction workforce Transportation, Sanitary ,Daycare/Crèche and other facilities for workers (as applicable)	Green building Consultant Project Manager Construction worker Transport manager Drivers
Stage 5: **System Commissioning**	[5A] System Commissioning	Commissioning Reporting Green building commissioning	Project Manager
Stage 6: **Interiors & External Development**	6 [A] Interior Planning & Designing	Space planning Design Development Sourcing HVAC	Architect Green Building Consultant MEP Specialist

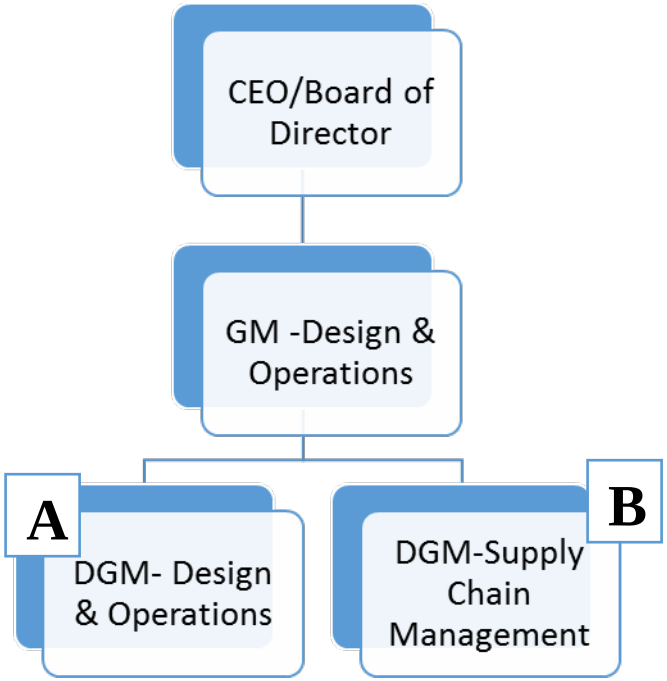
	[6B] Green material and Products , procurement and installation	Material procurement as per green standards Selection of Low VOC (volatile organic compounds) paints/adhesive/sealants. Energy Efficient interiors selection & installation –appliances Production and installation of Furniture	Green Building Consultant Painter Carpenter Electrician Welders
	[6C] External Development	Transplantation ,Turf development Electrical installations Irrigation system installation Vehicle Procurement (Campus) Installations of Charging systems on Campus	Landscape Architect Electrical Engineer Project Manager Plumbing specialist
Stage 7: **Operation & Maintenance (O&M)**	[7A] Waste management	Collection of waste Waste segregation Recycling of waste – On site composting Disposal of waste	Recyclable waste collector & segregator Project Manager Green Building Consultant Facility Manager
	[7B] Water management	Sewage Treatment Plant operation & monitoring Monitoring of Rainwater harvesting structure Water recycle and reuse monitoring	Operator –Utilities Project Manager Green Building Consultant Facility Manager
	[7C] HVAC maintenance	Heating, venting, air conditioning, and refrigeration maintenance	Green Building Consultant Facility Manager
	[7D] Compliance Monitoring	IAQ (Indoor Air quality) Survey and monitoring Energy Metering and monitoring Energy Audit Solar thermal/PV systems monitoring Testing of the mechanical, electrical and plumbing systems Inspection of wind turbines	Facility Manager Green Building Consultant Energy Auditors
	[7E] Certification and renewal of certification	Evaluation & Certification of Green Buildings Staff training on O&M Validation and maintenance of 'green' performance levels	Green Building Consultant

* The Occupational Job Roles for Existing Building would be similar to the above value chain, with a focus on stages 2B, 2C, 3B, 5, 6 & 7 while other stages would not stand valid for an Existing Building.

