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Building Energy Codes: Reviewing the Status of Implementation Strategies in the Global South

Tariene Gaum
Department of Architecture and Industrial Design, Tshwane University of Technology, South Africa

Jacques Laubscher
Department of Architecture and Industrial Design, Tshwane University of Technology, South Africa

ABSTRACT

The public understanding of climate change, methods, mitigation, adaptation and the reason behind it have been investigated in developed countries. The current knowledge levels in the Global South remains limited, this while countries forming part of the Global South are more vulnerable to resultant effects of global warming. This requires the urgent attention by both citizens, who lack relevant information as well as decision makers lacking environmental literacy to establish long-term sustainable strategies. With just 9 years left, the probability of achieving the Sustainable Development Goals (SDGs), is unlikely and will require the complete redevelopment of the building sector. Focusing on the built environment, this paper uses contemporary definitions of the Global South to establish the contribution, significance and lack of energy efficiency mechanisms in the face of climate change. A combination of literature, desk research and data gathering from various sources are employed to establish the contribution of the Global South built environment to climate change. Using Carbon Dioxide (CO_2) emissions, 2050 urban population figures and distinctive climatic regions as basis, this study selected the largest role players to establish the status, extent and efficacy of building energy codes. The review point towards a built environment lacking the necessary building energy codes, with approximately 47% of selected Global South countries not implementing any form of building energy efficiency regulations or related policies. As part of the recommendations, Global South countries lacking the necessary regulations are encouraged to revise, update or adopt possible best practice standards from relevant countries that implement mandatory building energy codes. This study aims to address the gap in knowledge, establish a way forward and facilitate a larger implementation of building energy codes and strategies in the Global South.

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Corresponding Author Contact:

GaumT@tut.ac.za

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1. Introduction

On a worldwide scale, communities are increasingly becoming more vulnerable to the effects of climate change. The European Union and 179 other countries spent two weeks in Paris setting out an agreement that could possibly keep global temperatures below 2°C. The twenty-first session of the Conference of the Parties (COP 21) was one of the largest gatherings of world leaders and stated that the reduction in temperatures would only be possible by significantly reducing greenhouse gas (GHG) emissions (United Nations Framework Convention on Climate Change [UNFCCC], 2016).

The Intergovernmental Panel on Climate Change (IPCC) claims, the main impacts of climate change in Global South countries will likely increase in urban areas within the next few decades (IPCC, 2014).The term Global South broadly refers to regions of Asia, Africa, Latin America and Oceania as a concept to describe third world countries, low income countries or developing countries (Dados & Connell, 2012). Evidence of the vulnerability of urban populations are demonstrated by the growing number of people that are seriously affected or killed due to extreme weather conditions caused by the effects of climate change (Hoeppe & Gurenko, 2007; Moser & Satterthwaite, 2008; Satterthwaite *et al*., 2009). According to the 2018 Population Division Report from the United Nation (UN), more than 55% of the global population are living in urban areas (UN, 2018). Further studies from 2016 indicate that an estimated 793 million people are exposed to conditions below the UN defined breadline of US$1.90 a day (UN, 2018) and although communities worldwide are affected by extreme weather events, the urban poor often living in informal settlements, are most vulnerable.

The Sustainable Cities Report states, *"[t]here is a direct link between buildings and climate change due to the high rate of carbon emissions from the construction and ongoing use of buildings. Building resources take up to 40 per cent of energy use and 17 per cent of fresh water use. Twenty-five per cent of wood harvested and 40 per cent of material produced are attributed to the built environment"* (De Lilly, 2009). Energy consumption in the built environment has increased significantly over the past years with buildings consuming more than one-third of the global energy (United Nations Environment Programme [UNEP], 2016). This is due to population growth, increase in floor area, time spent indoors and global climate change particularly referring to Global South countries (Pelling, 2003; Tanner *et al*., 2009). Climate change is projected to worsen by the year 2050 if no drastic energy strategies are implemented (Georgieva, 2018).

