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UNDERSTANDING INTERNATIONAL COST MANAGEMENT STANDARDS FOR SUSTAINABLE DEVELOPMENT IN THE CONSTRUCTION SECTOR'S EFFORTS TO MITIGATE CLIMATE CHANGE CHALLENGES

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Additionally, he has held professional leadership roles, including representing the Institution of Surveyors of Uganda at international bodies and serving as Chairperson for various committees within the construction community. He has contributed to industry publications and has organized significant professional conferences.

Abstract: This paper discusses the application of International Cost Management Standards (ICMS) to carbon emissions management and sustainable development, particularly in the construction sector's efforts to mitigate climate change challenges. It explores the necessity of global cooperation to mitigate climate change effects and the importance of understanding the historical context of emissions. In the global context, it reflects on past international efforts like the Kyoto Protocol and the Paris Agreement to combat climate change and position the roles of ICMS within prevailing challenges. The ICMS framework is proposed to harmonise the classification and reporting of global construction costs and carbon emissions. It acknowledges the pressing need for sustainability, with the construction industry called upon to transition from traditional methods to more eco-friendly practices in line with the Sustainable Development Goals (SDGs). It further discusses various standards, carbon tools, data sources used in carbon assessments, and the importance of their accurate and reliable implementation in managing carbon emissions. In conclusion, realising the impact of the activities of built environment professionals on climate change is essential, as the built environment currently accounts for around 40% of global CO2 emissions, which warrants substantial shifts in the design, construction, usage, and reuse of buildings and infrastructure.

Keywords: *Climate Change, Cost Management Standards, Sustainable Development*

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1. Introduction

The seminal report "Our common future: A global agenda for Change" (WCED, 1987), chaired by Gro Harlem Brundtland, introduced the concept of "Sustainable Development" (Gerasimova, 2017, p.31), initiating an international focus on improving social, economic, and environmental conditions. The 17 Sustainable Development Goals (SDGs), adopted in 2015, were substantially influenced by Brundtland's work, serving as a blueprint for a sustainable future. They address global challenges, including poverty and climate change, in which the construction sector plays a critical role.

Climate change, a global emergency emphasised in the Intergovernmental Panel on Climate Change's (IPCC) 2021 report, requires the construction sector's efforts in mitigating and adapting to challenges due to its significant emissions (Shafii et al., 2006). Transitioning from traditional methods to environmentally friendly practices is urged (Abdullah et al., 2009) to serve people, the planet and profit under the 'triple bottom line' that focuses on social, environmental and economic concerns.

The building and construction sector, responsible for nearly 40% of global carbon emissions (Abergel et al., 2017), faces complexities in achieving carbon neutrality. Population growth, global climate warming, and living standards all add to carbon emissions challenges, necessitating solutions with specific targets and pathways, considering both operational and embodied energy (OECD, 2019; Moynihan & Allwood, 2014) and which culminates in enhancing resource efficiency and creating better policies to govern the management of the built environment.

Therefore, sustainable development and climate change are critical considerations in modern construction management. With the growing awareness of environmental impacts, construction projects must prioritise sustainable practices to minimise their carbon footprint and contribute to combating climate change. Adopting green building technologies, efficient energy systems, and renewable materials reduces the construction's environmental impact and leads to long-term cost savings and improved occupant well-being. Quantity surveyors, construction managers, and all other allied professionals of the built environment play a pivotal role in integrating sustainable strategies throughout the lifecycles of their projects, from inception, design, and construction to operation and end-of-life considerations. By embracing sustainable development principles and addressing climate change concerns, these professionals can contribute positively to creating a more resilient and environmentally responsible built environment for future generations.

2. The Science, Economics, and Policies of Climate Change

2.1. Causes of Climate Change

The science of climate change reveals that human activities, especially the burning of fossil fuels, release greenhouse gases (GHGs) such as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated gases (F-gases) into the atmosphere, leading to the greenhouse effect and global warming. Whereas natural factors influence climate, experts consider human-induced emissions the primary driver of recent climate change, creating complexities in future global warming projections due to uncertainty arising from internal variability and modelling accuracies.

Whereas fossil fuel combustion represents the leading source of GHG emissions, followed by land-use changes and industrial processes, the construction industry significantly contributes to these emissions through energy-intensive construction processes, material transportation, and building operations. Furthermore, the production of building materials, particularly cement, releases significant CO2 during chemical processes. As shown in Figures 2, 3and 4, CO2 emissions are the leading contributor to GHG emissions and continue to proliferate. Therefore, to achieve sustainable development, the construction sector must react swiftly, embrace low-carbon technologies, incorporate renewable energy sources, and promote circular economy principles to mitigate emissions.

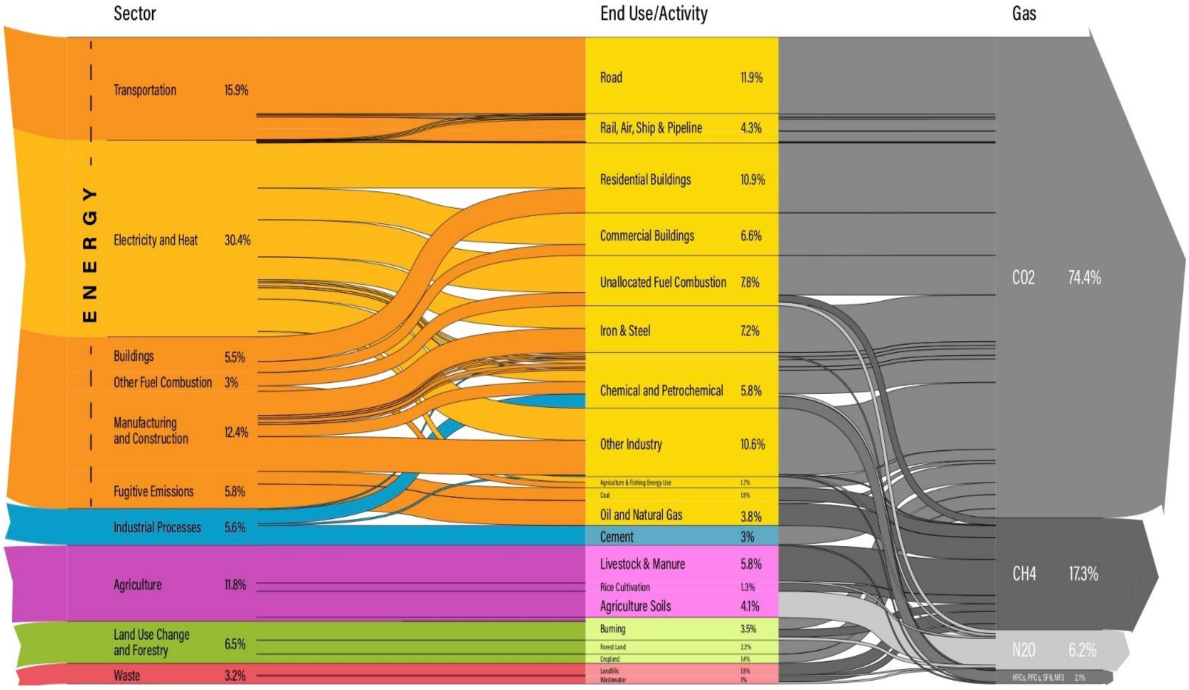

Figure 1: World Greenhouse Gas Emissions in 2016 by Sector, End Use and Gases - static (Source: Climate Watch, the World Resources Institute, 2020)