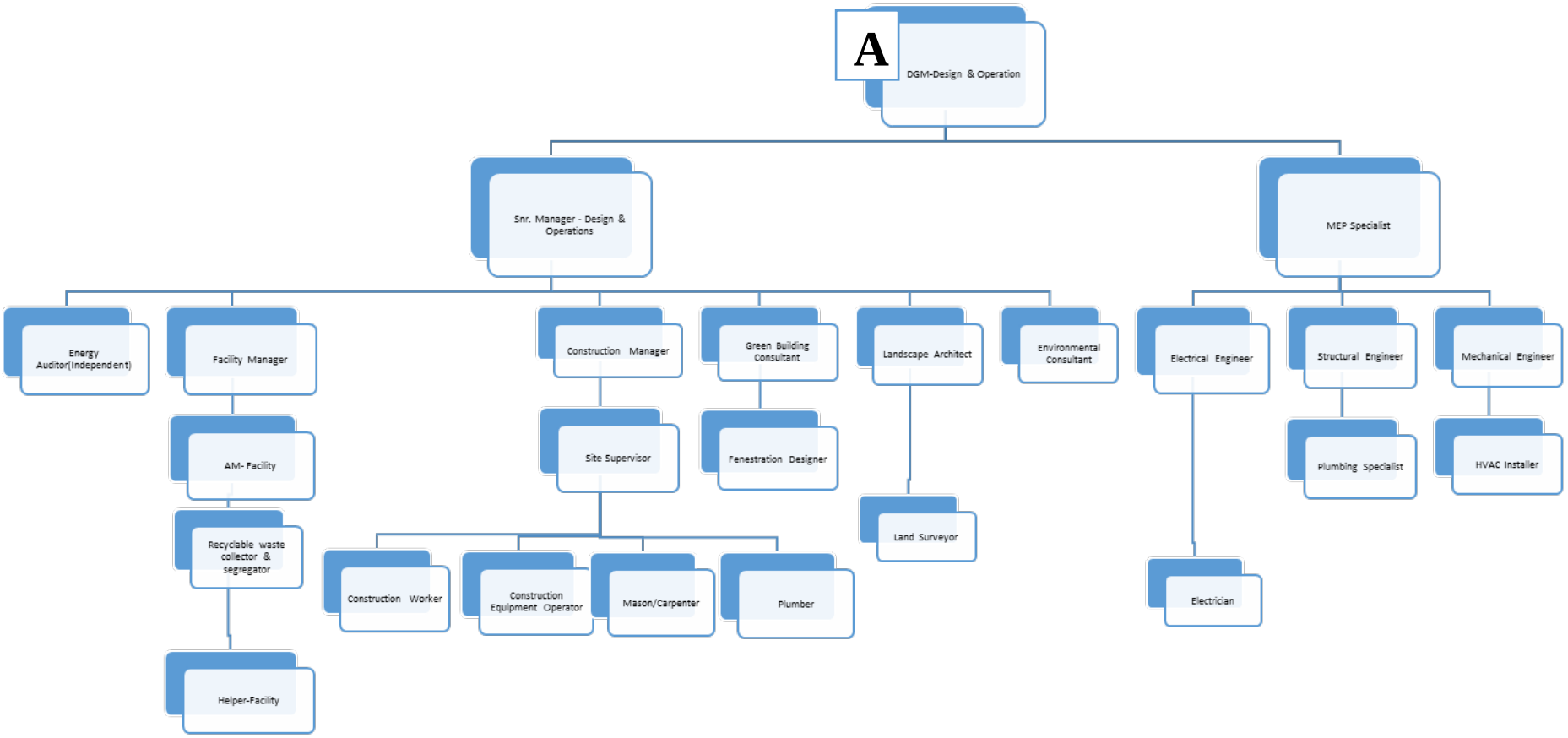
* The Occupational Job Roles for Green Campus would be similar to the above value chain, with a focus on the entire campus and an addition on sustainable transportation as mentioned in 2 A and 6 C.

