

Catalysing Science-Based Policy Action on SCP

Task Group IRP-One Planet network

Analysis of the Construction Value Chain

Understanding the value chain & identifying hotspots

Draft 10 December 2020

The science is clear on the need to decouple economic growth from natural resource use and environmental impacts. Yet this evidence does not always reach key decisions makers in a way that is relevant and actionable. To address this challenge, and as requested by the 4th UN Environment Assembly, the International Resource Panel and the One Planet network established a task group bringing together the experts on natural resources and the practitioners implementing sustainable consumption and production. The task group aims to catalyse science-based policy action on sustainable consumption and production, thereby providing actionable insights on the management of natural resources in relation to the 2030 Agenda for Sustainable Development. To achieve this, the task group took a sectoral focus and applied the value-chain approach.

The value-chain approach aims to identify hotspots and shape corresponding actions built on existing knowledge and available data. Data and information are analysed and organised under three key steps as illustrated in the diagramme below.

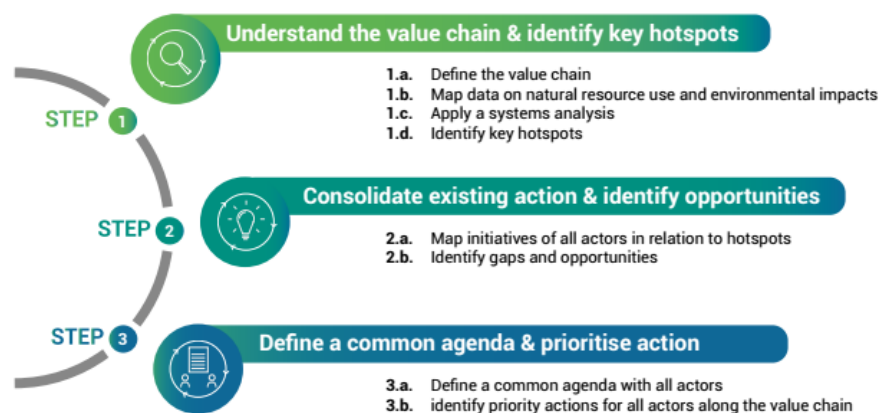


Figure 1: Overview of the key steps of the value-chain approach

The practical illustration of the benefits of the value chain approach to define SCP action that is informed by science is illustrated by its application to the three prioritised sectors of Food, Construction and Textiles.

This report focuses on the application of the first step of the value-chain approach to the Construction sector. **It provides an analysis and mapping of available information on natural resources, environmental impacts and the system within which the value chain operates to understand the construction value chain and to identify its key hotspots and intervention points.**

1. Overview of construction value chain and data availability or gaps

Construction can be categorised into four main types: residential buildings (e.g. apartments and houses), institutional and commercial building (e.g. schools, hospitals, shopping centres, retail stores, etc.), specialised industrial construction (e.g. chemical industry plants, power plants, etc), infrastructure and heavy construction (e.g. roads, tunnels, bridges, railways, sewage systems, pipelines, etc).

This value-chain analysis for construction is informed by various reports of the International Resource Panel that address aspects of construction, complemented by other sources. Based on these sources the construction value chain can be visualised as follows:

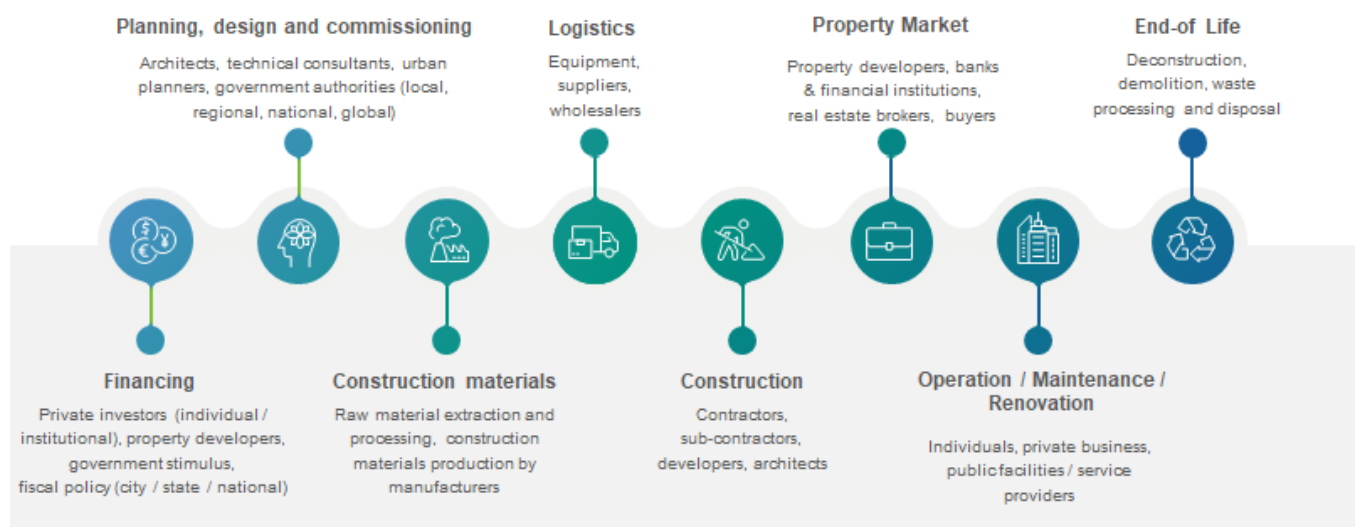


Figure 1: Stages of the construction value chain

For illustration purposes the stages of the value chain are reported as a linear sequence in Figure 1. However, some stages can take place simultaneously or with a different order (e.g. property market v. construction) and involve a mix of processes and actors in different parts of the world (e.g. for the production and supply of construction materials). Simplification and generalisation on the stages of the value chain is necessary while acknowledging that these may vary between and within types of construction, countries and region.

Data availability and gaps:

In line with the scope of the task group, the main source of information for this analysis are International Resource Panel reports, complemented by reports from UNEP and other organisations. Differently from other sectors (e.g. food systems), construction is not the object of a dedicated IRP report, rather the information on the construction value chain is featured across a variety of reports. Further, the following limitations in data availability were identified:

- **Material stocks and flows in construction to be addressed.** There is limited overarching information available on the use of materials along the global construction value chain. Information on materials used in construction is generally organised separately based on the specific type of material such as steel and cement, and its use across many different sectors. There is little analysis and knowledge to-date that combines an overarching view of the extraction and processing of the many different materials used along the construction value chain specifically. This may also be related to the general focus on energy efficiency over material use in construction sustainability. In order to better



understand the consequences of material usage in buildings and construction on natural resource use and environmental impacts, as well as the socio-economic implications, it will be necessary to bridge this knowledge gap around what materials are being used, where these materials are coming from and what the social, economic and environmental implications are of resource extraction to supply the global construction value chain.

- **Data at the different stages of the value chain on resource use and environmental impact.** Different parts of the information are available in different reports. For example, one report focuses on the operation and use of building and related GHG emissions (IRP 2020), while another report provides an overview of materials used in construction (IRP 2019). Information on the use of materials along the global construction value chain is also limited. Information on materials is generally organised separately based on the specific type of material such as steel and cement, and its use across many different sectors. There is little analysis and knowledge to-date that combines an overarching view of the extraction and processing of the many different materials used along the construction value chain specifically. This may also be related to the general focus on energy efficiency over material use in the reports addressing construction.
- **Materials as measured by material flow accounting do not show either the natural resources that people can understand, nor the finished materials that people can understand.** They are mostly something in between the two - that is more processed than a natural resource, but not processed enough for a finished material that can be used. This significantly limits the understanding of how materials used in construction connect to natural resource use and environmental impacts.
- **Political economy analysis of the value chain.** The International Resource Panel emphasises the importance of considering the role of all actors in shaping food systems and construction, and does provide sections and chapters on political economy issues and systems analyses in their reports. However, this information is presented in a way that is not necessarily immediately accessible, including a relatively complex presentation that assumes a detailed reading of the reports and a pre-existing understanding of the issues at stake. Considering the importance of political economy issues to understand the different value chains, there is an opportunity to strengthen its connection with natural resource use and environmental impacts. Moreover, there is an opportunity to re-think what information is highlighted when the reports are promoted and disseminated. For instance, by shifting from purely natural sciences towards the integration with knowledge from the political economy, sociology and anthropology that provide the understanding of the socio-economic system within which natural resource use and environmental impacts occur.

2. Natural resource use & impacts along the value chain

The mapping of available data and information to key stages of the value chain allows to filter and distil large volume of information to identify where the greatest opportunity for improvement occurs. The mapping includes the following: construction materials, natural resources, and environmental impacts.

2.1. Use of construction materials in the value chain

Buildings and infrastructure can be made of a broad list of construction materials (ISO). Construction materials are usually manufactured using a combination of natural resources – for example steel is composed principally of iron ore and carbon and requires energy to be produced. The following construction materials are of particular relevance to construction:

- **Concrete:** is a key product used for buildings and consists mostly of aggregates, including gravel (40.8%) and sand (31.1%), cement (10-15%), water, and burnt lime as binder. Concrete in buildings is the largest contributor to the use of sand and gravel by the sector (IRP, 2016).
- **Cement:** is key ingredient of concrete; it is made of limestone, clay, shells, chalk, shale, slate, silica sand, and sometimes even blast furnace slag or iron ore. These ingredients are crushed then heated at high temperatures to result in a material called “clinker”. Gypsum is added and the whole mixture is finely ground to produce cement powder.
- **Asphalt (or bitumen):** main material used for the construction of transport infrastructure (e.g. roads) and is mostly composed of petroleum and aggregates;
- **Metals:** steel, aluminium, copper, etc;
- **Timber and wood-based materials;**
- **Chemicals, Glass, Plastics and Stones;**
- **Earth:** nearly 30% of the world population live in earth construction and it is regaining interest in industrialised countries (Vyncke et al., 2018);
- Alternative construction materials can also be sourced locally – depending on their availability – as for example sugar cane bagasse, bamboo, typha, etc