In order to fulfil the SDGs for the built environment, the UN suggests implementation of energy efficiency policies and regulations addressing the design, construction and operation of buildings should be supported by developed countries both technically and financially. The Organisation for Economic Co-operation and Development (OECD) together with the International Energy Agency (IEA) state more than 60 countries worldwide implement both mandatory and voluntary building energy codes (IEA, 2017). Although the number of countries with energy codes are steadily growing, two-thirds (66.6%) of countries worldwide are still without mandatory energy codes and not addressing the effects of climate change (IEA, 2017). The Director of the Energy Research Centre at the University of Cape Town, Winkler (2006) is of the opinion that the implementation of codes or regulations are not meaningful without appropriate enforcement mechanisms and that a combination of policies are required to achieve greater results. However, according to the IEA (2017), enforcement of codes is still a major issue in many countries, and many of the existing energy codes need to be updated to address new building targets along with existing building practices.

It is therefore important to investigate the building energy codes across Global South countries, determining the percentage of countries with or without building energy codes and thereby establishing their current implementation status. The overall aim of this article is to magnify the lack of building energy codes in the Global South, contribute towards the knowledge gap using existing data and make recommendations towards future studies focusing on possible best practice guidelines and implementation strategies for Global South countries.

2. Methodology

Scholars in today's information age collect and archive vast amounts of data for use by researchers globally. Resultantly, the use of existing data is becoming common practice in research (Andrews, Higgins, Andrews & Lalor, 2012; Smith, 2008; Smith *et al*., 2011). Desk research usually refers to secondary data collected from the original source for another primary purpose. Commonly derived from international institutions who collect and store published report studies (Salkind, 2010). This study uses a desk research approach, to investigate existing information on building energy codes used by different implementing agencies in the Global South. The majority of data sources identified in this paper originate form official regulatory organisations that exists in each country.

The first subsection of this article serves as an introduction to the impacts of climate change and the importance of building energy code implementation, specifically within the Global South. Thereafter a comprehensive definition of the Global South is provided to eliminate any uncertainty. The desk study establishes the importance of the Global South, highlighting the current climate impacts and lack of building energy codes in developing countries. Further discussions include the effect of CO_2 emissions in relation to the built environment and the vulnerability of future urban expansion to the expected impacts of climate change in the Global South.

The literature survey establishes the criteria for selecting Global South countries with significant built environment attributes. This is followed by the data-gathering phase, focusing on collecting available building energy codes and reviewing the implementation and status of Global South countries. The relevant building energy codes, energy efficiency policies and related documents of the selected countries were sourced from various governmental departments, industry professionals, official regulatory bodies and personal communication via email, phone and interviews.

Building energy codes and implementation practices vary significantly amongst countries. Due to the diversity in energy codes within the Global South, challenges arise in evaluating the full impact of the energy efficiency regulations. However, this article aims to highlight the need for energy efficient building regulations in developing countries together with discussions and recommendations on how Global South countries could address the challenges of climate change by implementing energy efficient building strategies or mechanisms.

3. Literature Review

3.1 Definition of the Global South

The Global South is a term occasionally used by scholars and politicians to describe 'economically disadvantaged countries', 'developing countries' or 'third world' countries. These countries include Asia, Africa and Latin America (Hossain, 2006). In 1980, German Chancellor, Willy Brandt published a report identifying a North/South line, also known as the Brandt Line (Vanolo, 2010. The Brandt Report (1980) gave rise to the terms, Global North and Global South, often referring to the richer and more developed nations in contrast to the poorer and more underdeveloped world.

The Global South is also used by academics as a convenient geographical border to identify the world's poor countries lying South of Latitude 30 North, excluding Australia and New Zealand (Rigg, 2015). The geographical delineation is more complicated than the term suggests and it is anticipated to change in the future.

Figure 1 is adapted by the author to illustrate the division between the Global North and Global South using the Brandt Line. The study identified 141 countries that fall within the geographical delineation.