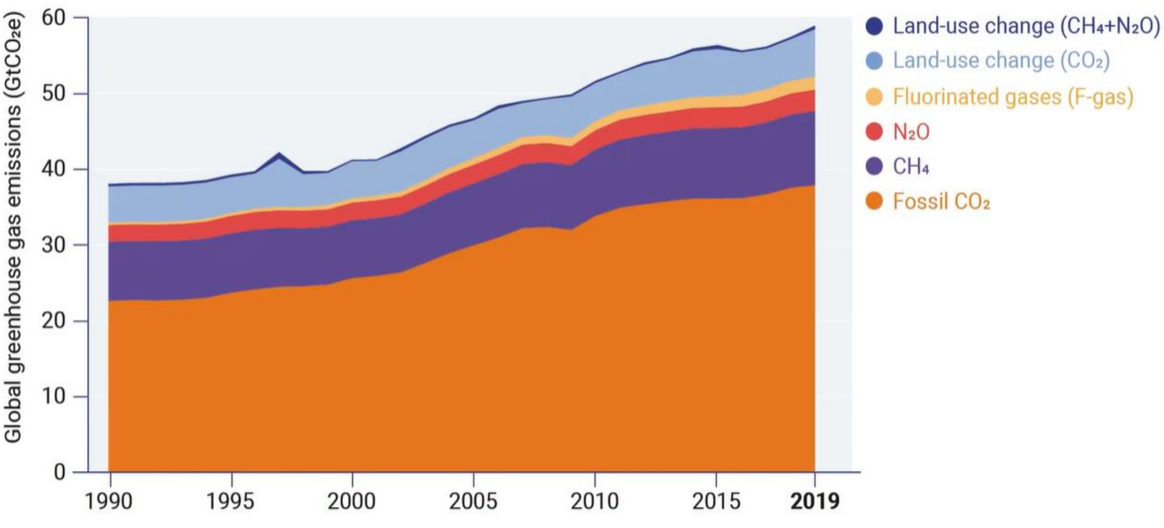

Figure 2: Global greenhouse gas emissions from all sources (Source: IPCC, Sixth Assessment Report, 2021)

2.2. Climate Change Damages

According to the IPCC report (IPCC, 2022), climate change presents a compelling argument for concern, as it induces extreme weather events like hurricanes, heat waves, and floods, resulting in severe natural disasters and ecosystem shifts with high welfare costs and risks to the construction sector, while rising sea levels impact vulnerable coastal areas, threatening infrastructure and millions of people. Furthermore, human-induced temperature rise intensifies extreme events, with major hurricanes in the North Atlantic increasing in frequency and severity and heat waves, epidemics, and wildfires imposing high welfare costs, particularly in countries with limited adaptive capacity. Moreover, climate change disrupts ecosystems, shifting precipitation patterns and challenging densely populated coastal regions and agriculture, notably in Southeast Asia. The non-linear nature of climate change introduces self-enforcing feedback loops that can trigger tipping points and cascades of irreversible damage, exemplified by the release of methane from melting permafrost accelerating global warming, underscoring the urgency of addressing climate change.

2.3. The Economic Consequences of Climate Change

The economic consequences of climate change have profound aggregate effects on human welfare, especially in less developed countries, small island states, and tropical regions where agricultural productivity is significantly reduced, posing a threat to global food security. This situation is further exacerbated for developing countries with limited resources, resulting in enduring impacts of weather anomalies, slow economic recovery after natural disasters, and increased vulnerability to future shocks (IPCC, 2021).

Furthermore, climate damages lead to heightened poverty, food insecurity, and various challenges, although these estimates are highly uncertain. Nonetheless, addressing climate change through early and targeted policy actions is crucial to avert damages, achieve carbon neutrality, and mitigate socioeconomic impacts on productivity, health, migration, poverty, inequality, and macroeconomic stability. In order to succeed in these endeavours, substantial reductions in greenhouse gas emissions are imperative.

3. A Proposed Framework for Global Actions to Mitigate Climate Change Effects

3.1. Context for Climate Change

Climate change presents a pressing and significant problem that requires urgent collective action and cooperation among nations. To address this issue effectively, it is crucial to understand International Cost Management Standards within the current context of climate change challenges.

Understanding the historical context of emissions is crucial for shaping international discussions on responsibilities and commitments, as the long-lasting presence of greenhouse gases in the atmosphere highlights the importance of cumulative emissions over time. Figure 3 illustrates the evolution of fossil fuel CO2 emissions, showing key trends. Before 1950, emissions were mainly from Western Europe and the US, but subsequently, these surged in various regions, notably the Soviet Blocal, with its energy-intensive economy. Recently, diverging trends have emerged as advanced countries have reduced emissions through improved energy efficiency and non-industrial sector shifts. The collapse of the Soviet Union led to significant emission reductions in Eastern Europe, while emerging markets, especially in Asia, experienced a surge in emissions as global industrial centres with high-energy intensity. Such an emissions trajectory aligns with any country's development whereby initially, emissions increase rapidly with economic growth, eventually slowing down and declining.

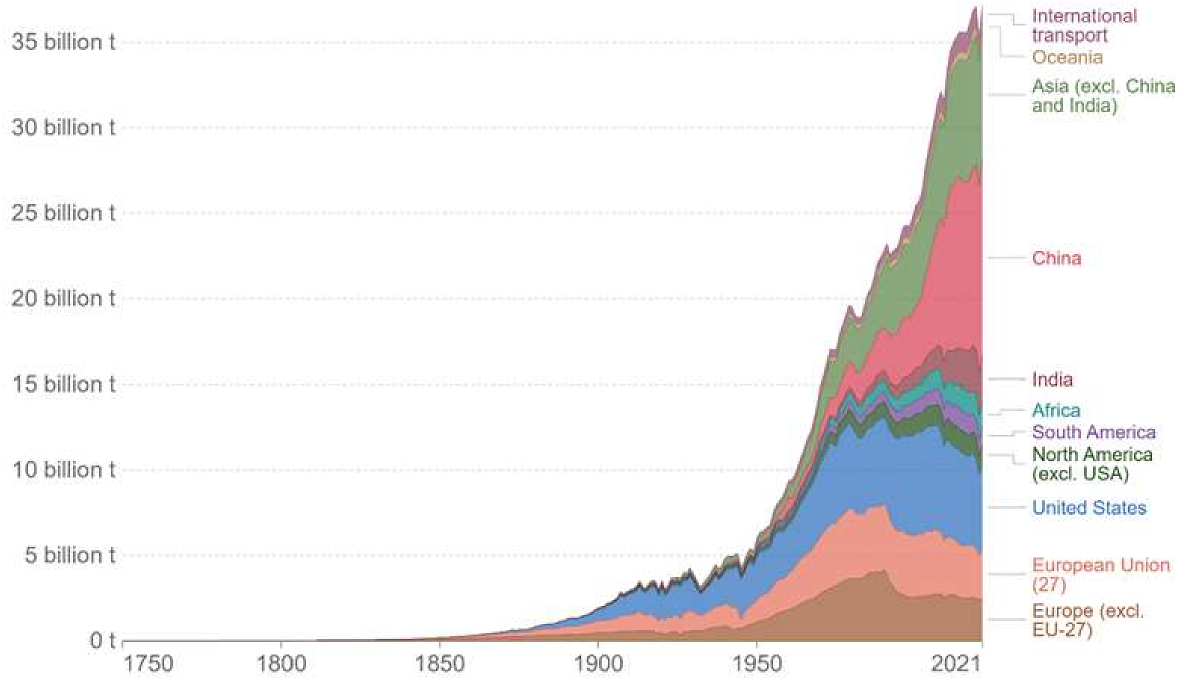

Figure 3: Annual Carbon Dioxide emissions by world region (Source: Global Carbon Budget, Friedlingstein et al., 2022)