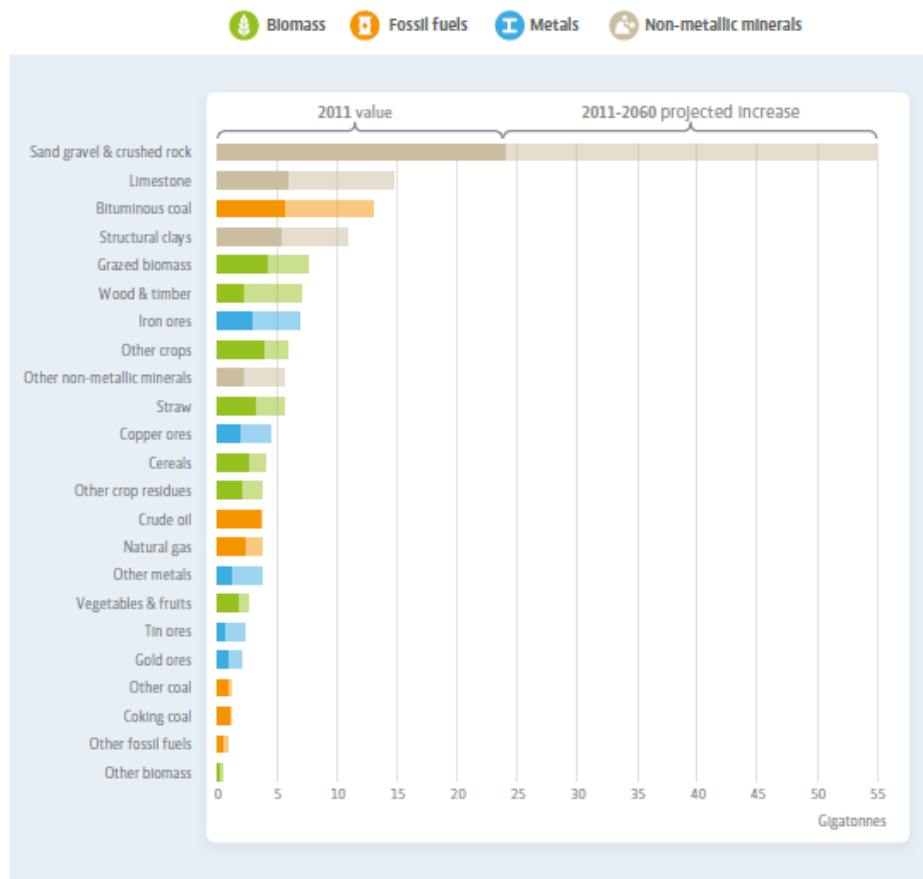


Figure 2: Global use of construction materials and other natural resources (from OECD 2018)

There is limited overarching information available on material flows and stocks and on the usage of materials along the global construction value chain, with different pieces of information available from individual sources often at a material-specific level such as on steel, or cement. This is also related to the general focus on energy-efficiency over material use in construction sustainability. However, some general trends can be observed around material usage in construction.

- A major shift from wood to other construction materials (e.g. concrete and steel) took place in the 20th century.
- The availability, durability and versatility of steel, iron and concrete resulted in their widespread adoption and enabled the massive construction of buildings and infrastructure that can be seen today.
- This also caused a massive consumption of non-renewable resources (mainly non-metallic minerals and to a lower extent metals) that further changed the nature and scale of environmental pressures (IRP, 2019).

2.2. Use of natural resources

A large amount of natural resources are used along the construction value chain to varying degrees at the different stages (table 1). While all stages of the value chain utilise natural resources to some degree, the table indicates that **their use is most intensive during the production of materials, the construction and the operation stages compared to other stages along the value chain.**

	Financing	Planning, design, commissioning	Production of Construction materials	Logistics	Property market	Construction	Operation	End-of-Life
Land, soils, landscape			●●●			●●●●●	●●●	●●
Water			●●			●●●	●●●	
Biodiversity, Ecosystem Services			●●●●					
Genetic resources			●●					
Minerals & nutrients			●●●●●			●●●●●		
Fossil fuels			●●●●	●●		●●●●	●●●●●	●

Table 1: Indicative mapping of the main resources used along the construction value chain (The dots in each square represent the intensity of use of the specific resource at each stage of the value chain. Blanks may indicate low significance of resource use or lack of data)

Natural resources of particular importance to the construction value chain, include land, water, minerals and fossil fuels. Land is required to extract and manufacture materials, and for new construction to be built upon. In most areas, new urban expansion is developed in the most fertile areas (IRP, 2014), thereby creating competition between land use for construction and agriculture. Twenty-five per cent of water and 12% of potable water used globally are associated with buildings (IRP 2017a; IRP 2017b), mainly for construction processes and occupation of buildings. Non-metallic minerals and metals are the main natural resources used in the construction sector (IRP 2019). On a global scale, the construction sector uses about 65% of non-metallic minerals, 15% of ferrous metals and 3% of non-ferrous metals (OECD 2018). Non-metallic minerals are mostly used for buildings and in construction they include sand, gravel and limestone (IRP 2016a; IRP 2019).

Land: Land is required to extract and manufacture materials, and for new construction to be built upon. Land occupation can last 25-100 years or longer, depending on country and type of construction. In most areas, new urban expansion is developed in the most fertile areas (IRP, 2014), thereby creating competition between land use for construction and agriculture.

Water: 25% of water and 12% of potable water used globally are associated with buildings (IRP 2017a; IRP 2017b), mainly for construction processes and occupation of buildings. The consumption of water in the construction sector is mainly associated with construction processes and occupation of buildings as well as with the extraction, processing and manufacturing of materials.

Minerals: Non-metallic minerals and metals are the main natural resources used in the construction sector (IRP 2019). On a global scale, the construction sector uses about 65% of non-metallic minerals, 15% of ferrous metals and 3% of non-ferrous metals (OECD 2018).

Non-metallic minerals are mostly used for buildings and in construction they include sand, gravel and limestone (IRP 2016a; IRP 2019). Sand and gravel are mined worldwide and account for the largest volume of solid material extracted globally: about 40-50 billion metric tons per year (IRP, 2019), of which 40.8% made by gravel and 31.1% by sand in 2010 (IRP, 2016).

Metals, such as iron, aluminium and copper, represent about 10% of global extraction of natural resources and are used for constructions, energy and transport infrastructure, equipment, manufacturing and for consumer goods.

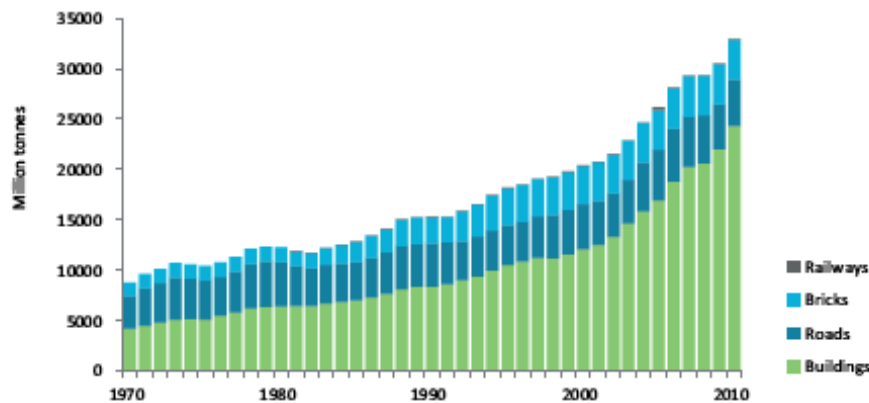


Figure 3: Global extraction of non-metallic minerals by sector of use, 1970-2010, million tonnes (IRP, 2016)

Fossil fuels: 40% of energy used globally is associated with buildings (IRP 2017, UNEP 2017). The operation of buildings is one of the main points of consumption of energy. Fossil fuels are also used as ingredient for key construction materials and as source of energy in the processes creating such materials (also called embodied energy). For example, asphalts and plastics products are based on crude oil, while 70.7% of steel worldwide is produced predominantly from iron ore, coal and recycled steel through the blast furnace-basic oxygen furnace route (Worldsteel, 2019). Furthermore, energy is also spent for the supply of construction materials and in the construction process, although to a lower extent compared to the previous two aspects.

2.3. Environmental Impacts

In addition to using natural resources efficiently, natural resources must also be used sustainably, meaning that the use of these resources does not cause harmful consequences to the environment such as biodiversity loss, global heating or reduced air, soil and water quality. **Pollution and greenhouse gas (GHG) emissions are among the most documented environmental impacts in construction.** The major environmental impacts caused along the construction value chain include:

IMPACT	Financing	Planning, design, commissioning	Construction materials	Logistics	Property market	Construction	Operation	End-of-Life
Deforestation and land-use changes			Land conversion; use of timber; mining			Land conversion	Occupation of land over time	
Biodiversity loss			Land conversion; use of timber			Land conversion		
Water - scarcity and pollution			River sand extraction				Wastewater	
Soil pollution and run-off			Mining; material extraction and production			Land conversion	Day-to-day waste and wastewater	Demolition, landfills, unmanaged waste
Air pollution			Material extraction and production			Dust emissions during the construction	Indoor air quality;	Landfills
GHG emissions			Embodied in construction materials	Transport		Construction activities; land conversion	Energy use	Waste

Table 2: Indicative mapping of main environmental impacts along the construction value chain (Impacts may more marginally occur also in other stages. Data gaps may exist)

Pollution - air, water, soil: Pollution of air, water and soil is in general associated with the extraction and processing of natural resources and the further manufacturing of construction materials, as well as with logistic activities and construction.

Air pollution from energy supply and use in homes and industries, as well as transportation and construction sectors of cities, is associated with about 6.5 million premature deaths per year. Indoor and ambient air pollution by fine particulate matter (PM_{2.5}) is the dominant risk factor accounting for 96 per cent of health effects (IRP, 2017a).

The extraction and manufacturing of construction materials can result in toxic mining tailings and require chemicals and energy-intensive processes, which result in the emission of pollutants to the environment.

Water scarcity: The massive collection of sand from riverbeds causes the lowering of water aquifers thus worsening the occurrence and severity of drought events (IRP 2017a, 2019b). It also causes water pollution, changes in pH levels and instability of riverbanks leading to increased flooding (IRP, 2019b).

Deforestation: Urbanisation and related constructions place direct pressures on land use that could potentially drive deforestation (IRP, 2019). Other possible causes of deforestation are mining to produce construction material and logging to produce timber. The conversion of land to be used for construction also contributes to **biodiversity loss** and reduced carbon sequestration.

Greenhouse Gas (GHG) emissions: The construction sector is responsible for 39% of global GHG emissions, 44% of which associated with residential buildings, 28% with non-residential buildings, 28% with other constructions (Global ABC et al., 2019). GHG emissions are mostly associated to the operation of buildings, as

well as from the production and supply of construction materials (embodied emissions). In terms of construction materials, a strong contribution to GHG emissions is associated to the use of cement and concrete (see Figure 4). Although the contribution from iron and steel is the largest on a global scale, it should be highlighted that these materials are also used in other sectors.