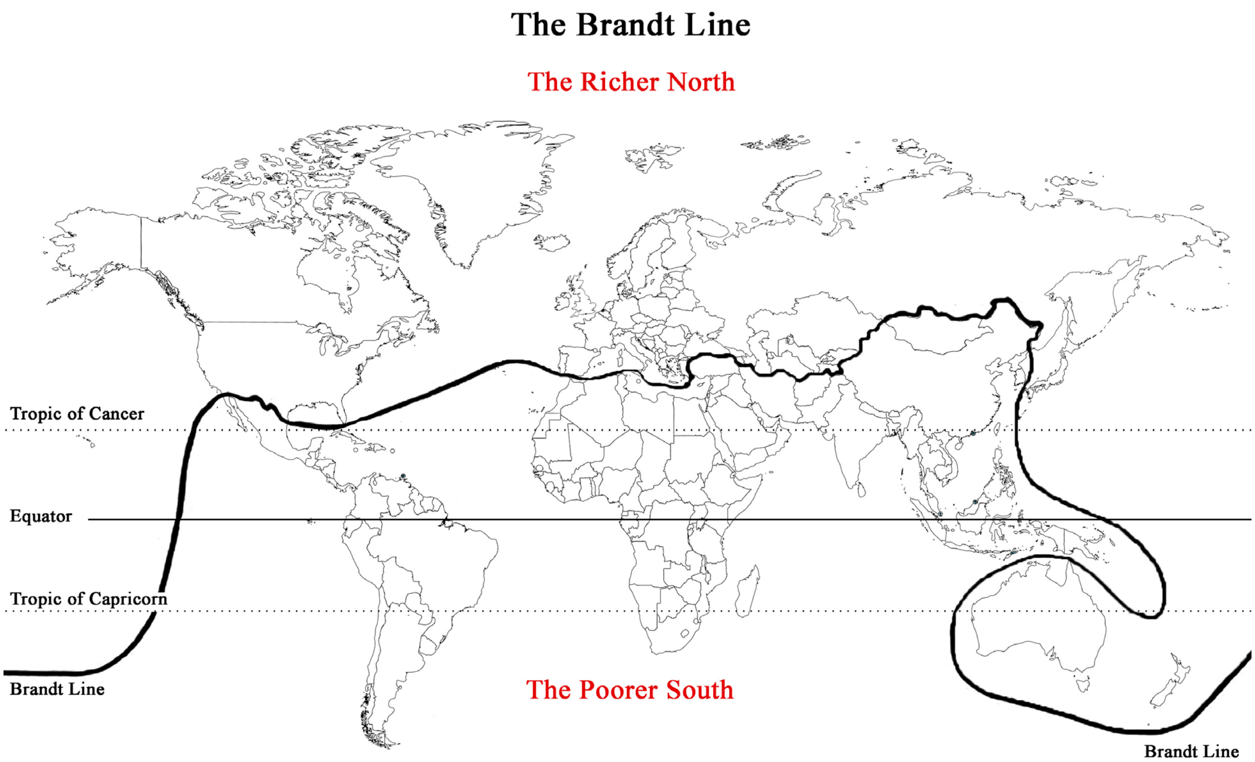

Figure 1 The Brant Line: The Rich North and the Poor South (Author, adapted from Grovers*,* 2016)

In 2015, the Global South Studies Center (GSSC) in Germany approached academics, journals and academic institutions to reflect on the term the Global South. Ming'ate (2015), researcher at the Department of Environmental Studies and Community Development in Kenya states that: "[t]he nations of Africa, Central and Latin America, and most of Asia are collectively known as the Global South. These nations are also referred to collectively as the poor world, the less-developed world, the non-Western world, and the developing countries".

Magallanes (2015), Director of the Institute of Political Studies in Venezuela is of the opinion that: "As underdeveloped countries become more visible, they are frequently referred to under the collective label the *"Global South*". Despite the advantages, this designation offers as a synthesizing term, I consider it ambiguous because it uses a simple geographical criteria to describe a complex social situation which distinguishes poor countries from the wealthiest".

The GSSC research fellow, Schwarz (2015), argues that the Global South is a neutral reference replacing the terms developed and developing countries. Schwarz argues that when using the term, it should be accompanied by an explanation. Dirlik (2015) and Rehbein (2015) state the definition of the Global South may change due to geo-political shifts leading to the re-consideration of which countries are part of the Global South and which are not.

In the context of the article, the Global South is defined as:

> Developing countries with typically poor economic growth that is also referred to as "third world countries", "less developed countries", "underdeveloped countries" and ultimately the "Poor South".