Another analysis based on economic categories demonstrates that emissions contributions from emerging markets are rapidly growing, in contrast to developed country emissions which have recently declined. Nevertheless, overall projections based on current policies indicate that these trends will persist, with emerging markets continuing to grow faster.

While emerging markets generally emit less per capita than advanced countries, the emission gap is narrowing and varies among nations. For instance, Australia, Canada, Saudi Arabia, and the US emit approximately twice as much per capita as China and nearly ten times as much as India (IMF, 2023). Addressing climate change necessitates substantial emissions reductions from both developed and developing countries. Moreover, it is crucial to recognise the negligible emissions from low-income countries, which face extreme vulnerability to climate change impacts, as many of these countries exhibit extremely low emission levels, both absolutely and per capita.

Figure 4 illustrates the distribution of global CO2 emissions between advanced and emerging economies, underscoring the importance of collaborative efforts from all nations in mitigating climate change. Therefore, an effective framework for global cooperation is indispensable in addressing this challenge through collaborative efforts such as the Paris Agreement, which plays a pivotal role in providing a foundation for international climate action and financial support to developing countries. All nations must therefore commit to achieving climate goals to mitigate the extensive effects of climate change on human welfare and the planet.

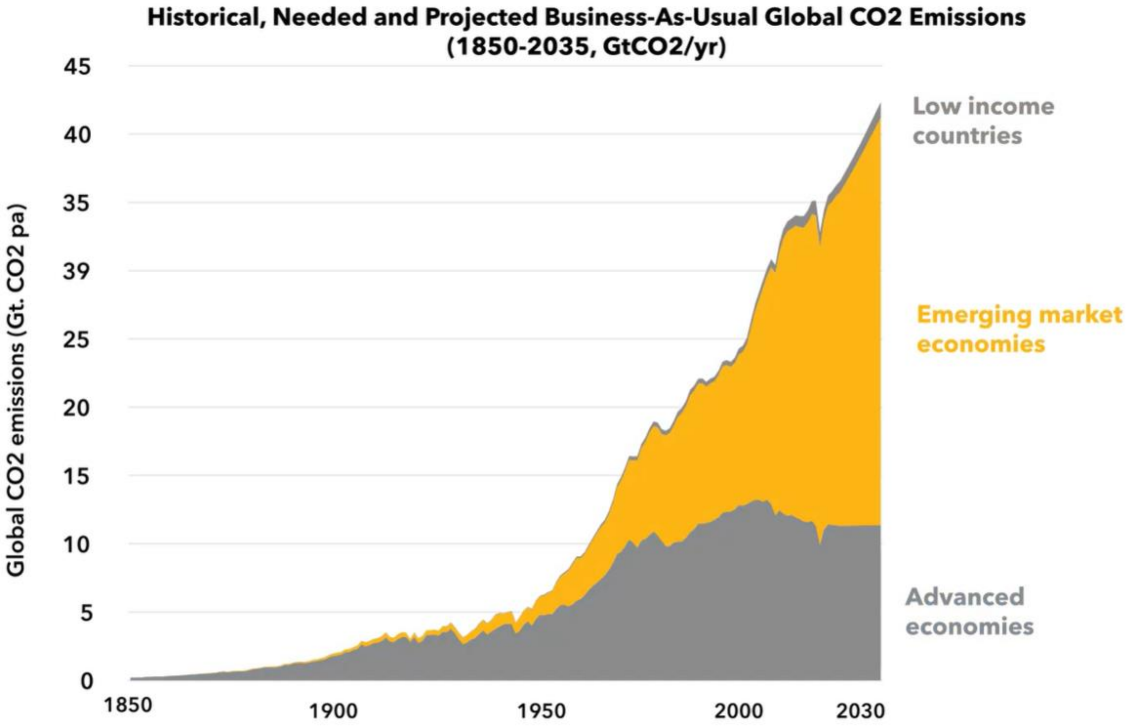

Figure 4: Distribution of Global CO2 emissions between Advanced and Emerging Economies (Source: Global Carbon Budget, Lienert, 2021)

3.2. Evolution of International Climate Change Agreements: From Kyoto to the Paris Agreement

Although the history of international climate change negotiations dates back to identifying the greenhouse effect in the 19th Century, significant efforts to address the potential threats only began in the 1970s and 80s as scientific consensus grew. In 1988, establishing the International Panel on Climate Change (IPCC) marked the commencement of serious international endeavours to tackle climate change. In 1992, the UN Framework Convention on Climate Change (UNFCCC) was signed by 154 states at the Earth Summit in Rio, setting the foundation for collective action to reduce atmospheric greenhouse gas concentrations. The Conference of the Parties (COP) was subsequently established under the UNFCCC and has convened annually since 1995.

A pivotal step in operationalising commitments and addressing the collective action problem was the Kyoto Protocol of 1997, which imposed legally binding obligations on advanced economies to reduce greenhouse gas emissions. However, the United States never ratified the Kyoto Protocol and withdrew in 2001, while Canada followed suit in 2012. Whereas most developed countries in Europe met their targets, emissions rose in other regions, offsetting their efforts.

The draft Copenhagen Accord of 2009 aimed to cap global warming below 2 degrees Celsius and proposed emissions targets for developed countries and mitigation actions for developing countries. However, it was not formally adopted and garnered signatures from only a subset of countries, leading to the perception of Copenhagen as a failure. Despite this setback, groundwork continued in subsequent years, culminating in the Paris Agreement 2015.

The Paris Agreement represents a groundbreaking milestone in the international response to climate change, as virtually every country signed onto this historic accord. The agreement acknowledges the shared responsibility of all nations in reducing emissions and serves as the primary framework governing global efforts to combat climate change.

The Paris Agreement sets two primary objectives: mitigation and adaptation. Mitigation aims to limit global temperature rise to below 2 degrees Celsius, while adaptation seeks to enhance adaptive capacity and resilience to reduce vulnerability to climate change impacts. The agreement introduced a process known as the "ambition enhancing mechanism" or "ratchet mechanism" to achieve these goals, a process mandates that countries periodically review their progress and reinforce their Nationally Determined Contributions (NDCs) every five years, ensuring a continuous commitment to strengthening their efforts.