Occupational Mapping

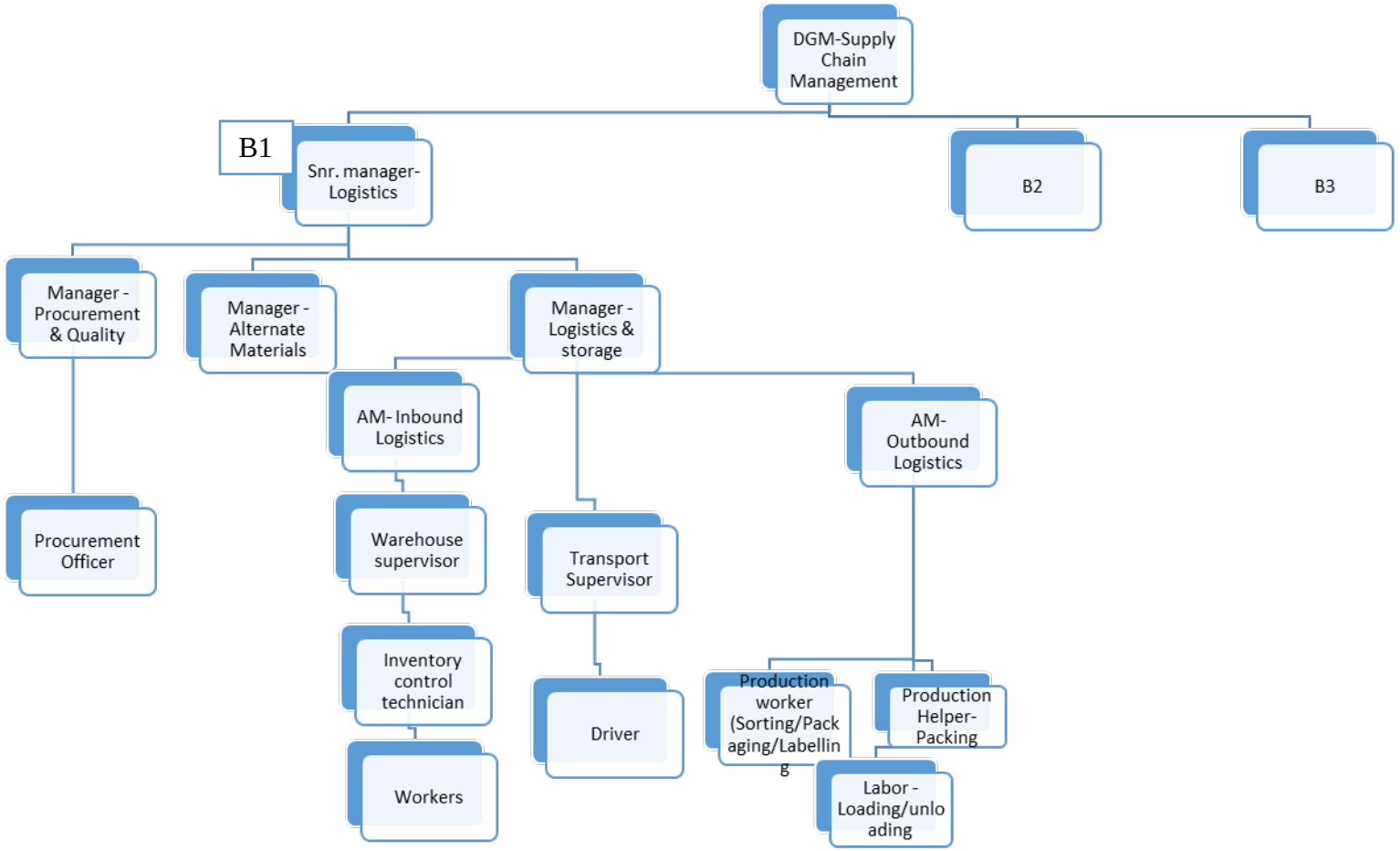
NSQF Level
Level 10
Level 9
Level 8



NSQF Level
Level 8
Level 7
Level 6
Level 5
Level 4
Level 3
Level 2
Level 1



NSQF Level
Level 8
Level 7
Level 6
Level 5
Level 4
Level 3
Level 2
Level 1

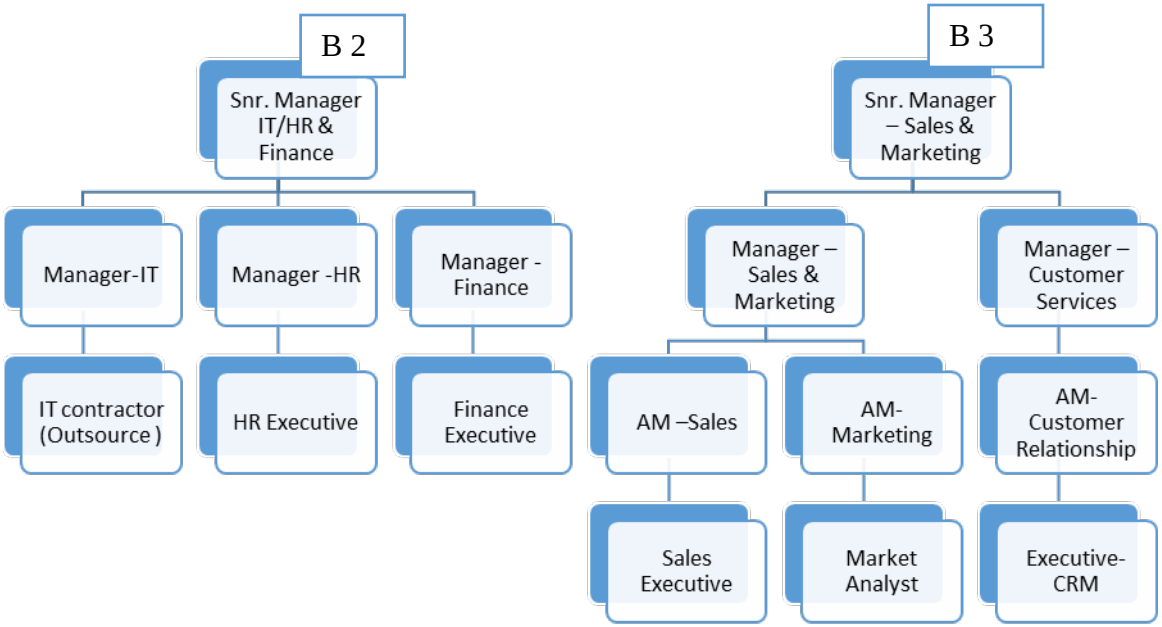