3.2 Climate change in the Global South

The Global South is known for its history of weak institutions, armed conflict, poverty and humanitarian crises. Different countries in the Global South have been trying for decades to overcome and improve their domestic circumstances and now also have to address the effects of global warming (Ortiz, 2016). The complex phenomenon of climate change has both direct and indirect effects on human security and influence the stability of states and communities across the globe. However, the cities and people of the Global South are most vulnerable to the effects of a continuous warming world (Brock, 2012). These are the people who least can afford preparation for future uncertainty.

Vivekananda (2016), an expert in security and climate change states: "Disaster Risk Reduction and climate change adaption in fragile and conflict-affected states in the Global South have long been overlooked, as it is often perceived as too challenging or a lower priority". With the increased impacts resulting from climate change, floods and droughts will gradually become more severe and extreme weather conditions will have an indefinite impact on the Growth Domestic Product (GDP), economy, food, energy and agriculture of each country. Resultantly, existing social hurdles in Global South cities with high population figures of urban poor will be more difficult to overcome (Alam & Rabbani, 2007).

According to the IPCC (2014), Africa has been identified as one of the most vulnerable continents facing climate change. The major contributing factors are the African geography and Africa being one of the hottest continents of the world. It is predicted to warm up to 1.5 times quicker than the global average (IPCC, 2014). Fossil fuel emissions are understood to be the primary source of emission largely being attributed to Africa's growing population (IPCC, 2014).

According to Engelbrecht (2017), chief researcher at the Council for Scientific and Industrial Research (CSIR) states: "Research into how global warming will impact the planet decades into the future; how will this affect South Africa, and will our situation stay the same or get any worse". He argued that the current progression of mitigating climate change is not taking place at a fast enough pace and a 3°C increase in temperature by 2040 could be expected (Engelbrecht, 2017). However, should aggressive implementation action of energy efficiency strategies be implemented as suggested by the Paris Agreement, climate change could still be addressed affectively by the end of the century (Engelbrecht, 2017).

In an attempt to address these challenges, organisations such as the CSIR, National Oceanic and Atmospheric Administration, the UN and the International Institute for Climate and Society are focusing on finding possible solutions for the current and future challenges of climate change. This complex task need to be addressed urgently to achieve global climate change targets.

3.3 Role of energy efficiency regulations

One of the major built environment SDGs highlight the need for sustainable energy services and infrastructure in developing countries, in particular least developed countries. While the use and implementation of building energy codes and standards exist in almost all developed countries, developing countries are slow to introducing such legislation (UNEP, 2009a, 2009b).

Energy efficiency regulations are a set of standards that prescribe the minimum energy performance for buildings or manufactured products. The term energy efficiency should not be confused with sustainability or "green buildings" as the criteria includes renewable materials and embodied energy (Communities, 2010). Typically, energy efficiency only refers to the energy usage and demand of a building.

One of the main objectives for energy codes and standards are to set out minimum requirements for energy efficient design principles and construction processes. Building energy codes specify the construction, performance and consumption of new buildings as well as additions, alterations and renovations. Implementation of these codes can sometimes take place on a voluntary basis however, they are mostly written in mandatory, enforceable language to describe the cost effective energy saving measures and significantly reduce overall built environment energy consumption (Bartlett *et al.*, 2003; Iwaro and Mwasha, 2010).

In context of this article, building energy codes are defined as:

> Guidelines specifying the minimum requirements for design and construction in order to save energy as cost-effectively as possible. These regulations are written regulatory documents that the local government enforce and should be adopted in the design stage of buildings to possibly maximise the potential energy savings (Bartlett *et al.,* 2003).

3.4 The significance Building Energy Codes in the Global South

The incorporation of energy efficient measurers into international standards, national policies, strategies and planning to alleviate climate change impacts are crucial to the development of Global South countries.

According to the UN Environment and IEA's Global Status Report (2017) the global building sector will presumably double in floor area by 2060, adding an additional 230 billion m² worldwide. This increase is equivalent to the current floor area of

Japan being built every single year for the next 40 years, until 2060 (UN Environment and IEA, 2017). Expected growth in building floor area of 63% is predicted for Global South countries (IEA, 2017). Harvey (2014) states: "it is impossible to know what the net effect of increasing building floor area and global extension of the proposed tightening of building codes for new and renovated buildings would have on overall fuel and electricity demand".