While the Paris Agreement is legally binding, the targets specified are not legally binding. Instead, they emphasise procedural commitments, such as setting national targets, to promote collective action. However, this non-legally binding nature also creates challenges, as concerns arise about the possibility of free-riding members and credibility gaps in achieving the agreed-upon objectives.

3.3. Nationally Determined Contributions

The Paris Agreement's adaptation efforts centre on Nationally Determined Contributions (NDCs), where countries voluntarily declare emissions targets for a specified timeframe. For some developing countries, their commitments may depend on the provision of climate finance, which developed countries have pledged to mobilise, aiming to reach $100 billion annually by 2020 to support the mitigation and adaptation requirements of developing nations.

Since 2020, countries have been submitting their national climate action plans, known as NDCs, under the Paris Agreement, and more than 140 countries have submitted new or updated NDCs. However, according to the UNFCCC secretariat, there are gaps and challenges in the implementation and transparency of NDCs, highlighting the need for more action and support from all stakeholders (UNFCC, 2022).

As an example, Tanzania's Nationally Determined Contribution (2021) builds upon the National Climate Change Response Strategy (2021), the Zanzibar Climate Change Strategy (2014), and other national climate change and development frameworks to guide stakeholders on enhancing adaptive capacity and long-term climate resilience of social systems and ecosystems, while also encouraging participation in climate change mitigation activities to support international efforts while promoting sustainable development. However, Tanzania faces several challenges, including weak institutional capacity, limited financial resources, inadequate technology access, poor climate knowledge management, insufficient stakeholder participation, and low public awareness (Nationally Determined Contribution, 2021). Moreover, the estimated cost of implementing the NDCs is substantial, with an initial estimate of USD 500 million per year for addressing current climate change risks and a projected increase to USD 1 billion annually by 2030. Additionally, achieving 100% renewable energy for electricity, buildings, and industry by 2050 would require an investment of approximately USD 160 billion, while the net economic costs of addressing climate change impacts are estimated to be equivalent to 1 to 2% of GDP per year by 2030. Similar challenges are experienced elsewhere within the East African region and beyond.

3.4. Strengthening Mitigation Incentives: Proposals Beyond the Paris Agreement

The Paris Agreement possesses strengths in its universal membership but faces challenges in negotiating among 195 signatories with diverse emissions levels. For example, whereas voluntary pledges foster inclusivity, they present concerns about free-riding (whereby some members attempt to benefit from the shared resources without contributing their fair share of effort or resources), and the absence of commitment to achieving pledges creates an ambition gap. Furthermore, the ratchet mechanism (requiring countries to review and strengthen their climate commitments periodically every five years) should be more enforceable to improve its transparency. In addition, conditional pledges for developing countries depend on hoped-for climate finance, which has yet to materialise fully.

Proposals to strengthen mitigation incentives through carbon pricing coordination among critical countries, like the International Carbon Price Floor, could accelerate emissions reductions and address border carbon adjustments while considering equity considerations and alternative emissions-equivalent measures (UNFCC, 2022).

3.5. Climate Finance

Climate finance is critical in addressing climate change, encompassing financial flows from advanced to developing countries to support mitigation and adaptation efforts. Developing countries require assistance to cope with climate impacts and contribute to mitigation. Notably, many developing nations' mitigation commitments hinge on receiving promised climate finance.

Officially, various funds operate under the UNFCCC framework, including the Green Climate Fund, guided directly by the COP on policies, program priorities, and eligibility criteria. Additionally, market-based finance mechanisms, which facilitate investment in mitigation projects between developed and developing countries, might be replaced by a global emissions trading scheme if Article 6 issues are resolved.

Outside the UNFCCC, Multilateral Development Banks (MDBs) and UN Agencies play vital roles in delivering climate finance. Carbon finance involves partnerships with the private sector to utilise carbon market revenues for emission reductions.

The $100 billion target enshrined in the Paris Agreement for mobilising climate finance by 2020 has yet to be fully met, with bilateral public finance and multilateral finance from developed countries being significant components. Adaptation funding remains limited despite developing countries' substantial needs, raising calls for increased finance, emphasising adaptation, and viewing the $100 billion target as a minimum rather than a specific goal.

4. The Role of International Cost Management Standards (ICMS) in Construction Projects

4.1. Evolution and Expansion of ICMS Standards

The International Cost Management Standards (ICMS) were developed in response to the World Economic Forum's research advocating rigorous international standards for cross-border comparisons in construction design and processes. The first edition, ICMS 1, focused on benchmarking capital costs and resulted from collaboration among 45 professional cost management organisations worldwide, led by RICS (Royal Institution of Chartered Surveyors).

Recognising the importance of whole-life costing, ICMS 2 expanded its scope to include life cycle costs. It was published in September 2019, providing a common reporting framework for the through-life costs of assets, encompassing renewal, operation, maintenance, and end-of-life costs.

The growing awareness of climate change and its impact on the construction industry prompted the Coalition to expand ICMS further, leading to the development of ICMS 3. Released in November 2021, ICMS 3 takes a comprehensive approach by including carbon emissions reporting alongside life cycle costs. This expansion acknowledges the interrelationship between costs and carbon emissions, allowing stakeholders to explore and optimise sustainability efforts through ICMS 3.

ICMS 3, therefore, serves as a common reporting framework for life cycle costs and carbon emissions in the construction sector. Its primary purposes are as follows:

- Comparative Benchmarking: ICMS 3 facilitates consistent and transparent benchmarking of construction life cycle costs and carbon emissions on an international, national, or regional level. This empowers stakeholders to make informed comparisons between projects, facilitating effective decision-making.

- Options Appraisal: By identifying the causes of differences in life cycle costs and carbon emissions between projects, ICMS 3 enables better decision-making and option appraisal during the design and planning phases. Understanding the drivers of costs and emissions variations aids in selecting the most suitable project approach.

- Investment Decision-Making: ICMS 3 enables stakeholders to make well-informed investment decisions, considering both cost efficiency and environmental impact. The standardised reporting system empowers decision-makers to align investments with sustainability goals effectively.

- Certainty in Data Usage: The comprehensive reporting framework provided by ICMS 3 ensures that data can be used confidently for construction project financing, investment decisions, and related purposes, promoting certainty in the construction sector.

The ICMS framework is structured into four hierarchical levels, comprising Project Type, Categories, Groups, and Sub-Groups, and covers costs and carbon emissions associated with various phases, including Acquisition, Construction, Renewals, Operation, Maintenance, and

End-of-Life. While Levels 1, 2, and 3 are mandatory for reporting, Level 4 is discretionary, offering exemplars and prompts for data capture.

At Level 1, the framework defines Projects as a single or series of construction interventions with a defined start and end date commissioned by a Client, Employer, or Owner. These projects are further subdivided into Sub-Projects, which a single set of attributes and values can describe. The framework covers 19 project types, each with specific attributes and values. At Level 2, the framework is characterised by the acronym ACROME, which stands for Acquisition, Construction, Renewal, Operation, Maintenance, and End of Life. These categories (traditionally referred to as lifecycle stages) encompass the entire life cycle of a project, from its inception to its disposal. The scope of these categories is based on ISO 15686-5:2017, which covers service life planning for buildings and constructed assets.