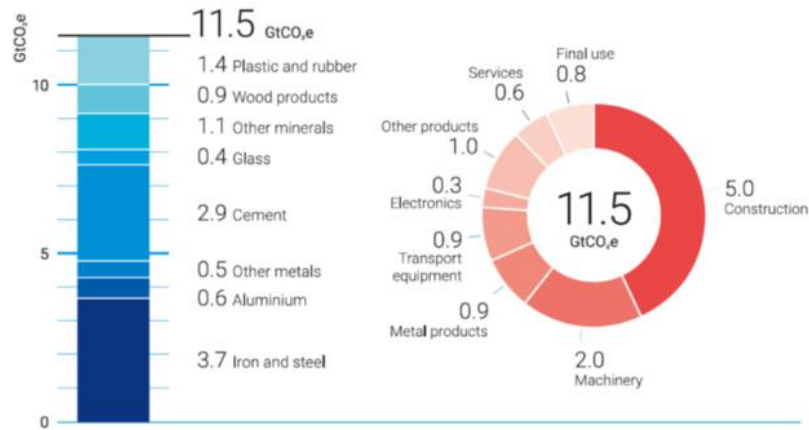


Figure 4: GHG emissions associated with materials production (left) and use (right) (UNEP, 2019)

2.4. Conclusion

The data presented above demonstrates that the **majority of both natural resource use and environmental impacts** that take place along construction value chain **occur at the manufacturing of construction material, the construction and the operation stages** of the value chain.

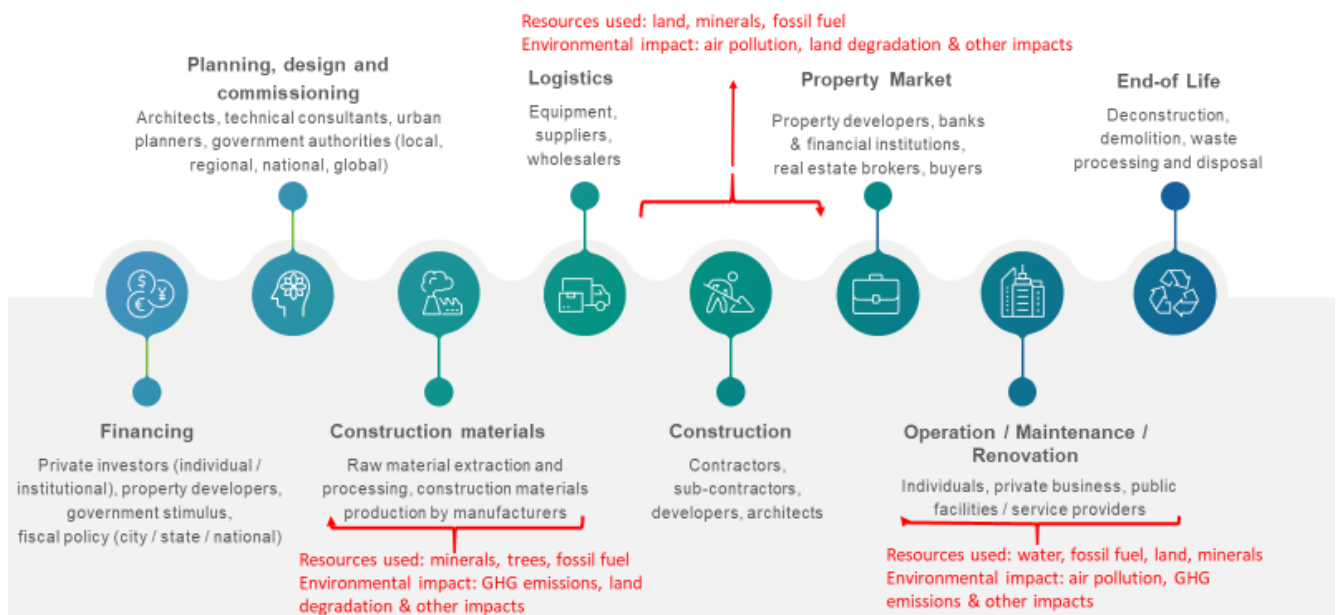


Figure 5: Stages of the construction value chain in which most natural resource uses and environmental impacts occur

3. Applying a systems lens to the construction value chain

Even though natural resource use and environmental impacts occur at the manufacturing of construction material stage, the construction stage and the operation stage of the value chain; the solutions can be found at many different stages. The interactions within the systems mean that the operations and behaviours of actors at different stages of the construction value chain can have a significant influence on the operations

and behaviours of actors at other stages of the value chain. For example, the actions of investors and planners can shape the practices of construction companies, which in turn shape the characteristics of buildings and infrastructure available to users. It is therefore necessary to apply a systems lens to the analysis of a sector to move beyond a siloed and disconnected analysis, and toward understanding how different drivers of a given sector - such as institutions, regulation, demographics and economic factors - shape the operations of along the value chain.

Each of the drivers in the diagramme below contribute to shaping the construction value chain, influencing the behaviour of the actors along it and determining what options are available to them. Equally, each of these drivers are all possible points of intervention to positively shape the way the sector works and the behaviour of actors along the value chain.

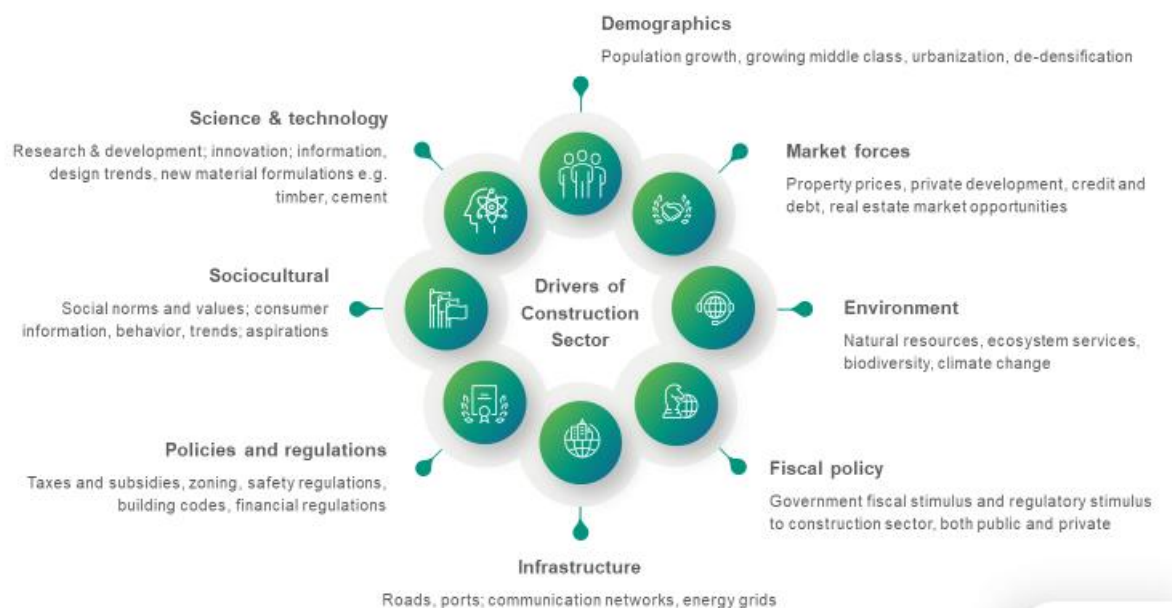


Figure 6: Drivers of the construction value chain

Understanding the what, how much and how along the construction value chain

Construction as a sector globally has the highest material consumption footprint, consuming almost 50% of the total material footprint across the global economy (SCP-HAT 2020). As outlined, this involves the use of a range of natural resources and results in many environmental impacts. However, the construction sector also contributes in a variety of ways to socio-economic outcomes and to meeting the Sustainable Development Goals, in particular SDG 11 which calls for safe and affordable housing; sustainable and affordable transport systems; and inclusive, gender responsive and sustainable urbanisation. It is therefore essential to analyse the socio-economic outcomes of the construction sector alongside the associated natural resource use and environmental impacts, to be able to balance any trade-offs. In order to undertake such an analysis and consider these trade-offs, three questions must be applied to understanding natural resource use and environmental impacts along the construction value chain: 1) What is being built and where, 2) How much is being built; 3) How it is being built.

Discussion on sustainability in the construction sector often focuses on the third question of *how things are being built*, with an emphasis on circularity of materials, energy efficiency and material substitutes and innovations, as well as on the safety of constructions and their resilience to natural disasters and to the impacts of global warming. By changing how constructions are built through sustainable materials and practices, the associated natural resource use and environmental impacts of the sector can be reduced.

While this is a critical question, it is also necessary to ask what is being built and where? For example, is it residential, commercial, industrial or public infrastructure? Is the sector working on new builds or renovations of existing construction? Is the housing being built affordable or in cities and regions that have the greatest need for development? What land is being used for new construction? (e.g. is it fertile land converted from agricultural purposes, or land already occupied by informal settlements.) Depending on what type of construction is being built and where, this can have different levels of impact on natural resource use and environmental impacts, as well contribute in varying degrees to meeting the SDGs, thereby influencing how trade-offs are balanced.

The other question that must be asked is how much is being built? The overall volume of constructions being built is a key determinant of the volume of natural resources that the sector is using as well as the degree of environmental impacts that are caused by the sector. The volume of construction activity is also connected to the different social and economic development pathways of countries.

The answers to the three questions above are shaped by a range of drivers along the different stages of the construction value chain, with much interaction and many feedback loops between stages. The following section applies a systems analysis to the construction value chain to highlight several important features at the different stages of the value chain.

3.1. Key observations along the construction value chain

3.1.1. A variety of construction projects involve different actors

At a global scale, residential buildings hold the largest portion of construction. In relative terms, residential buildings constitute the major part of constructions in North America and Europe. Infrastructure dominates in Asia-Pacific, Latin America, Africa, and the Middle East; while non-residential buildings makes the strongest contribution in Eastern Europe (HIS 2013). Overall, Governments are key player in the design, execution and management of institutional buildings and infrastructure, often with the co-participation of the private sector. Private companies play a prominent role in the conception, execution and management of residential and commercial buildings.