The rapid growth in population and purchasing power within developing countries could lead to a 50% increase in energy demand in buildings by 2050 (IEA, 2016). A growth in building floor area is linked to economic growth and the associated increase in energy use of the building sector. The IEA (2016) states 85% of projected growth for global energy demand until 2050 is expected to occur within the Global South. Building energy demand is one of the biggest contributors to the future effects of climate change. The linked building growth is expected to be particularly rapid in Africa and Asia (UN Environment and IEA, 2017). This projected increase is concerning because many countries, especially developing nations are not implementing mandatory building energy efficiency strategies (UN Environment & IEA, 2017).

The 2013 United Nations Development Programme (UNDP) Report indicates rapid economic development could be expected in smaller countries like Bangladesh, Chile, Vietnam, Mauritius, Ghana, Tunisia and Rwanda (UNDP, 2013). This report estimates that by 2030 approximately 80% of the world's middle-class population will be living in the Global South (UNDP, 2013). The rapidly growing Global South cities are housing high concentrations of urban poor being particularly sensitive to climate change and the related vulnerabilities (Alam & Rabbani, 2007).

The UN believes that sustainability, "green buildings" and energy efficient building practices could contribute towards meeting the SDGs of 2030. Therefore, future building and construction processes have to be reviewed. Ideally, the construction of energy-efficient buildings should be promoted, while the energy systems of existing buildings should focus on the reduction of CO_2 and other GHG emissions.

3.5 Lack of Building Energy Codes in the Global South

Building energy codes and regulations of countries in the Global North (developed nations) are widely researched and implemented, whereas similar research in the Global South (developing countries) is almost non-existent.

As mentioned earlier, the IEA (2019) report indicates that in 2019 almost 66,6% of countries worldwide still lacked mandatory building energy codes, as a result it was calculated that approximately 5 billion m² of buildings was built without the necessary energy performance requirements. The enforcement of building energy codes need to include high-performance construction that will increase the current 275 million m² in order to cover the 5 billion m². Further research confirms the implementation of mandatory or voluntary building energy codes are only present in 75 (38,5%) countries globally and of these countries, approximately 45% only have codes that partially cover the building sector (IEA, 2019).

Figure 2 highlights the lack of information and building energy codes in the Global South. It is clear from Figure 2 that most of the developed Nations already have existing mandatory building energy codes with a few countries implementing voluntary standards. It is evident that there is a major lack of information and implementation in Global South countries and this study seeks to address the gap in knowledge.

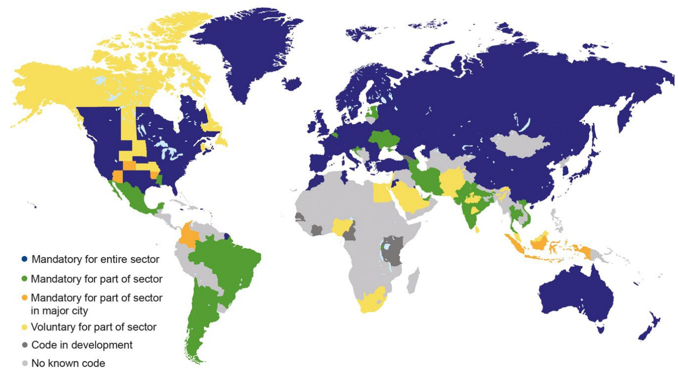

Figure 2 Building energy codes by jurisdiction (Author; adapted from IEA Report, 2019)

The overall performance of buildings, building envelopes, energy efficient designs and construction practices are crucial to the success of the overall sustainable development. A proven method to reduce energy consumption in the built environment is the implementation of building energy codes and standards. However, most countries have not made this a priority and in order to meet SDGs and ambitions within the next decade, all countries need to establish and implement mandatory energy codes (IEA, 2019).

The need to accommodate rapidly growing building sectors, improving thermal comfort and reducing overall energy consumption, specifically in the Global South calls for immediate action and drastic measures to be introduced.

4. Review of pertinent aspects

4.1 Urban population and vulnerability in the Global South

Globally, more than half of the world's population live in urban areas and the continuing growth of the world's population and urbanisation is expected to increase by an additional 2.5 billion people by 2050, with approximately 90% of the increase taking place in Asia and Africa (UN, 2014). Roughly two-thirds of the world's population is projected to live in urban areas by 2050, with the greatest growth expected in China, India, Africa and other developing economies (UN DESA, 2018). India, China and Nigeria are expected to account for 37% of the world's total urban population by 2050 (UN DESA, 2018).