At Level 3, the cost and carbon emissions groups (traditionally called elements) are the same for construction, renewal, and maintenance. However, groups for operation and end-of-life differ due to the nature of activities involved at these stages of the asset's life cycle. Although using Level 3 groups is mandatory, reporting carbon emissions for specific groups may not be necessary, as they are considered negligible.

At Level 4, reporting is not mandatory but at the discretion of the user. Sub-Groups are provided as exemplars or prompts and can be modified or expanded per the project's specific requirements, allowing flexibility in reporting. These sub-groups can be looked at granularly as work sections and trades in the traditional standard methods of measurement of building and civil engineering works.

To facilitate fair comparisons between projects, each project's context is described through a series of attributes and values capturing the principal characteristics that significantly impact costs and/or carbon emissions. It should be emphasised that ICMS is not a Method of Measurement but a standardised reporting system that can complement or be used when no local standard Methods of Measurement are adopted.

Development principles for ICMS prioritise a balance between detail and value, simplicity of content and language, engagement with subject matter experts, and comprehensive consultation exercises to ensure its fitness for purpose. Graphics and colour coding are employed to aid understanding and navigation through the standards, enhancing its usability and accessibility for various stakeholders involved in construction projects (RICS, 2022).

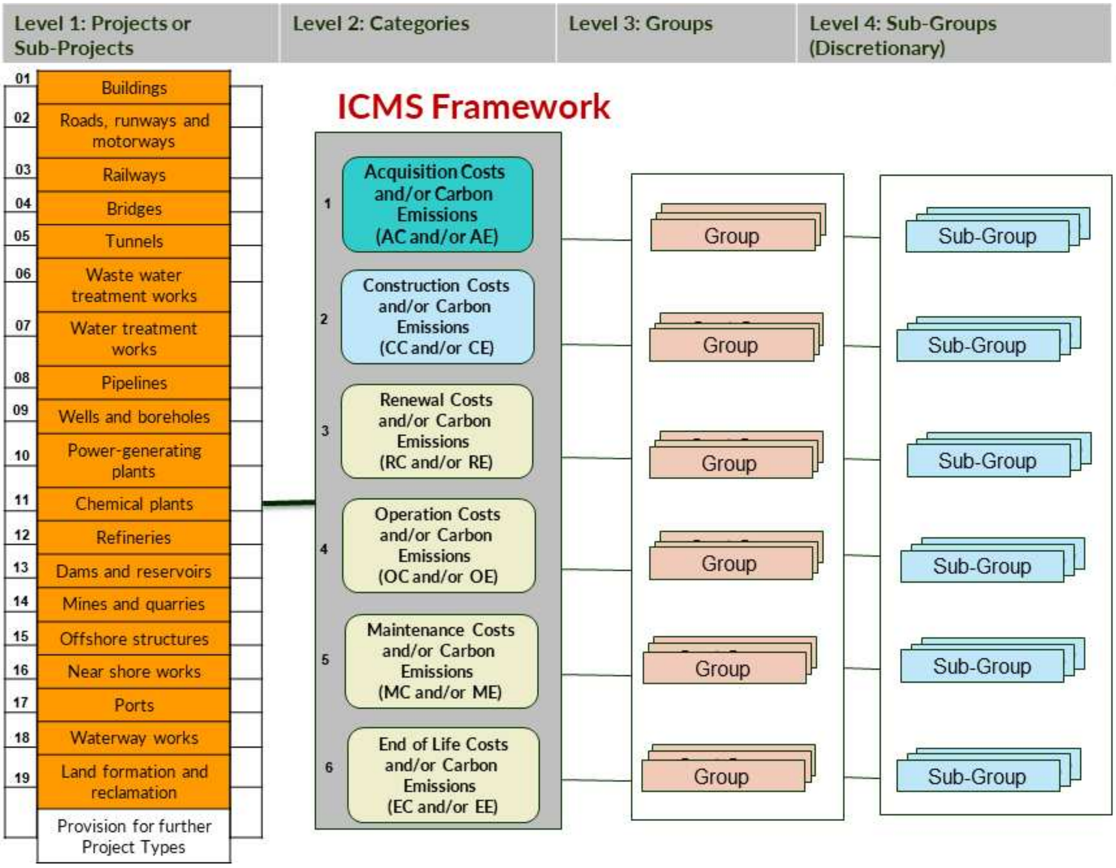

Figure 5: ICMS Framework Overview (Adapted from ICMS 3; Muse et al., 2021)

4.2. *Exploring Life Cycle Costs, Carbon Emissions, and the Hierarchical Approach*

ICMS is a robust and consistent framework that serves as a powerful tool for reporting both life cycle costs and carbon emissions in construction projects. Life cycle costs, encompassing vital expenditures from inception to disposal, offer insights into the project's economic sustainability. It excludes non-construction costs like acquisition and occupation expenses, streamlining the focus on key elements. The power of ICMS lies in the parallel reporting frameworks for life cycle costs and carbon emissions, ushering in transparency and comparability vital for comprehensive decision-making.

Understanding the intricate relationship between life cycle costs and carbon emissions becomes paramount in making informed investment decisions and achieving sustainable development goals. By grasping this connection, stakeholders can effectively assess the environmental impact of cost decisions, enabling a more harmonious alignment of financial objectives and environmental aspirations.

The significance of the ICMS hierarchy rests in its elemental approach, delving into individual elements that compose a project rather than activities or quantities of materials. This approach becomes a cornerstone in life cycle costing, as it considers critical factors like renewals, operations, or maintenance, ultimately influenced by the likelihood of an element's failure. With such granularity, ICMS empowers project planners to gain a comprehensive understanding of costs and carbon emissions, thus facilitating the identification of key elements that impact sustainable development profoundly.

ICMS also offers a plethora of benefits that resonate across the global landscape. By fostering consistent benchmarking of life cycle costs and carbon emissions internationally, stakeholders can gauge a project's efficiency and sustainability on a grand scale. Moreover, it is a powerful tool for identifying cost disparities between projects, ensuring better-informed investment decisions. Not stopping there, ICMS is invaluable in mapping out cost and carbon emission planning, analysis, and target setting, streamlining dispute resolution, asset valuation, and insurance reinstatement costs.

However, ICMS, like any tool, does have its limitations. The absence of a mandated breakdown structure below Level 3 poses a potential challenge in identifying granular cost or carbon emission differences between projects. Project planners and researchers need to be aware of this limitation and address it through alternative methodologies to achieve the desired level of detail. ICMS's elemental nature also diverges from the more common activity-based methods prevalent in most national and local standard measurement practices. This discrepancy may necessitate an adjustment for professionals accustomed to traditional estimating methods, emphasising the need for adaptability and openness to embrace this powerful yet distinct framework.

Figure 6 visually captures the interrelationship between ICMS, life cycle costs (LCC), and whole life costs (WLC), as adapted from ICMS 3 and Muse et al. (2021). This illustrative depiction visually underlines the symbiosis between cost management and environmental considerations, highlighting the critical role of ICMS in tailoring a harmonious relationship between cost management and sustainability construction practices.