	Residential buildings	Institutional and commercial buildings	Specialized industrial construction	Infrastructure and heavy construction
Examples of type of use	Apartments, houses, dormitories, sheds, etc	Schools, hospitals, offices, shopping centres, retail stores, stadiums, etc	Chemical industry plants, power plants, etc	Roads, tunnels, bridges, railways, sewage systems, pipelines, etc
Design	Architects, engineers	Architects, engineers	Specialized engineers	Government, architects, engineers
Execution	Construction companies, builders	Construction companies, builders	Industrial corporation or specialized companies	Government agencies and construction companies
Management	Individuals, real estate company	Retail: company / private owner. School, hospitals: local / national government	Industrial corporation	Construction companies

Table 3: Main types of construction and indicative key players in their design, execution and management

3.1.2. Construction activity does not necessarily correspond with development

Global construction has been on an increasing trend over the last century (HIS 2013), to a large extent due to growing populations, increasing GDP and economic development, as well as growing rates of urbanisation across the world, that have taken place since the end of the second world war.

- Constructions were built massively in developed countries mainly between the 1950s and 1990s, whereby in Europe over 80% of residential buildings were built before 1990 (Renovate Europe, 2017).

- This was followed, starting from 1970, by the major build-up of buildings and infrastructures in transitioning countries such as China, India, Brazil and South Africa (IRP, 2017a,2019).
- Other countries in Africa and Southern Asia are now entering into a construction phase (IRP, 2018).

However, while emerging markets are today growing in importance in the construction sector, advanced economies continue to make up a significant proportion of global construction activity.

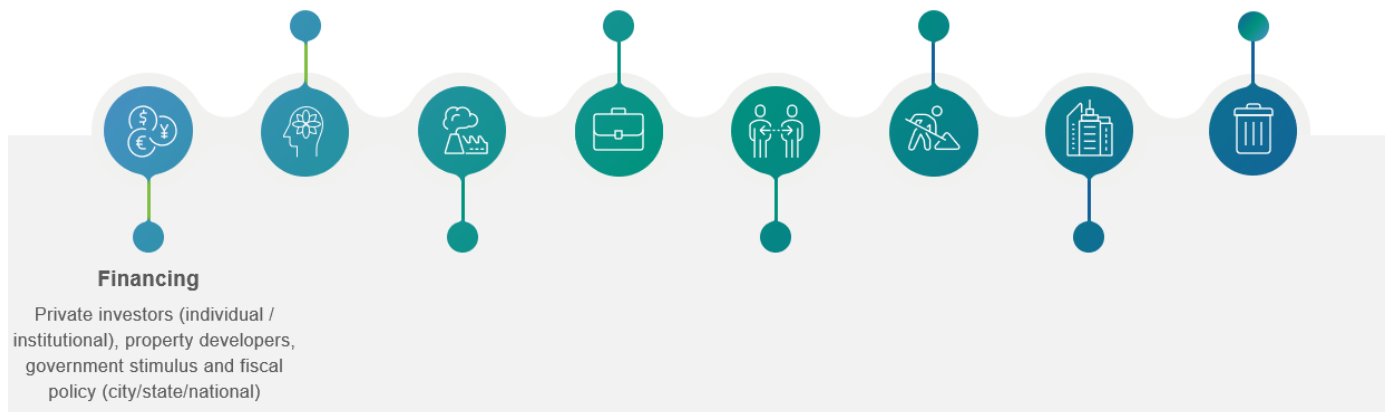
- Emerging markets have grown from a 35% share of the global construction market value in 2005 to 54% in 2014.
- As of 2017, 31% of the emerging market share was comprised of just four countries (20% China, 5% India, 3% Russia, 3% Indonesia 3%).
- At the same time, just six high-income countries comprised 29% of the global market (12% USA, 5% Japan, 3% Germany, 3% UK, 3% France, 3% Canada).

These figures demonstrate that, while increasing GDP, population growth and urbanisation in developing countries can result in increased demand for homes, buildings and infrastructure, these socio-economic factors only partially explain the volume of activity in the global construction market.

- With just ten countries accounting for 60% of the global construction market, the majority of the world, most of which is developing and in need of buildings and infrastructure, is under-served by just 40% of current global activity in the construction sector.
- Equally, with 29% of global construction taking place in just six developed countries where population growth and urbanisation rates remain stable, and GDP growth is comparatively low, the high volume of construction in those countries does not necessarily correspond to increasing levels of development.

3.2. Decisions by governments & investors largely determine activity along construction value chain

3.2.1. Financing: Financial flows shape the construction value chain



A key sector for national economies and economic stimulus. The construction sector is one of the largest and most important economic sectors in the global economy.

- About USD 10 trillion is spent on construction-related goods and services every year (McKinsey Global Institute, 2017).
- The construction sector also accounts for around 10% of jobs and 10% of GDP in many countries (IRP, 2017b).

This contribution to GDP and employment makes construction a strategic and important sector for many national economies. Particularly during times of economic crisis or downturn, the construction sector is often a focus for governments when planning economic recoveries. This is due to the ‘multiplier effect’ that construction spending can have, increasing activity and incomes that flow on throughout other parts of the economy.



- Recent recovery packages and programmes from many national governments responding to the economic challenges of the Covid-19 crisis have included plans to stimulate the construction sector, including, for example:
 - The UK government has implemented planning reforms intending stimulate the construction sector and help revive the economy (Financial Times b, 2020).
 - The South African government is focusing on infrastructure development in its economic recovery plan (Bloomberg, 2020).
 - The Australian government announced a plan to give citizens \$25,000 grants to build or renovate their homes to boost demand and maintain employment in the construction sector (ABC, 2020).
- Similarly, following the 2008 global financial crisis, the Chinese governments undertook a significant economic stimulus package with a focus on construction of buildings and infrastructure across the country which helped shield China from the worst impacts of the crisis (Lowy Institute, 2017).

Government stimulus to the construction sector can be an opportunity to direct construction activity towards achieving the 2030 Agenda in countries (IISD, 2020). However, stimulus packages and programmes can sometimes prioritise short-term economic metrics over meeting the longer-term socio-economic needs of countries.

- For example, stimulus to boost housing construction may not include social or environmental criteria to ensure that the housing is affordable, that it is built in the locations where the need is greatest, and that it is built in a way that is resource efficient with as few environmental impacts as possible.
- This can result in building more constructions than are socially necessary, building types of constructions or in locations that do not meet social needs, and these constructions being built using materials and practices that are resource-intensive or environmentally damaging.
- This can also result in harmful socio-economic consequences such as greater levels of housing unaffordability, increased inequality, and property price inflation which can be associated with economic instability.

The construction sector is integral to achieving the 2030 Agenda for Sustainable Development. Yet the importance of the construction sector to national economies can sometimes result in construction activity that serves economic purposes, without necessarily balancing social goals and environmental considerations.

Governments and financial institutions facilitate speculation in property market. One of the major influences on the construction sector is financialisation, which sees property, especially housing, as an investment asset rather than an essential service and a human right.

- Property market speculation sees financial capital invested in housing with a view of making a short-term profit from increasing house prices, or as a safe way to store capital, especially in more stable or higher growth markets abroad.
- Speculation has also resulted in a polarised housing market, in which the wealthy are active and the less well-off are increasingly shut out.
- This is at the time of a global housing crisis in which more than 1.8 billion people worldwide lack adequate housing, and the number of people living in informal settlements has now surpassed 1 billion, including one-third of the urban population in the Global South (IRP, 2018; UNHCR, 2019).
- According to the UN Special Rapporteur on the Right to Adequate Housing, the current global housing crisis is linked to growing socioeconomic inequality, large-scale financialisation of housing and land and unsustainable housing systems that treat housing as a commodity (UNHCR 2019).

Governments play a key role in regulating financial and property markets, they can shape the way that these markets operate through various policy levers, and thereby have a strong influence on the activities of the construction sector.



- According to the International Resource Panel, “governance arrangements at global, national and local levels have, in most countries, tended to facilitate financial instruments and property speculation to drive short-term growth” while “more equitable new wealth creation via innovation and skills development in the manufacturing and agricultural sectors became less important than returns from financialisation and urban property development” (IRP 2018).
- Recent decades have seen governments facilitate and encourage the private sector’s role in housing through incentives such as tax breaks to real estate speculators, tax advantages for homeowners and “golden visas” to foreign investors, as well as through deregulated rental markets and encouraging development that primarily produces housing for the wealthy (UNHCR 2019).
- According to the UN Special Rapporteur on the Right to Adequate Housing “through legislative measures, policies and programmes, many States have treated housing as a commodity for trading and speculation, rather than as a social good and a human right” while “international financial institutions and development banks have (...) imposed deregulation, the liberalisation of housing markets and austerity measures, including the selling of social housing, and required mortgage finance programmes that do not assist the lowest-income households” (UNHCR 2019).

This speculation and stimulus in the property market is taking place, while at the same time there is a surplus of constructions, with both commercial and residential buildings remaining unoccupied throughout major cities across the world.

- There are a reported 11 million empty residential dwellings in Europe (The Guardian 2014), which would correspond to about 10% of the residential stock.
- In 2019, approximately 13% of all US commercial space was vacant (Reuters 2019).

While housing insecurity is an ongoing issue in both developing and developed countries, and new housing supply is part of the solution, the new dwellings currently being constructed do not always achieve these goals. Rather, much of the current construction activity can result in properties that are unaffordable and inaccessible for those in need while fuelling speculation in property markets. The socio-economic impacts of this speculation can include increased inequality and financial instability, while the construction activity also results in natural resource use and environmental impacts.

Government a big investor in the construction sector. Governments can have major influence in the volume and type of activity in the construction sector not only indirectly through regulation of the financial and property markets, but also directly through their role as procurers of major infrastructure projects.

The majority of global infrastructure project investments in 2017, 83 percent of a total US \$0.5 trillion, came from the public sector including investment by government entities and state-owned enterprises (World Bank 2017). At a global level, international organisations and multilateral development banks also play a significant role in financing infrastructure, as do individual countries via their overseas development finance. In 2018, the total overseas development finance spent on infrastructure projects was US \$77.6 billion, both from countries and multilateral development banks (OECD 2020).

Governments also often play a role in supporting the financing of private infrastructure projects either directly or indirectly, as way of attracting investment. According to the World Bank “when governments seek private investment in infrastructure projects, they usually find themselves asked to provide grants, guarantees, or other forms of fiscal support.” (World Bank, 2003).

Governments and international organisations therefore have a strong ability to influence the construction sector, through their role as procurers of public infrastructure constructions, and facilitators of funding in private infrastructure constructions. Through implementing public procurement measures that apply sustainability criteria, governments and international organisations can influence how public constructions

are built to reduce natural resource use and environmental impacts, as well as ensuring that the volume and type of public constructions that are built balance development needs with environmental trade-offs.