Level 7

Level 6

Level 5

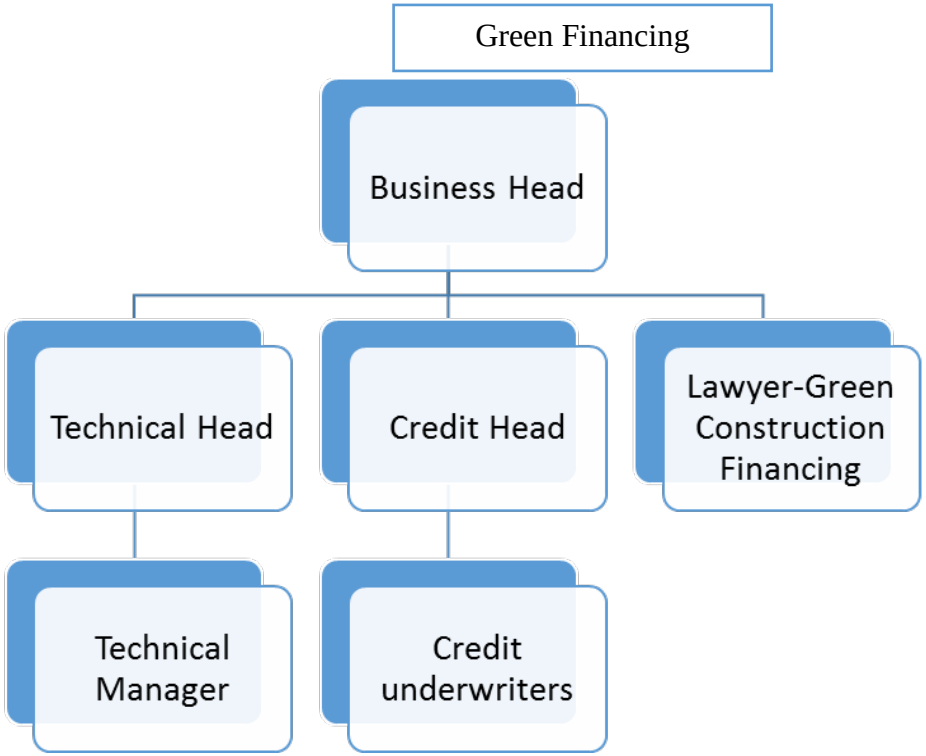
Level 4



Level 9

Level 8

Level 6



Job Roles and NSQF categorization

Based on the consultation with stakeholder following job roles have been identified, below is the list of job roles and mapping as per NSQF levels.