Overall, ICMS is an indispensable tool in pursuing sustainable development in the construction industry. Through its consistent reporting, elemental approach, and holistic vision, ICMS paves the way for environmentally-conscious investment decisions, making progress towards a greener and more sustainable built environment. As the construction industry and stakeholders embrace this robust framework, its potential to drive transformative change in global construction practices becomes increasingly evident.

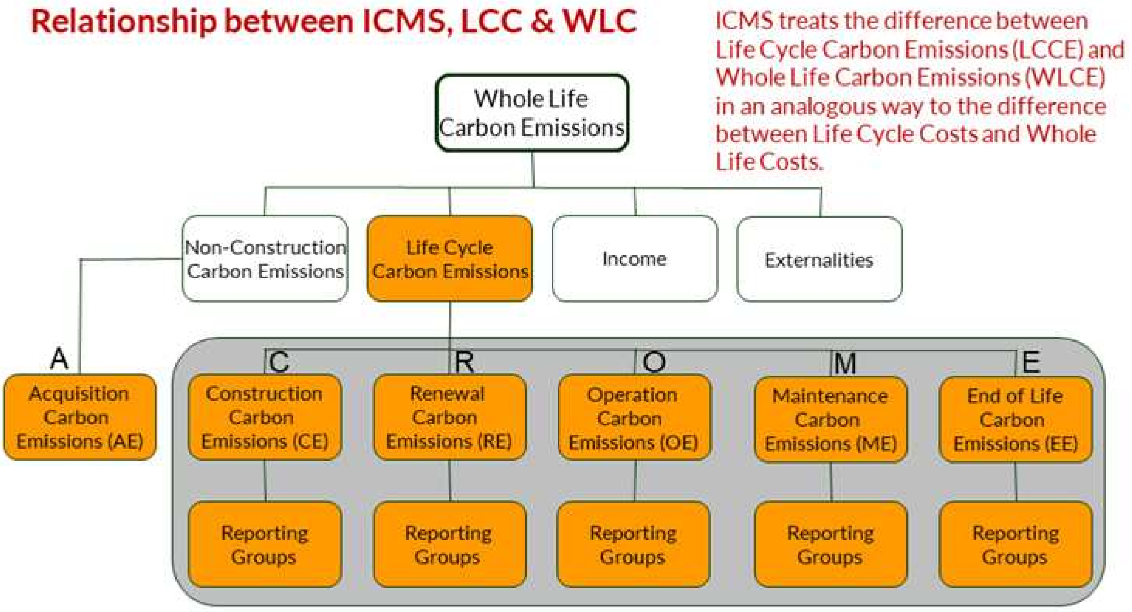

Figure 6: The relationship between ICMS, LCC and WLC (Adapted from ICMS 3; Muse et al., 2021)

Notably, ICMS delineates life cycle carbon emissions reporting instead of whole life carbon emissions, with further elaboration presented in section 2.5 of the ICMS guidelines (Muse et al., 2021). The ICMS framework explicitly identifies specific carbon emissions, labelled 'externalities,' outside the defined life cycle. These external emissions sources encompass a wide array of factors, including but not limited to energy generation or recycling-derived savings, carbon sequestration or storage (for example, associated with tree planting initiatives linked to the project), and carbon emissions benefits and loads that extend beyond the project's system boundary, such as those originating from products designed for future reuse, under principles of the circular economy.

While these external emissions sources and associated reduction opportunities constitute a valid and valuable aspect of whole-life carbon assessment and management, it is essential to emphasise that they are not mandated for inclusion in ICMS reporting. In the interest of precision, clarity, and comparability, ICMS recommends that these external factors be documented separately from the overall lifecycle carbon emissions figures. This approach ensures a nuanced understanding of the carbon emissions landscape. It is a significant step towards achieving a comprehensive and transparent evaluation of sustainability practices within the construction sector.

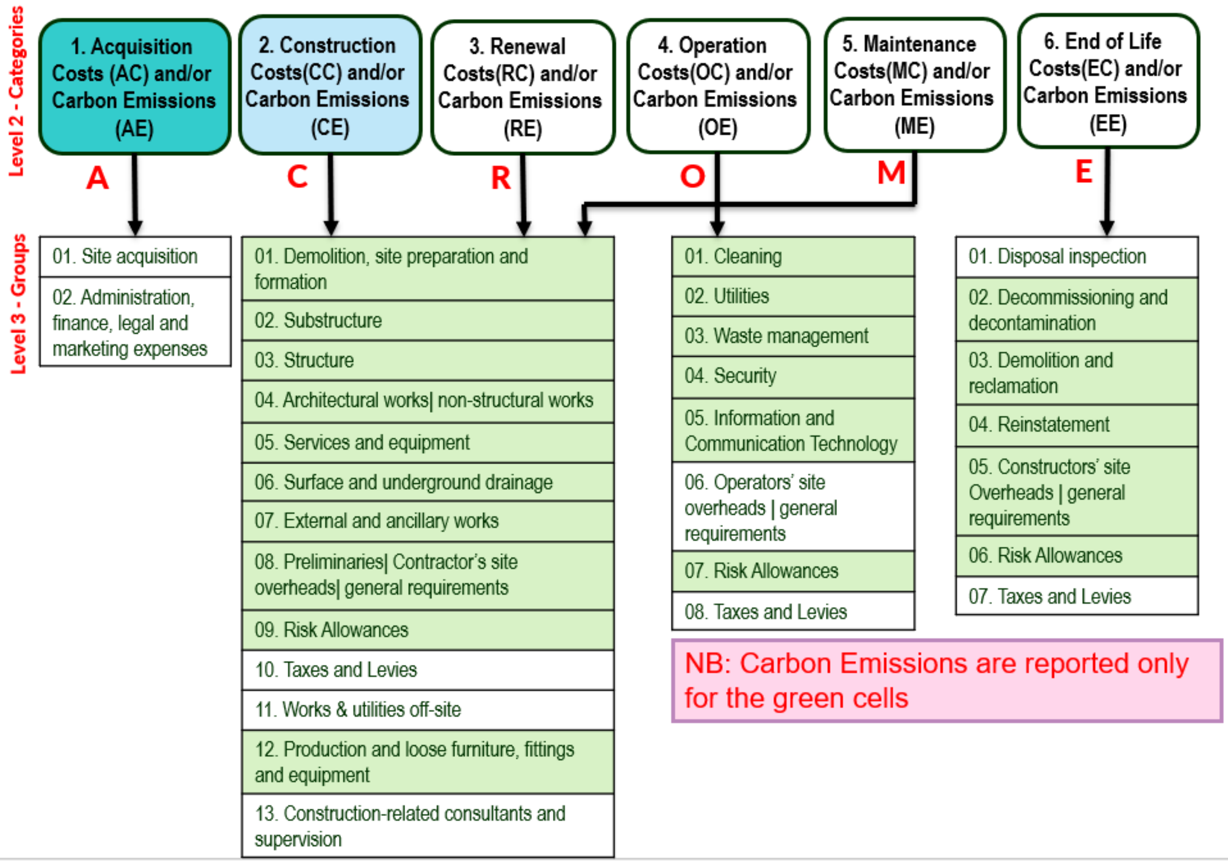

Figure 7: ICMS Framework: Level 2 Categories and Level 3 Groups (Adapted from ICMS 3; Muse et al., 2021)

4.3. *Carbon Assessment Standards and Guidance*

Carbon assessment standards are pivotal in promoting systematic and credible quantification of carbon emissions in construction projects. These standards offer best practice guidelines aligned with international sustainability objectives, facilitating adoption of sustainable development practices. To ensure reliable carbon assessment results, it is imperative to select a recognised standard suitable for the project's scope and objectives. Several international standards cater to various aspects of carbon assessment, encompassing different projects within the built environment, including buildings, civil engineering works, construction products, and organisational levels.