Mismatch of investment in global infrastructure with development needs. Despite the growing volume of construction activity taking place around the world, developing countries face a US \$1-1.5 trillion gap in financing the infrastructure necessary for social and economic development (UN IATF, 2020), with developing country governments often unable to finance the projects publicly and unable to attract private investors.

- The majority of investment funding for infrastructure is being spent in developed countries, as well as India and Brazil, while little is going to developing countries where the infrastructure gap is hardest to overcome (Mann 2020).
- The amount of investment in developing countries and regions like Africa does not adequately meet the demand for buildings and infrastructures (IISD 2019).
- Where infrastructure is increasingly promoted as an asset class to provide a return on private investment, the perception of risk around financing projects in developing countries can mean projects are often unable to attract funding. This results in a mismatch in terms of where funds are invested in infrastructure versus where the need for infrastructure is greatest (Mann 2020).
- A growing proportion of global infrastructure is being driven by private investors such as corporates and investment funds (PwC 2017). This typically takes the form of public-private partnership, where the involvement of private actors is driven on the one hand by the desire of governments to provide services to society and grow the economy while limiting public debt, and on the other by private investors seeking for long-term and stable returns.

Construction is both a key sector for national economies, as well as a critical sector for meeting the SDGs, if it is employed in pursuit of these goals. While some level of natural resource use and environmental impacts associated with the construction sector is a necessary trade-off for the socio-economic benefits that construction can bring for human development, it is not necessarily evident that the current construction activity taking place is in line with global development needs and priorities.

3.2.2. Planning & design: Construction value chain determined by planning and design



Construction value chain shaped by planning and regulation. The ways in which governments, public authorities, business and civil society shape urban areas and design and construction practices has a strong influence on natural resource use and environmental impacts, as well as socio-economic outcomes.

- Urban and territorial planning aims to realise economic, social, cultural and environmental goals through developing visions, strategies and plans and applying policy principles, tools, institutional and participatory mechanisms, and regulatory procedures (UN-Habitat 2015).

- Traditionally, public welfare has been the primary concern in urban planning. Sustainable development was added as one of the main goals of all planning endeavours in the late 20th century when the detrimental economic and the environmental impacts of the previous models of planning had become apparent.

Territorial planning mostly occurs at multiple scales, including national, regional, local and neighbourhood level. This can help balance the challenges or decisions taken at each level, for example the deregulation or weak legal framework at one level can be balanced by legally-binding codes and sanctions for non-compliance at another level. Proposed construction projects must comply with local, regional or national regulations on land-use planning:

- Public authorities usually assess the design of the construction project prior to authorising it, to ensure that the policies and standards are met, the potential impacts on neighbouring properties, and upon existing infrastructure (transportation, social infrastructure, and utilities including water supply, sewerage, electricity, telecommunications, etc).
- Public authorities usually also inspect the ongoing work periodically to ensure that construction adheres to the approved plans and the building policies and codes.

The construction value chain is heavily shaped by practices of urban and territorial planning, as well as regulation such as building codes, which are applied primarily by governments and public authorities at national, regional, local and neighbourhood levels, and are also influenced by business and civil society. These planning practices and regulations have a significant impact on what constructions are built, how many constructions are built, and how constructions are built, and therefore on the associated levels of natural resource use and environmental impacts along the construction value chain.

Planning practices and regulation of construction sector not always consistent or effective. Urban and territorial planning practices and regulation of the construction sector are not equally applied across all countries, with many developing countries stills without building codes. For example, of the new buildings expected to be constructed to 2060, more than two-thirds of these will be built in countries that do not currently have mandatory building energy codes in place (WGBC 2017).

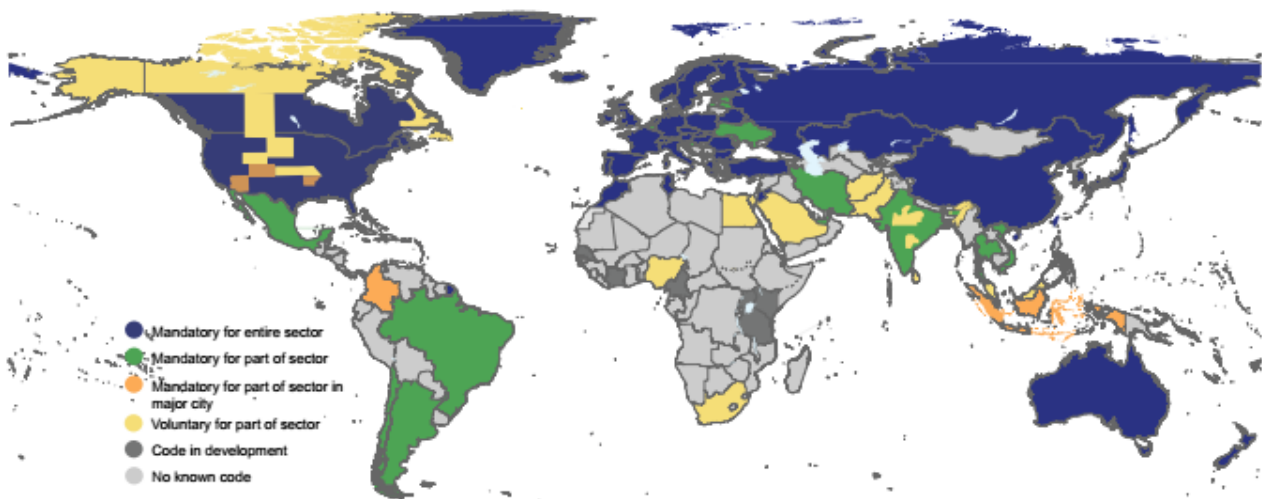


Figure 7: Existence of mandatory building energy codes across countries (adapted from Global ABC et al. 2020).

Due to the significance of the sector for both GDP and employment, regulation of construction can be a politically important issue for governments and economically important for private sector actors.

- Regulation of the construction sector has the potential to be used by governments to for political aims, such as appealing to certain constituencies or stakeholders.
- Governments may also choose to deregulate the construction sector or weaken planning codes as a level to stimulate the sector in order to drive economic growth.



- Key private sector players working in the construction sector may undertake lobbying activities or make political donations that seek to influence the way governments regulate the sector in ways that are favourable to private interests (TIA 2019). This can sometimes relate to influencing the building code in order to promote the adoption and endorsement of particular building materials or technologies, which could influence the natural resource use and environmental impacts of the sector.
- In some cases, the construction industry can also be subject to corrupt dealings between private companies and politicians, resulting in regulations, safeguards or assessments overlooked to make way for developments (World Bank 2007).

Urban planning and regulation of the construction sector by governments has strong potential to influence the natural resource use and environmental impacts of the sector, however the existence of such regulation, as well as its quality and the degree to which it is effectively implemented, are influenced by a number of factors and interests across different countries. As a result, urban planning practices and regulation of the construction sector are not always consistent or effective.

Choices at design & planning stages determine sustainability in 'operation and use' stage. Planning of buildings and infrastructure determines their construction, which in turn shapes the operation and use of constructions.

- Design and planning of buildings and infrastructure determine the amount of material resources and the energy necessary to build a construction, as well as the associated environmental impacts of that construction.
- Consequently, these choices also to a large degree fix how much energy and water will be used for operation throughout the construction's lifetime, as well as how waste will be managed (IRP, 2017a).
- The design of the buildings – including floor space, orientation, insulation – will determine the need for lighting, heating and cooling.
- In the case of multi-residential buildings this will also include design decisions on whether electricity, water and heating is centralised.

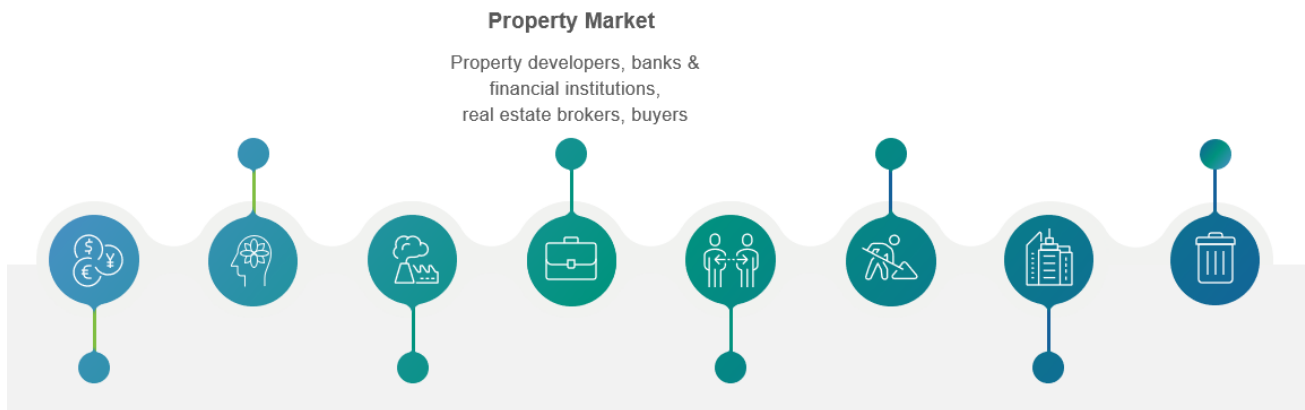
Social and cultural norms around what is considered desirable in a home or building, as well as the lifestyles of owners and occupants within different cities, countries and regions, play a role in shaping choices of what type of constructions are built and how they are built. Actors along the construction value chain, including governments, private investors, construction companies or real estate agents, will seek to produce constructions that fit prevailing social and cultural norms as well as the existing lifestyles of inhabitants.

Sustainable design practices that integrate energy efficiency and GHG emission aspects are emerging. These are driven by cost and energy saving factors, as well as by the widespread concern over climate change and other environmental aspects.

- Many national and international bodies have set targets and guidelines for improving the environmental performance of buildings and reducing carbon emissions (IRP, 2017b).
- However, sustainability is still not the major focus for design and planning of constructions. In 2018, out of the US \$4.5 trillion in global spending on buildings construction and renovation, only 3% was used for energy efficiency investments (Global ABC *et al.*, 2019).
- There is growing awareness around the issue of material efficiency in construction, however the focus of sustainability in buildings remains primarily on energy efficiency.

While the natural resource use and environmental impacts of construction projects are increasingly considered during the planning and design stages of the construction value chain, these considerations are still not yet widespread and continue to compete against a range of other drivers.

3.2.3. Property market: Actors optimise their outcomes within the available conditions



Mortgage-lenders, real estate and individual buyers perpetuate property speculation. Where governments and financial institutions have facilitated speculation in property markets, especially for housing, actors downstream in the construction value chain respond to these signals and further perpetuate property speculation.