Urban areas currently account for 67 – 76% of the total global energy consumption and 71 – 76% of CO_2 emissions derived from fossil fuels (Seto *et al.,* 2014). A study by the IEA suggest that the largest increase in CO_2 emissions from energy use will be from developing countries (IEA, 2008). It is expected that the expansion of urban areas could increase the total energy use intensity, GHG emissions and economic activity that would contribute towards the effects of climate change (Seto, Güneralp and Hutyra, 2012; UN DESA, 2012). Should the proposed and current energy saving systems been implemented already, it is estimated that the primary energy demand would have reduced from 70% in 2013 to 66% in 2050 (IEA, 2016).

Urbanisation across international borders is seen as an important driver in poverty reduction. This is especially true for immigrants coming from countries with a low GDP and Gini coefficient. In contrast, the unplanned and rapid growth of urban population in the Global South could adversely affect existing development and infrastructure of developing countries (UN, 2014). Therefore, it is important to highlight the need for sustainable urban energy paths and indicate the importance of meeting global low-carbon targets within the built environment (IEA, 2017).

4.2 Impact of CO_2 emissions on the built environment and the Global South

Unfortunately, policy makers see the global issue of climate change as confrontational, with the debate of also becoming one between the Global North and the Global South. In the Global North, the average carbon emission per capita is about five times more than in the Global South (Gosh, 2009). This gap is expected to narrow with developing countries requiring increased access to adequate housing, electricity and wealth. The expected rapid growth of the future urban population of the Global South and associated increased use of energy will increase the CO_2 emissions from related fossil fuels and power generation. Currently, approximately 40% of the total global CO_2 emissions originate from energy use by the building sector (IEA, 2020; IEA & UNEP, 2018; UNEP, 2016).

The future energy requirements of the aforementioned trend will significantly impact on the origin and method of providing energy for urban areas (IPCC, 2014). The effect of the expected rise in floor area and income per capita will lead to an increase of double or perhaps even triple the current energy use and related emissions by 2050 (IEA, 2016)). All of the above taken into consideration, the building sector is becoming less likely to meet future climate change targets in addition to fulfilling potential goals set out by the SDGs and the Paris Agreement.

It should be priority for developing countries to establish and implement new sustainable building strategies, taking urbanisation trends into account. Energy efficient systems and renewable energy technologies should form an integral part of the future building sector, ultimately reducing energy consumption and lowering levels of GHG emissions.

4.3 Distinctive climate zones in the Global South

The Köppen-Geiger Climate Classification system was developed by the German botanist-climatologist Wladimir Köppen, arguing native vegetation bests defines climates. The map was first published in 1884 with subsequent revisions by German climatologist Rudolf Geiger in 1940 (Kottek *et al.,* 2006). A group of scientists from Australia and Germany updated the Köppen-Geiger Climate Classification to the first digital world map (Belda *et al.*, 2014).

Using a large global data set of long-term monthly precipitation and temperature measurements, the Köppen-Geiger map is divided into five major climatic zones with each type represented by a capital letter (A – E) and 31 climate types. The major climatic types are then further sub-divided based on precipitation (second capital letter) and temperature (third lower case letter) as seen in Figure 3 (Kottek *et al.*, 2006). The detailed Köppen-Geiger map is widely used by researchers across various disciplines as a basis for assessing the output of global climate models (Peel, Finlayson & Mcmahon, 2007).

The worlds various climate zones can be derived from the Figure 3, adapted by the author from the Köppen-Geiger climate classification (Kottek *et al.*, 2006) for background into the North/ South delineation, illustrating the various climatic zones above and below the defining line.