Among the prominent standards are:
ISO 21931-1:2010: This standard provides a comprehensive framework for assessing the environmental performance of buildings, including energy efficiency and carbon emissions, ensuring consistent practices for carbon assessment in building projects.
ISO 21931-2:2019: Extending the assessment framework to civil engineering works and infrastructure projects, this standard aligns with sustainability principles, including carbon reduction strategies.

ISO 21930:2017: Focusing on environmental product declarations (EPDs), this standard offers transparent information on the lifecycle environmental impacts of construction products, including embodied carbon.

EN 15978:2011: Outlining a standardised methodology for calculating the environmental performance of buildings, including quantification of carbon emissions.

EN 15804:2012 + A2:2019: Similar to ISO 21930, this standard deals with environmental product declarations and establishes core rules for quantifying environmental impacts, including carbon emissions, associated with construction products.

EN 15643:2021: Providing a comprehensive framework for assessing the sustainability of buildings and civil engineering works, including carbon emissions, throughout their lifecycle.
EN 17472 (draft): This draft standard focuses on sustainability assessments for civil engineering works and encompasses carbon emissions calculation methods.

PAS 2080:2016: Specifically addressing carbon management in infrastructure projects, this standard offers guidance on measuring, reporting, and reducing carbon emissions.

The proper selection of a suitable carbon assessment standard is crucial to ensure the authenticity and credibility of carbon inventories, leading to effective carbon reduction strategies and fostering sustainable practices in the construction industry

4.4. *Lifecycle Stages in Carbon Assessment*

Carbon assessment involves analysing the carbon emissions associated with different stages of a construction project's lifecycle. Understanding these lifecycle stages is vital for accurately quantifying and managing carbon emissions throughout the project's existence. The widely recognised lifecycle stages in carbon assessment include:

The Product Stage (A1 - A3) constitutes the initial phase of the lifecycle, involving emissions associated with the creation and production of construction materials and products before their use in construction. It encompasses processes such as raw material extraction, transportation of raw materials to manufacturing facilities, and the actual manufacturing of construction products. Embodied carbon, representing the carbon footprint of materials and products, is critical in this stage. Proper selection of low-carbon materials and eco-friendly manufacturing practices can significantly reduce the overall carbon impact during this stage.

The Construction Stage (A4 - A5) involves emissions related to the transportation of construction materials to the construction site, and the construction processes themselves. Activities such as site preparation, assembly of materials, and on-site construction operations contribute to the carbon emissions during this stage. Reducing emissions at this stage can be achieved through optimising transportation routes, utilising energy-efficient construction equipment, and implementing sustainable construction practices.

The Operational or In-Use Stage (B1 - B7) accounts for emissions released or removed during the service life of the constructed asset. It includes energy consumption for heating, cooling, lighting, and operating electrical appliances for buildings. For infrastructure projects, it involves factors like energy usage in transportation systems and the operation of facilities. The operational stage typically represents the most significant portion of the project's lifecycle emissions. Implementing energy-efficient technologies, renewable energy sources, and intelligent building management systems can effectively reduce carbon emissions during this phase.

The Maintenance, Repair, Replacement, and Refurbishment (B2 - B4) stage encompasses activities carried out throughout the operational life of the asset, generating additional carbon emissions. Proper maintenance and repair can extend the life of the asset and delay the need for replacements, thereby reducing the overall carbon impact. Additionally, refurbishment projects that prioritise sustainability and carbon reduction can significantly contribute to lowering emissions.

The End-of-Life Stage (C1 - C4) involves emissions associated with the asset's decommissioning, demolition, waste transportation, processing, and disposal. Proper waste management practices, such as recycling and reusing materials, can help minimise the carbon impact during this stage.

Understanding the different stages of carbon assessment is essential for aligning ICMS reporting with whole-life carbon assessment, facilitating informed decision-making, and effective carbon reduction strategies in construction projects.

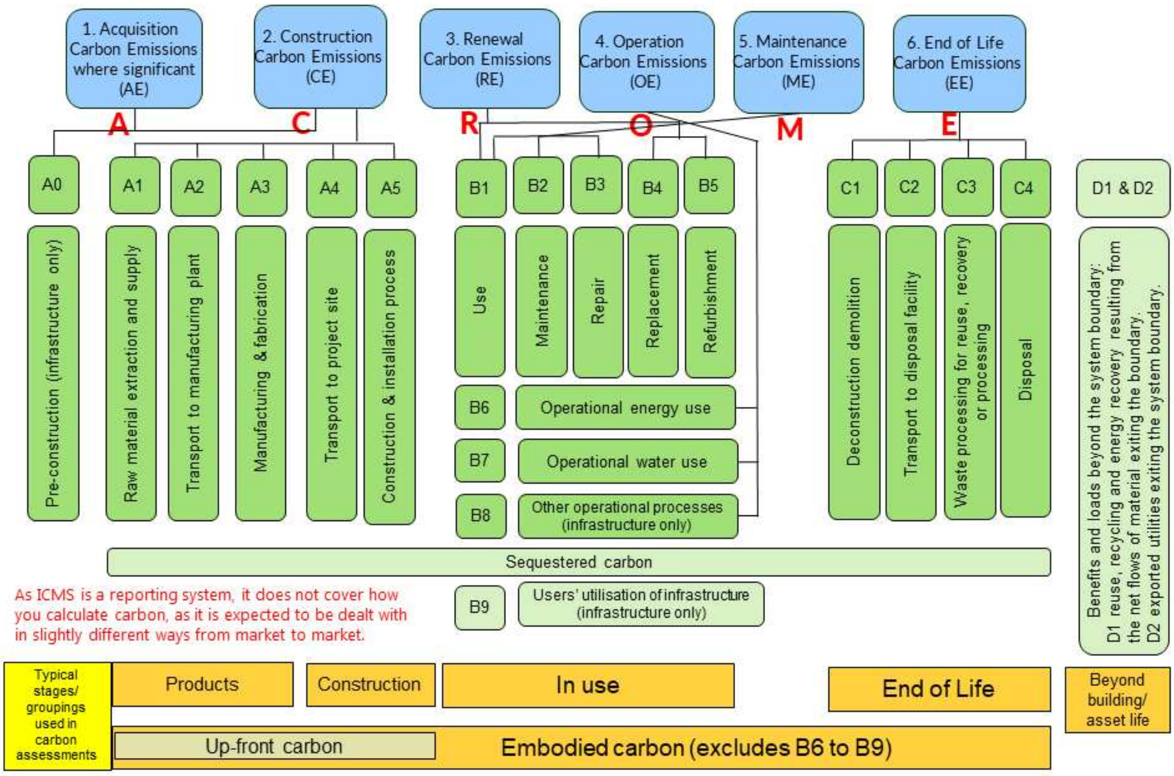

Figure 8: How ICMS reporting maps to the stages associated with whole life carbon assessment (Adapted from ICMS 3; Muse et al., 2021)

4.5. Carbon Emissions in Buildings and Infrastructure Facilities: 'Upfront' Embodied Carbon and Operational Carbon

Carbon emissions in buildings and infrastructure facilities comprise two main components: Embodied carbon and Operational carbon. Embodied carbon represents the total greenhouse gas emissions, mainly CO2, associated with construction materials, from extraction to end-of-life disposal. It includes raw material extraction, manufacturing, transportation, and construction emissions. On the other hand, Operational carbon refers to emissions resulting from day-to-day building operations, such as heating, cooling, and electricity consumption. Both components require attention for effective carbon reduction strategies.