- Where governments have put in place the regulatory frameworks to facilitate financialisation of the housing sector, property developers, banks and real estate agents also act as a catalyst.
- Working within regulations set by governments, mortgage lenders can increase the amount of available credit, which can drive the number of individuals taking out loans in order to purchase properties.
- For individuals, property can increasingly become an investment plan rather than an essential service of housing. This is especially the case in the last decade where interest rates remain at record lows, which both reduces the possible return from other types of investment, as well as making it very cheap to borrow money for a mortgage.
- This is facilitated by the aforementioned tax arrangements put in place by governments, that can make it advantageous for individuals to purchase investment properties.
- Particularly in countries with limited state welfare provisions, property can be seen as a financial plan, especially for retirement, in the absence of a social safety net or public pension systems.
- The macroeconomic impacts of increasing private debt and speculation in the housing market can include rising house prices that reduce affordability and increase inequality, as well as financial instability such as was seen in the US during the sub-prime mortgage crisis in the lead up to the 2008 global crisis.

Where governance arrangements promote property as a financial investment instead of an essential service, this can direct the behaviour of actors along the construction value chain including mortgage lenders, real estate companies and individual buyers. The behaviour of these actors in turn can influence what type of constructions are being built and where, how many constructions are being built, as well as how these constructions are being built, all with consequences for natural resource use and environmental impacts that cannot necessarily be balanced against social needs as acceptable trade-offs.

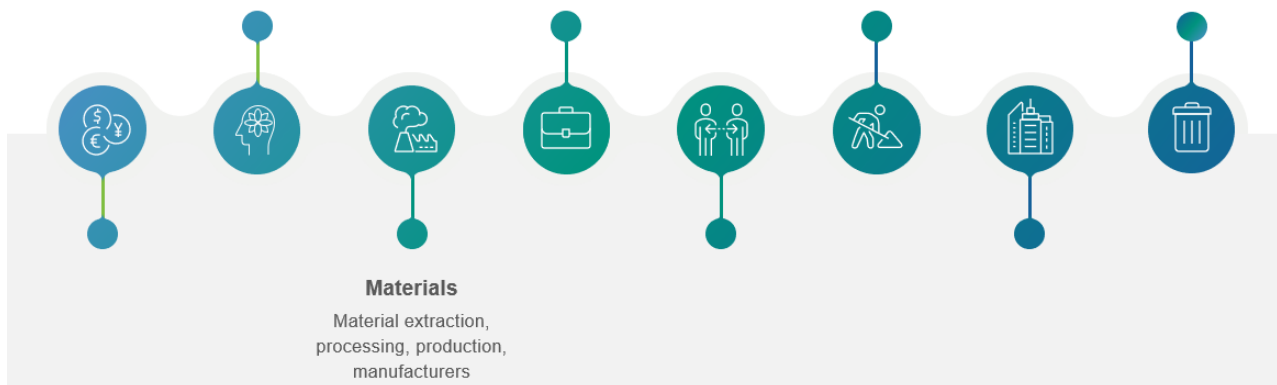
Uneven access to credit across the world. Property constructions, whether residential or commercial, are long-term investments that usually require access to credit or other funding arrangements up-front before the work can commence. The access to credit or lack of access to credit is a major influence on what types of constructions are being built and where, how many are being built and how they are being built.

- Many advanced economies currently have historically low interest rates and easy access to credit, especially for mortgages, which can partly explain the high volumes of construction activity taking place, particularly in housing.
- While in advanced economies the banking and finance systems make access to credit commonplace, in much of the world the banking and finance systems are less developed.
- In many developing countries, where there is a strong need for new constructions including housing, there is often very limited access to credit, especially for mortgages, which can hold back the economic and social development that is needed.
- In some developing countries, innovative financial schemes are created to facilitate access to credit such as for housing construction, including through community-based financial associations or loans provided directly to buyers through real estate stakeholders rather than banks. Other examples include schemes where people buy building materials incrementally to eventually construct their own home.

The banking and finance systems across different countries and the differential access to credit is a key driver of the types and volume of activity in the construction sector, and therefore a relevant factor in considering the natural resources use and environmental impacts along the construction value chain.

3.3. Limitations at points of resource consumption inhibit sustainability

3.3.1. Material extraction & production: Environmental and social issues



Increasing construction activity demands growing volumes and new sources of materials. As the total amount of construction activity grows year on year, this requires an ever-increasing source of materials which in turn drives growth of activity at the material extraction and production stage of the construction value chain.

- This increase in total volume of materials is especially noteworthy in the construction activity in China that consumed more cement between 2011 and 2013 than the USA did in the whole 20th Century (IRP 2018).
- Sand, gravel, limestone and crushed rock, primarily used in constructions, account for one-third of all materials consumed today in gigatonne terms, and this amount is set to more than double by 2060 (OCED 2018).
- In the USA, the amount of sand and gravels used in construction is almost exactly ten times the amount of final cement produced. If this were extrapolated to the rest of the world, the total sand and gravels used for construction would be 41 billion tonnes per year (UNEP 2019b).

Emerging economies are responsible for a growing share of resource extraction, partially reflecting their increase in construction activity. However, many countries are also exporting construction materials to other countries where the constructions are being built.

- Generally, the construction sector aims to reduce high transport costs by extracting materials for construction as close as possible to where they are used.



- China produces the most cement globally, at an estimated 2.4 billion tonnes in 2017, followed by India at 270 million tonnes, and the USA at 86.3 million tonnes in the same year, which reflects the large amount of construction activity taking place in these countries.
- China is the top steel producer, producing more than 50% of all steel produced in the world, followed by India, Japan, the USA and Russia (WorldSteel 2019). China is also the top consumer of steel and uses more than 50% of all the steel produced in the world in 2019, followed by 10% by the rest of Asia and the 9% from the EU. In comparison, Australia and Brazil are the leading exporters of iron ore, the core raw material used in steel production.
- International trade is growing due to high demand in regions without local resources. Trade in sand and gravel is forecast to rise 5.5% a year with urbanisation and infrastructure development trends. For example, Singapore imports most of its sand from neighbouring Indonesia, Malaysia, Thailand and Cambodia.
- Material- and energy-intensive stages of the construction value chain have in recent decades been increasingly relocated and outsourced to poorer countries where production costs and environmental standards are lower (IRP 2019).

Information on materials used in construction is generally organised separately based on the specific type of material, and its use across many different sectors, with little analysis and knowledge to date that combines an overarching view of the extraction and processing of the many different materials used along the construction value chain specifically.

In order to better understand the consequences of material usage in buildings and construction on natural resource use and environmental impacts, as well as the socio-economic implications, it will be necessary to bridge this knowledge gap around what materials are being used, where these materials are coming from and what the social, economic and environmental implications are of resource extraction to supply the global construction value chain.

Material extraction and production in developing countries is often informal, unregulated and sometimes illegal. The material extraction stage of the construction value chain is often informal and unregulated, especially where it is taking place in developing countries, and can be associated with negative social and environmental consequences.

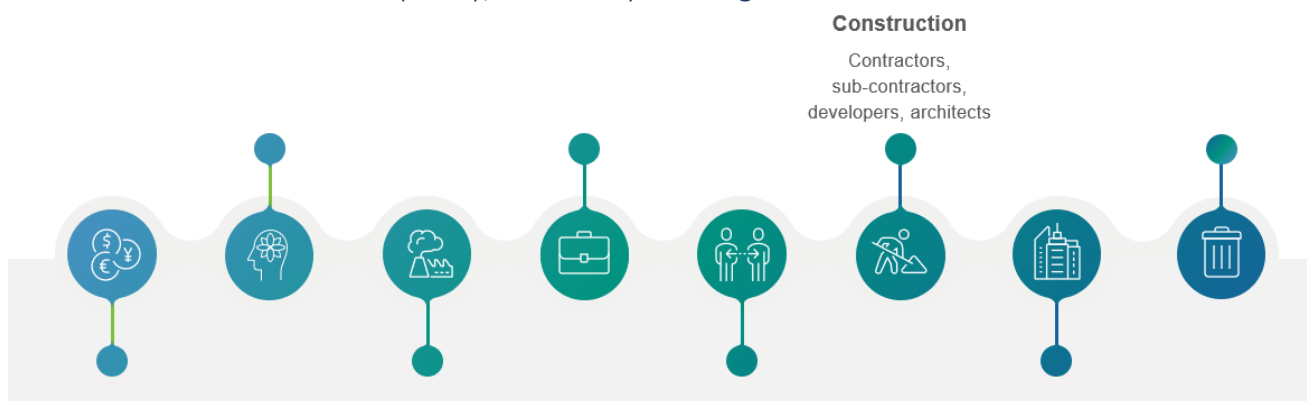
- The extraction, production and supply of construction materials can also be associated with poor working conditions and labour exploitation, with cases of child labour reported in the brick making industry of developing countries (ICED 2018).
- In particular, the huge demand for sand to make essential construction materials concrete and glass is often informal.
 - Many sand extraction operations in emerging and developing economies are not in line with extractives and environmental management regulations (UNEP 2019b).
 - Uncontrolled extraction comes at the expense of other economic sectors, local livelihoods and biodiversity. Direct safety risks for those working in the sector and living in the communities where this takes place including drowning, subsidence and landslides in extraction areas.
 - Illegal sand extraction is becoming an issue, with “Sand mafias” in places such as India and Morocco threatening local communities and their livelihoods as well as the environment (UNEP 2019b).
 - The people working in unregulated sand extraction, and those living in and around these sites, risk their safety and even their lives when they try to stop uncontrolled extraction (UNEP 2019b).
 - Where regulation does exist, it is either insufficient or not enforced adequately due to corruption, the absence of monitoring, or resources to prosecute offenders (UNEP 2019b).

As global construction activity grows and demand for construction materials increased, ensuring governance, oversight and regulation of materials extraction and production will be crucial to reducing natural resource use and environmental impacts.

Price as key consideration in the demand for materials for constructions. For most constructions, whether residential, commercial, industrial or infrastructure, price is a decisive factor when it comes to what construction materials, technologies and practices are utilised, and keeping costs down is often a key objective. Cost considerations can often work against sustainability measures in constructions, with the cheapest options usually being those materials which are most abundantly used and easily accessible on the market. Though the focus on price may also work in favour of sustainability, when sustainable options are more affordable or would imply long-term savings in operational costs. However, where the developer of a construction is not the owner, or where the owner is not the long-term occupant, these long-term cost savings may be less appealing than short-term price considerations. Keeping costs down can be of particular importance in the developing countries where many people live in informal settlements and the need to provide affordable housing is great.