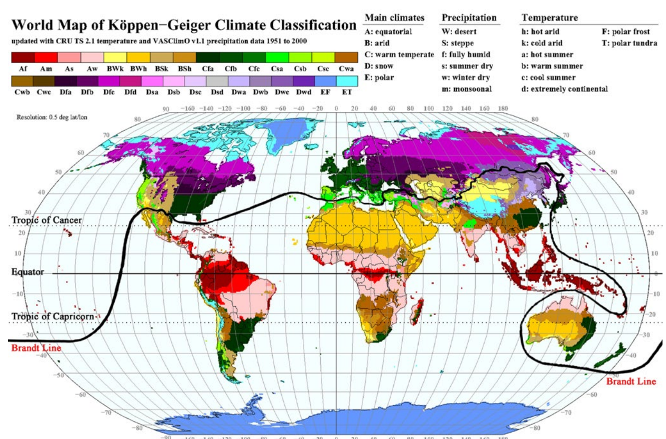

Figure 3 World Map of Köppen-Geiger Climate Classification (Author, adapted from Kottek *et al.,* 2006)

The Köppen-Geiger identifies five distinctive climate zones, namely: Equatorial, Arid, Warm Temperature, Snow and Polar. The map indicates most Global South countries have similar climatic zones, with the exception of China and small parts in South America. Except for the Polar climate zone all other distinctive climate zones are represented within countries present in the Global South.

5. Data and research study area

5.1 Selection criteria for data collection

The selection of countries were determined by the comprehensive literature review on the contribution, significance and role of building energy codes in the Global South to determine their relationship with climate change. The research reveals three major components that contribute to the effects of climate change namely; future urban population, carbon emissions and distinctive climate zones. These components became significant in the selection criteria because the impact of climate change is projected to increase should no drastic energy strategies be implemented.

After identifying the different countries from the selection criteria, a comprehensive investigation was conducted on each of the 61 countries building regulations and regulatory codes based on the issues surrounding climate change. This article illustrates the major gap in knowledge regarding built environment energy efficiency policies and makes recommendations towards future studies focusing on possible best practice guidelines and implementation strategies for Global South countries.

5.2 Sampling size and the level of representation on the population

The sampling size was determined by the aforementioned criteria being the three major components contributing towards climate change namely; 2050 urban population, carbon emissions and distinctive climate zones. Current definitions of the Global South (and the 141 countries included in the Brandt delineation) are largely based on opinion and geopolitical aspects.

5.2.1 Criteria 1: Urban Population in 2050

It is generally accepted that Global South countries with the highest 2050 urban population will be the biggest energy consumers with resultant GHG emissions and impacts on climate change (Seto, Güneralp & Hutyra, 2012). For the purpose of this study, it was important to target these countries specifically.

Countries with an urban population of 19.3 million or greater in 2050 was included in this study as it represents approximately 91% of the Global South's 2050 urban population and 75% of the World's 2050 urban population.

Using this delimitation, 49 of the 141 (34, 8%) Global South countries fall within the selected criterion. Table 1 identify and list the selected countries and the respective urban population projected for 2050.

5.2.2 Criteria 2: Total CO_2 emission contribution

Countries with high CO_2 emission rates contribute significantly to climate change, making this one of the inclusion criteria. Using the information obtained from the COP 21 agreement (UNFCCC, 2016) the 49 countries identified in Table 2 represent 97.3% of the Global South's CO_2 emissions and 51.5% of the world's total CO_2 emissions.

Countries in the Global South with significant CO_2 emission are ranked accordingly. The 49 highest CO_2 emitters are compared against the previous identified 49 countries with highest 2050 urban population, as listed in Table 1.

Table 2 identify and list the 49 countries with the highest CO_2 emission rates while highlighting the countries not appearing in Table 1.

Table 1 Global South countries with an Urban Population ≥19.3 Million (UN, 2018)

Rank	Country	Urban population 2050 (Total Million)
1	China	1 014,5
2	India	834,0
3	Nigeria	275,5
4	Indonesia	227,9
5	Brazil	211,7
6	Pakistan	176,4
7	Mexico	141,9
8	Congo (DRC)	119,3
9	Bangladesh	112,4
10	Egypt	86,8
11	Philippines	85,1
12	Turkey	80,0
13	Iran, Islamic Republic	78,5
14	Tanzania	73,2
15	Ethiopia	71,8
16	Iraq	63,6

Table 2 Countries in the Global South with the highest level of CO_2 emissions (UNFCCC, 2016)