Embodied carbon accounts for 10 to 20% of a building's carbon footprint, but it is projected to rise to 49% by 2050 due to increased material consumption driven by population growth and economic expansion (OECD, 2019). The construction industry must address embodied and operational carbon to tackle the challenge of increasing carbon. This can be achieved by specifying low-carbon materials, employing energy-saving design solutions, promoting green spaces, adopting efficient construction practices, and advocating for renewable energy sources.

Figure 9: Elements Influencing Carbon Balancing (Buildings as Carbon Banks, 2020)

The significance of reducing CO2 emissions in the construction sector and conducting rigorous carbon calculations lies in promoting environmentally friendly and energy-efficient buildings. Achieving net-zero carbon by 2050 necessitates transformative practices, and comprehensive carbon assessment is crucial in this endeavour. Consistent measurement of both embodied and operational carbon enables meaningful comparisons, enhancing our understanding and progress towards net-zero carbon goals.

4.6. Leveraging Design for Carbon Impact Reduction

Amidst the impending irreversible impacts of climate change, the built environment's role in global CO2 emissions calls for innovative design approaches like Carbon Balancing. Such an approach aims to make buildings act as carbon banks by sequestering more carbon than they emit over their lifecycle. It utilises renewable materials like timber construction and implements carbon sequestration elements to achieve the intended balance. Timber construction offers avenues for carbon sequestration, as wood naturally absorbs and stores carbon dioxide, leading to lower embodied carbon than traditional materials. However, responsible forest management and sustainable sourcing are essential for maximising the carbon sequestration potential of timber construction.

Furthermore, addressing overdesign in buildings and infrastructure is critical to reducing material demand and meeting carbon targets. Carbon balancing, exemplified in timber construction, is one approach, along with reusing and extending the life of existing buildings to achieve zero carbon design. Adopting a circular economy approach prioritising reuse is essential for reducing environmental impact and achieving sustainable design goals, making end-of-life considerations integral to environmentally responsible building design and construction (Gibbons et al., 2022).

4.7. Emission Factors in Carbon Assessment

Emission factors are vital for accurately calculating greenhouse gas emissions, representing the amount of greenhouse gases emitted per unit of activity, typically expressed in carbon dioxide equivalent (CO2e). They vary for different emission sources within each lifecycle stage and are vital in precise carbon assessments. These factors depend on the activity or material, such as per kilogram of a material or kilowatt-hour of electricity use. Widely available for various sources of greenhouse gas emissions, they are essential components of carbon calculations.

Critical aspects of emission factors in carbon assessment include variations for different sources based on their characteristics, encompassing different scopes of emissions (Scope 1, Scope 2, and Scope 3) to provide a comprehensive picture of carbon impact, potential changes over time due to technological advancements, and the importance of using reputable data sources such as databases, scientific publications, industry reports, and environmental product declarations (EPDs) to ensure accuracy and reliability. Addressing the implementation gap within East Africa, it is paramount for the built environment professionals in the region to develop a toolkit of carbon emissions data.

4.8. Carbon Tools in Carbon Assessment

Carbon tools are vital software applications or online platforms that simplify carbon emissions calculations based on activity data. They play a dynamic role in making carbon assessments more efficient and accessible to construction professionals. Various carbon tools have been developed and used in the construction industry, which is constantly evolving and expanding. Examples include the ICE Database, One Click LCA, The Structural Carbon Tool, eToolLCD, Athena Impact Estimator, Tally, Carbon Leadership Forum (CLF) Calculator, SimaPro, and CarbonScope.

The ICE database offers emission factors for construction materials and products, while One Click LCA facilitates the lifecycle assessment of building and infrastructure projects. The Structural Carbon Tool estimates embodied carbon in designs and identifies carbon hotspots. eToolLCD evaluates environmental impacts and identifies sustainable choices. Athena Impact Estimator assesses the environmental impact of materials and assemblies. Tally is a Revit plugin that visualises environmental impact in real-time. The CLF Calculator estimates embodied carbon based on Environmental Product Declarations. SimaPro conducts comprehensive environmental assessments, and CarbonScope estimates carbon emissions in buildings.

Considering the urgency to address climate change, construction professionals should consult the latest literature and industry experts to identify relevant and up-to-date carbon tools, thereby empowering the construction industry to effectively address climate change and contribute to a low-carbon future by integrating lifecycle stages, emission factors, and carbon tools in assessments.

5. Conclusion

Promoting sustainable development in the construction sector must take urgent action, which entails aligning its practices and procedures with global climate policies. Embracing sustainable practices and adopting low-carbon technologies, supported by commensurate access to climate finance, would empower the construction sector to address the apparent mitigation and adaptive capacity gaps within the local, regional, and global perspective, all of which are essential steps to establish a climate-friendly construction sector.

However, despite the need for a broader planning horizon to prepare for potential future events, the construction industry still needs to improve due to significant variations in construction output definitions and measurements. This lack of comparability and consistency impacts certainty and investments in the industry. The International Cost Management Standards (ICMS) present an opportunity for built environment professionals to actively contribute to achieving net-zero carbon by incorporating life cycle costs and carbon emissions reporting to enable stakeholders to make well-informed decisions for environmental sustainability and cost efficiency. Embracing ICMS will empower the construction industry to play a significant and proactive role in global climate change efforts.

Mainstream built environment professions must therefore increase their engagement rather than treating sustainability as a niche activity, for it is through enhanced collaboration, such as developing a carbon emissions database jointly for regions like East Africa, that the impact of the construction sector would be enhanced through consistent and transparent benchmarking of construction life cycle costs and carbon emission, optional appraisals to identify causes of differences in costs and carbon emissions, enabling stakeholders to make well-informed investment decisions, and improving certainty in data usage.

Realising the impact of professional activities on the climate is crucial, considering that buildings and construction currently account for around 40% of global energy-related CO2 emissions. Achieving a sustainable environment for the projected global population of 9.7 billion, including 6.5 billion city dwellers, by 2050 necessitates profound changes across the design, construction, use, and reuse of buildings and infrastructure. These changes are vital for mitigating the challenges of climate change and ensuring a sustainable future for all.

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