S.no	Job Roles	NSQF Level
1	GM Design & Operations	10
2	DGM Supply Chain Management	9
3	Senior Manager - Design & Operations	8
4	Plumbing Specialist	5
5	Environmental Consultant	6
6	Land Surveyor	4
7	Green Building Consultant	6
8	Construction Manager	6
9	Construction worker	3
10	Mason	3
11	Plumber	3
12	Welder	3
13	Fenestration Designer	5
14	Manager Logistics & Storage	6
15	Driver	2
16	Carpenter	3
17	Electrician	3
18	Facility Manager (Operation & Maintenance)	6
19	AM Facility	5
20	Helper Facility	2
21	Recyclable waste collector & segregator	4
22	Manager (Alternate Materials)	6
23	Landscape Architect	6
24	Energy Auditor	6
25	MEP specialist	6
26	Structural Engineer	6
27	Construction Equipment Operator	3

28	HVAC Installer	4
29	Electrical Engineer	6
30	Mechanical Engineer	6
31	Snr. Manager -Logistics	7
32	Manager –Procurement & Quality	6
33	Manager – Finance	6
34	Manager-IT	6
35	Manager -HR	6
36	Supervisor -Primary Processing	4
37	Supervisor -Secondary Processing	4
38	IT contractor (Outsource)	3
39	Transport Supervisor	4
40	Warehouse Supervisor	4
41	Finance Executive	3
42	Executive CRM	3
43	Driver	2
44	Helpers - Processing	2
45	Worker - Processing	2
46	Procuring Officer	4
47	Inventory Control technician	3
48	Workers - Inbound Logistics	2
49	Production worker (sorting, Packaging & Labelling)	2
50	Production Helper- Packing	2
51	Labor – Loading/unloading	1
52	Sn.Manager- Sales & Marketing	7
53	Manager - Sales & Marketing	6
54	Sales Executive	3
56	Market Analyst	4
57	Customer Services manager	6
58	AM – Customer Relationship	5
59	Executive - Customer Relationship Management	3

60	Technical Head - Green Construction Financing	8
61	Technical Manager - Green Construction Financing	6
62	Credit Head	8
63	Credit underwriters	5
64	Lawyer - Green Constructions Financing	8
65	AM- Sales	5
66	AM-Marketing	5

Annexure 1

List of Pre-certified products

GreenPro Certified Products (002).xlsx

References

- *Buildings and Climate Change, Summary for decision makers: United Nations Environment Programme , Sustainable Buildings & Climate Initiatives (UNEP SBCI), 2009.*
- *Green Growth and Building Sector in India: The Energy & Resource Institute (TERI), 2015.*
- *Wynn Chi-Nguyen Cam, Technologies for Climate Change Mitigation – Building Sector, UNEP; August 2012.*
- *Ramesh SP, M Emran Khan: Energy Scenario and Energy Efficiency: Programme and Policies of Booming India: American International Journal of Research in Science, Technology, Engineering & Mathematics; 2013.*
- *Hari Pullakat, "A tough to-do list for India from Paris'COP21 climate summit", The Economic Times; December 22, 2015.*
- *IGBC targets 10 bn. Sq. ft. green building area by 2022: Press Trust of India, New Delhi June 18, 2014 (http://www.business-standard.com)*
- *Indian Green Building Council: Source; https://igbc.in*
- *Ministry of Power, Government of India: Source: http://powermin.nic.in/en/content/energy-efficiency*
- *National Mission on Sustainable Habitat. (2010). Ministry of Urban Development (MoUD), Government of India.*
- *Indian's Intended Nationally determined contribution: working towards climate change*
- *India: Addressing Climate Change and Moving Toward a Low-Carbon Future, November 2015, National Resources Defense Council (NRDC)*
- *Bureau of Energy Efficiency, Government of India: Source https://beeindia.gov.in/content/buildings, https://beeindia.gov.in/content/ecbc,https://beeindia.gov.in/content/new-construction*
- *World Green Building Trends 2016 , Developing Markets Accelerate Global Green Growth ;Smart Market Report*
- *Role of Green Buildings in Sustainable Construction- Need, Challenges and Scope in the Indian Scenario 2015*
- Human Resource & Skill Requirements in the Building, Construction and Real Estate Services Sector (2022); NSDC
- http://inhabitat.com/building-modelled-on-termites-eastgate-centre-in-zimbabwe

▪*Bamboo as a low cost and green alternative for reinforcement in light weight concrete, SAITM – RSEA 2013*

▪Viola Polesello & Katie Johnson, Energy Efficient buildings for low-carbon cities, International center for climate governance,2016