As price considerations and keeping costs down continue to be major drivers of activity along the construction value chain, the additional costs associated with more sustainable materials, whether actual or perceived, continue to be a barrier against shifting towards constructions that prioritise reducing natural resource use and environmental impacts.

3.3.2. Construction: Complexity, informality and fragmentation



Different levels of size and power among construction companies globally. The size and makeup of the companies that undertake constructions varies significantly across the globe as well as within countries, as well as depending on whether construction companies work on residential, commercial, industrial or infrastructure developments.

- Construction companies range from large enterprises employing up to 100,000 people and engaged in the design and construction of major building and infrastructure projects, to large number of small-scale sub-contractors of sometimes 5-6 people, undertaking specific tasks such as plumbers and electricians (McKinsey Global Institute 2017).
- The overall majority of global construction activity is undertaken by small and medium sized companies.
- Larger companies have the means to cover both design and construction, while smaller enterprises are usually limited to the construction.
- Large construction companies can influence local administrations to grant construction permissions and award contracts for construction works, due to the size of investment that they bring and the employment they can generate in communities.
- However, most construction companies will be limited by land use regulations and construction policies on the one side, and the property market on the other side, leaving little margin for transformative decisions.

A small number of very large construction companies dominate a comparatively large share of the global market, with global sales of 100 top companies in 2018 at US \$1.39 trillion (Deloitte, 2019). In terms of market capitalisation, 40% of value from top 100 construction companies in 2018 was held by Chinese and Japanese companies, with European and North American companies holding a similar percentage of total (Deloitte, 2019). This provides an indication of where the economic and financial capacity of construction companies is stored. The 10 top construction companies in the world based on total sales are included in table 4 and indicate:

- Five of the companies with the most sales in 2018 are based in China, with Chinese construction companies making up 37% of the top 100 companies' sales.
- Chinese companies are followed by globally important but smaller players based in high-income countries: 13% in Japan, 9% in USA, 8% in France, 7% in Korea, 5% in Spain, 4% in the UK.
- Whereas sales of Chinese construction companies were primarily domestic, international sales made up a significant proportion for construction companies from France, Spain and South Korea.
- Of all international construction company sales in 2018, 57% were attributed to European companies, with the largest income made by ACS (Spain), Vinci (France) and Bouygues (France).
- However, international sales of Chinese companies (e.g. CCCC, CSCEC) are also significant in absolute terms.
- International sales are likely to refer to participation in major construction projects worldwide, partly deployed in emerging markets (eSUB, 2020).

Company	Country	Total sales in 2018 in USD million (% of sales from top 100 companies)	International sales as % of total sales
CHINA STATE CONSTRUCTION ENGINEERINGCORP. LTD. (CSCEC)	China	181,467 (13%)	8%
CHINA RAILWAY GROUP LTD. (CREC)	China	112,026 (8%)	6%
CHINA RAILWAY CONSTRUCTION CORP. LTD.(CRCC)	China	110,473 (8%)	5%
CHINA COMMUNICATIONS CONSTRUCTIONCOMPANY LTD. (CCCC)	China	73,939 (5%)	19%
VINCI	France	51,378 (4%)	43%
METALLURGICAL CORPORATION OF CHINALTD (MCC)	China	43,809 (3%)	8%
ACTIVIDADES DE CONSTRUCCION Y SERVICIOS,S.A. (ACS)	Spain	43,279 (3%)	86%
BOUYGUES	France	41,975 (3%)	39%
DAIWA HOUSE INDUSTRY CO.	Japan	34,260 (2%)	0%
SAMSUNG C&T CORP.	South Korea	28,342 (2%)	32%
Total of top 100 companies	-	1,393,173	

Table 4: Top global construction companies in 2018 based on total sales (Deloitte 2019)

The great variation between types of construction companies presents different challenges and opportunities for reducing natural resource use and environmental impacts along the construction value chain, and will require different tools, levers and incentives targeted to the various types of actors.

Construction SMEs face a range of challenges. Construction companies deal with many competing obligations, drivers and barriers that can result in particular characteristics within the construction industry, many of which can limit the ability to transition to more sustainable activities and mean environmental considerations are often at the bottom of the list.



- Construction companies, especially SMEs, generally work with low profit margins, meaning keeping costs down is of prime importance which can limit the scope for using more sustainable materials and practices.
- At the same time, construction SMEs must often abide by complex building codes, leaving them squeezed between regulation and costs.
- The construction industry is characterised by a low labour productivity (the added value by construction workers per hour of work) compared to other industrial sectors, with a worse condition for smaller companies.
- A low productivity can mean inefficient use of resources and can be due to factors such as market fragmentation, re-negotiation of contracts and missed transparency on costs, inefficient design that does not take standards into account, insufficient time dedicated to plan how to manage and execute projects, lack of skills and access to innovation, informal and low wage work (McKinsey Global Institute, 2017).

The construction industry is also highly complex and fragmented, with a large number of different actors operating at a small-scale.

- Workers directly employed by construction companies include construction workers, carpenters, electricians and, to a lower extent, managers, architects and engineers, equipment operators, providers of legal and administrative services.
- Innovation in the construction industry is slow moving because of the time dimension of construction projects and because various actors and experts address different aspects often in isolation.

Informality in the construction sector is also a major challenge, especially in many parts of the developing world which lack building codes, formal regulation of the construction sector and effective implementation of labour rights and conditions.

- In most countries, construction companies outsource elements of the project to various subcontractors and other intermediaries.
- Many developing countries rely largely on informal and non-standard employment that include part-time, casual and temporary contracts.
- Migrants are frequently employed in non-skilled and semi-skilled jobs, especially where the sector is not heavily regulated.
- Informality in the construction industry can result in a number of negative consequences such as poor conditions and safety of workers, as well as unsafe and unsound constructions.
- Informality in the construction industry can also impact the types of building materials used and result in increased natural resource use and environmental impacts along the construction value chain.
- For example, where construction is informal, the production of concrete is also informal, often being mixed onsite and not controlled by any authorities. Informal or on-site concrete mixes in Costa Rica and Colombia can consume nearly 30-40% of more cement per cubic metre, producing more CO₂ emissions in the same construction (Asocreto 2020).

While construction companies are a key actor along construction value chains, the various challenges and limitations faced by the sector reduce its ability to transition more sustainable materials and practices, and to decrease natural resource use and environmental impacts.

3.3.3. Operation & Use: Opportunities & barriers for end-users to influence resource use and environmental impacts



Final users face limited choices and awareness of sustainable construction options. Individual users of constructions, especially occupiers as homes as either buyers or renters, face limited choice in the types of constructions available to them, particularly as regards the sustainability of these buildings and the natural resource use and environmental impacts involved in either the construction to the use phases.

- Few end users of constructions have the opportunity to contribute to the design or planning stage of a building, with most needing to choose from the existing building stock that is available or purchase a new building for which the design and planning has already been determined.
- In many cities, people have no choice but to live in rundown areas or in informal settlements, highly depending on fossil fuels for transport (IRP 2018).
- Although users have limited choice at the time of deciding where to live, they can have some influence on the water, energy and materials consumed in buildings through their lifestyle choices.

Another factor that influences natural resource use and environmental impacts of constructions at the use and operations stage is that a large part of the housing stock is either rented or undergoes regular changes in ownership. Investments that result in long-term benefits are often not a high priority for short-term renters and temporary homeowners (IRP 2017b).

Furthermore, a share of population lack of awareness on environmental issues associated with constructions. For example, despite the colossal quantities of sand and gravel being used and the environmental impacts related to their extraction, the issue is largely unknown to the general public and policymakers (IRP 2019). This can make it difficult for users to make more sustainable decisions in regard to the constructions that they own or occupy.

While the use and operations stage of the construction value chain makes a major contribution to natural resource use and environmental impacts along the construction value chain, the actors at this value chain often lack the ability and awareness to make a change.

Renovation can improve the performance of buildings and constructions. The ability to reduce natural resource use and environmental impacts at the use and operation stage of constructions is to a degree pre-determined before the construction is built by decisions that are taking at the design and planning stage of the value chain. Many buildings were originally designed without taking energy efficiency aspects into account.

However, opportunities do exist to renovate existing buildings to make them more efficiency, such as through renovating windows, doors and insulations. Although technologies and methods to reduce environmental



impacts exist, their investment cost could be prohibitive for certain population categories, especially low-income groups (IRP 2017b).

Financial support is vital to develop new technologies and methods and to facilitate their uptake.

- This requires collaboration of building owners and users, businesses and governments, as well as alignment with long-term sustainability goals.
- Examples of forms of financial support are government-sponsored cost-efficient loans for homeowners to renovate or retrofit their homes.
- It is possible to ensure that such loans are affordable and accessible for all through programmes specifically targeting low-income households (e.g. as done in Mexico or Boston).

While natural resource use and environmental impacts of the use and operation stage of value chains is to a large degree determined at the design and planning stage, renovation of existing buildings presents an opportunity to improve sustainability at this stage, however barriers will need to be overcome to bring this about.

4. Conclusions

4.1. Construction is integral to achieving the SDGs, but direction is needed

Construction is the sector with the largest global material footprint and is responsible for 50% of total global material consumption (SCP-HAT 2020), and the materials used in construction are associated with significant natural resource use and environmental impacts. Natural resource use primarily occurs at the material extraction and production stage, at the construction stage, as well as during the use and operation of buildings and infrastructure. Associated with the consumption of natural resources and the production and consumption of building materials, there are significant environmental impacts along the construction value chain, including climate change and air pollution.

Construction also plays an integral role in meeting Sustainable Development Goals. Construction is critical to achieving the human right to adequate housing; to building essential infrastructure necessary to provide mobility, energy, drinking water and sanitation; as well as to building the commercial and industrial infrastructure necessary to support economic development, all the while providing opportunities for employment and decent work.

The importance of construction to meeting the SDGs means that there may be some trade-offs when it comes to natural resource use and environmental impacts of the construction sector, though it is also imperative that the sector transitions as much as possible toward resource efficiency, circularity and a smaller environmental footprint. However, the analysis has also shown that not all constructions contribute to sustainable development, and some activity in the construction sector can even result in harmful socio-economic consequences, making the natural resource use and environmental consequences difficult to justify.

4.2. Key decisions are made far from where natural resources are used

The analysis in section one identifies that the majority of natural resource use and environmental impacts along the construction value chain take place at the material extraction and production stage, the construction stage and the use stage. However, the systems analysis in section two highlights that there is limited scope at these stages of the value chains to make changes to reduce natural resource use and environmental impacts

for a number of reasons, including the informality, fragmentation, complexity at these stages, as well as limitations in knowledge, awareness and available options.

In contrast, the systems analysis demonstrates that the most influential actors along the construction value chain are governments, international organisations, financial institutions and major market players, who are primarily acting at the financing stage and the planning and design stage of the construction value chain. The key decisions made at these stages largely determine what types of constructions are built, how many constructions are built, and how constructions are built, and thereby shape the activity along the rest of the value chain.

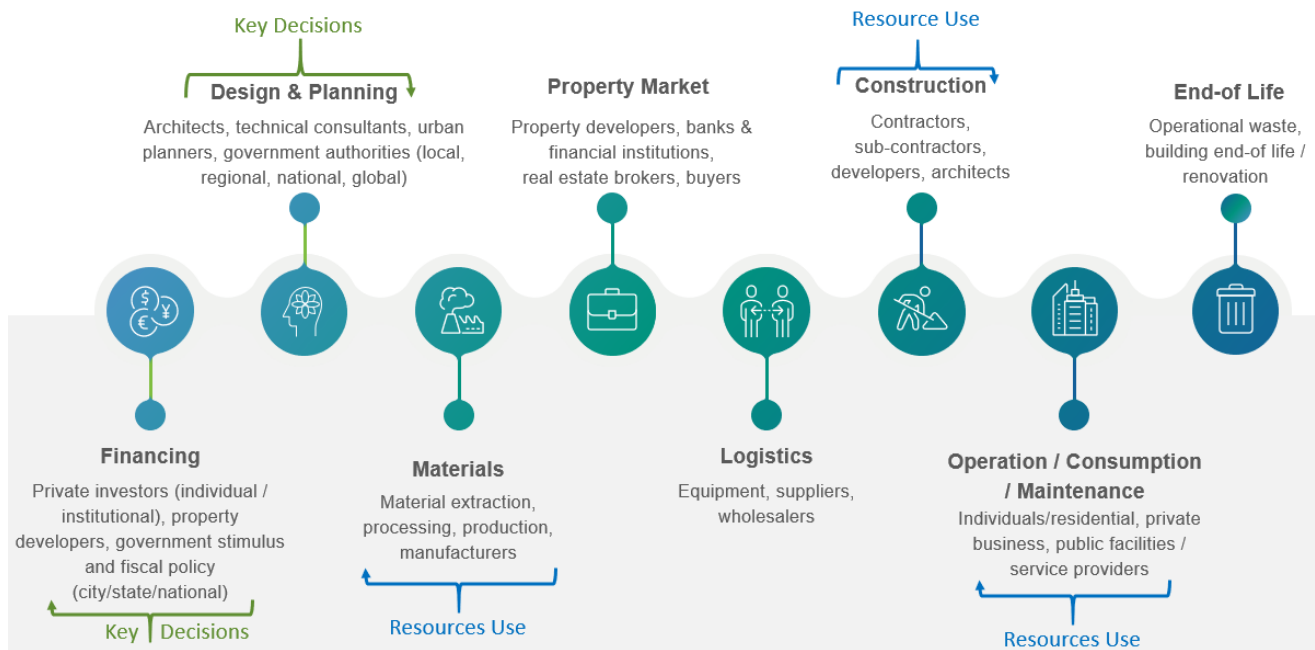


Figure 9: Key stages of the construction value chain where decisions are taken

4.3. Governments exert significant influence along construction value chain

Compared to other sectors, the role of governments and multilateral organisations in shaping activity along the construction value chain is significant, and occurs in three key ways:

1. As **regulators of financial markets**, the **banking system**, and **tax systems**, governments influence how much and what type of constructions are built, especially for housing, particularly at the financing stage and property market stage of the construction value chain.
2. As **investors in the construction** sector through the **public procurement** of buildings and infrastructure, governments can directly influence what is being built, how much is being built and how constructions are being built through the procurement criteria they apply and the vendors they choose to engage.
3. As **urban and territorial planners**, and **regulators of the construction sector**, governments also indirectly determine what is being built, how much is being built and how constructions are being. How governments regulate the construction sector through tools such as building codes and zoning laws can influence the operations of actors along the construction value chain, especially at the planning and design stages; the construction material stages; the construction stages; and, as a result, the use stage.



Through the above three levers, governments have a major influence along the construction value chain on shaping what is being built, how much is being built and how constructions are being built, and it is these three levers that governments already use a combination of when stimulating the construction sector to boost economic activity or promote recovery during times of economic downturn or crisis.

Governments therefore have a strong opportunity to reduce the natural resource use and environmental impacts of the construction sector through using these three key levers to drive resource efficiency in the sector and ensure construction activity is directed towards meeting the 2030 Agenda for Sustainable Development.

5. Challenges and Opportunities

Addressing the three challenges outlined below of what type of constructions are being built and where, how many constructions are being built, and how constructions are being built can contribute to reducing natural resource use and environmental impacts along construction value chains.

Importantly, while each of the below opportunities may target other stages along the construction value chain, they can all influence the use of natural resource use and the environmental impacts that takes place at the material extraction and production stage, the construction stage, and the use stage.

Challenges	Opportunities
<p>1) What type of constructions are built and where?</p> <p>Different types of construction built in different locations and regions contribute in different ways to meeting needs of societies and achieving the sustainable development goals, and can cause different pressures on use of resources and environmental impact. These can depend on, for example: residential/commercial/industrial/infrastructure; affordable/luxury; private/public; utility/commercial and related service provision; multi-residential v. mono-residential buildings</p>	<p>Promote and enable adequate and sustainable constructions:</p> <p>Examples:</p> <ul style="list-style-type: none"> - Reshape regulation and planning of the territory to ensure the participation of different actors and the adequate allocation of urban and rural spaces to different activities without reducing spatial density (and increasing consumption of resources); - Public authorities working with real estate, construction companies and financial institutions for prioritising investments in sustainable construction projects (e.g. renovation of existing buildings v. construction of new buildings); - Promote sustainable constructions through public procurement processes. - Ensure economic stimulus programmes are designed to meet social needs and deliver on the SDGs.
<p>2) How much is being built?</p> <p>The construction market is growing worldwide, which causes pressures on resources and environmental impacts. However, constructions do not necessarily follow demand. For example, empty buildings and property speculation is registered in many developed countries, while there is a construction gap in developing countries.</p>	<p>Align development needs with supply of constructions worldwide</p> <p>Examples:</p> <ul style="list-style-type: none"> - Capital investments made by governments and privates are the engine determining what, where and how much we build. There is a strong opportunity to focus investments where there is a deficit of constructions, rather than oversupply constructions where not needed. - Continued and better use of buildings, which would limit the demand for new constructions, can be promoted through financial and fiscal incentives for the renovation of the existing stock. - Taxation of additional properties, especially in case of empty property, acts as a disincentive to property speculation and as mean for the redistribution of welfare.



	<ul style="list-style-type: none">- Although constructions are planned and approved by public authorities, territorial planning must ensure that new constructions do not harm the environment and meet real demands of society (e.g. through regulations).
<p>3) How are constructions built and used?</p> <p>Impacts of constructions are associated with:</p> <ul style="list-style-type: none">- Type and amount of construction materials used: a construction can be made using different combinations of materials that come with different “embodied” impacts (e.g. if sustainably sourced, an increased use of timber can be a promising option);- Consumption of resources in the operation of buildings: water and energy resources are consumed in buildings, which vary depending on design and users;- Construction and demolition processes: they make 40% of solid waste production in developed countries, less than one third of which is recovered. <p>Changing design, construction and use practices is fundamental to use resources more efficiently and reducing environmental impacts.</p>	<p>Adopt more sustainable practices relating to the manufacturing of construction products and the design, construction and use of buildings and infrastructure</p> <p>Examples:</p> <ul style="list-style-type: none">- Rethink design: design, and to a lower extent construction, are key phases to determine the environmental impacts of buildings and infrastructures. Sustainable design practices promoting material and energy efficiency are emerging on the market.- Develop and apply building codes and certifications: sustainable design concepts such as material and energy efficiency can be integrated in existing regulatory and market instruments such as building codes and certification systems.- Understand and improve the procurement of construction materials: more sustainable construction materials options can be identified based on certification and labelling systems (e.g. type III environmental labels), and their management in construction projects can benefit from digitalisation opportunities such as Building Information Modelling.- Recover construction and demolition waste: while recycling rate targets are set in some countries, there is the need to promote the reduction and reuse of waste, as well as incentivize their recycling (e.g. through taxation or fiscal incentives).- Develop and implement innovations: technical options are available that can allow a more efficient use of resources in the construction and operation stages.- Exploit catalytic actions by governments (e.g. public procurement, investment and incentives on eco-innovations) and civil society (public awareness campaigns).

Annex I: Key International Resource Panel reports addressing Construction

The table below lists the main International Resource Panel reports that address an aspect of the construction value chain.

Report	Content
"Global material flows and resource productivity" (IRP, 2016)	Description of key materials used in buildings and constructions , impacts and material efficiency strategies
"Resource efficiency: potential and economic implications" (IRP, 2017)	Overview of impacts associated with buildings , and discussion on drivers, material efficiency strategies and other improvement options from a system perspective
"Assessing global resource use" (IRP, 2017)	Overview of impacts associated with buildings and constructions, and discussion on drivers, material efficiency strategies and other improvement options from a system perspective
"Resource efficiency for sustainable development: key messages for the group of G20" (IRP, 2018)	Indication of key improvement options for buildings
"The weight of cities: resource requirements of future urbanization" (IRP, 2018)	System approach to the analysis of resource consumption and efficiency in cities , with a focus on urbanism, transport, commercial buildings and building heating/cooling
"Emission gap report" (UNEP 2019)	Information about global greenhouse gas (GHG) emissions in buildings and constructions, as well as strategies to improve material efficiency in residential buildings and quantitative indications about the related GHG savings in G7 countries, China and India.
"Global resource outlook" (IRP, 2019)	Description of key materials used in buildings and constructions , impacts and material efficiency strategies
"Resource efficiency and climate change: material-efficiency strategies for a low-carbon future – Summary for policy-makers" (IRP, 2020)	Information about global greenhouse gas (GHG) emissions in buildings and constructions, as well as strategies to improve material efficiency in residential buildings (the most important category in terms of climate change impact within the construction sector) and quantitative indications about the related GHG savings in G7 countries, China and India.

Furthermore, the following databases were consulted for a preliminary analysis of data on use of resources and impacts occurring along the value chain:

- <http://scp-hat.lifecycleinitiative.org/methods/>
- <http://www.materialflows.net/visualisation-centre/>
- <https://www.resourcepanel.org/global-material-flows-database>



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