Rank	Country	CO_2 Emissions (Gg CO_2 Equivalent)
1	China	7 465 862
2	India	1 523 767
3	Brazil	923 544
4	Korea,	688 300
5	Mexico	632 880
6	Indonesia	554 334
7	South Africa	544 314
8	Iran, Islamic Republic	483 669
9	Turkey	459 102
10	Sierra Leone	365 107
11	Argentina	332 499
12	Kenya	313 442
13	Saudi Arabia	296 060
14	Cote d'Ivoire	271 198
15	Vietnam	266 049
16	Ecuador	247 990

17	Vietnam	59,2
18	South Africa	57,8
19	Argentina	52,3
20	Angola	48,5
21	Algeria	47,2
22	Thailand	46,9
23	Colombia	46,2
24	Korea (South)	44,2
25	Kenya	41,9
26	Sudan	40,0
27	Saudi Arabia	40,0
28	Venezuela	38,2
29	Cote d'Ivoire	36,4
30	Ghana	36,1
31	Peru	35,9
32	Malaysia	35,8
33	Cameroon	34,9
34	Myanmar	34,2
35	Uganda	33,9
36	Morocco	33,8
37	Mozambique	33,3
38	Madagascar	29,6
39	Afghanistan	28,1
40	Mali	26,5
41	Yemen	26,1
42	Syrian Arab Republic	24,3
43	Niger	24,2
44	Zambia	23,9
45	Burkina Faso	22,5
46	Somalia	20,7
47	Senegal	20,6
48	Uzbekistan	20,2
49	Korea (North)	19,3

17	Thailand	236 974
18	Nigeria	212 444
19	Uzbekistan	199 837
20	United Arab Emirates	195 308
21	Malaysia	193 397
22	Egypt	193 238
23	Venezuela	192 192
24	Cameroon	165 725
25	Pakistan	160 589
26	Colombia	153 885
27	Philippines	126 879
28	Algeria	111 023
29	Bangladesh	99 442
30	Chile	91 576
31	Korea (North)	87 330
32	Peru	80 591
33	Syrian Arab Republic	79 070
34	Turkmenistan	75 409
35	Iraq	72 658
36	Zimbabwe	68 541
37	Sudan	67 840
38	Angola	61 611
39	Qatar	61 593
40	Morocco	59 700
41	Azerbaijan	48 209
42	Ethiopia	47 745
43	Singapore	46 832
44	Bolivia	43 665
45	Tanzania	40 506
46	Tunisia	39 342
47	Myanmar	38 375
48	Cuba	36 340
49	Ghana	33 660

Table 2 identified 12 countries not included in the list of highest Global South 2050 urban populations. However, the identified countries contribute significantly to CO_2 emissions and it becomes necessary to include these in the final list.

The following 12 countries are added to the previously identified 49 countries: Azerbaijan, Bolivia, Chile, Cuba, Ecuador, Qatar, Sierra Leone, Singapore, Tunisia, Turkmenistan, United Arab Emirates and Zimbabwe. This increased the total to 61 of the available 141 (43, 3%) Global South Countries, falling within the selected criteria.

5.2.3 Criteria 3: Distinctive climate zones

The distinctive climate zones in the Global South carries significant value due to specific climate conditions. Research indicates that the distinctive climate conditions of some countries could possibly lead to an increase in drought, heat waves, excessive flooding and storms (IPCC, 2018). Resultantly, communities who are not resilient to this will be destroyed, devastated and even poorer than they currently are.

This article deems it important to also use the Köppen-Geiger Climate Classification as part of the selection criteria in order to ensure that all possible climate zones are included within the study. In this article, the selected countries in the Global South represent all distinctive climate zone set out by the classification, with the exception of the Polar Climate zone.

According to the Fragile Planet Report of the Hong Kong and Shanghai Banking Corporation (HSBC) (2018), the following countries are amongst the list of most vulnerable to the effects of climate change and extreme weather conditions: India, Pakistan, Philippines, Bangladesh, Mexico, Kenya, South Africa, Thailand and Vietnam. All of the identified countries with distinctive climate zones are already included in the current list of 61 countries.

5.3 Data analysis of study area

A graphical summary of the selection criteria mentioned above is presented in Figure 4. This provides a comprehensive view of the 61 countries included in the study using a geographical representation. After finalising the selected countries using the identified criteria, the building energy codes were traced for each country. This was done to establish the current implementation status of building energy codes in each country.

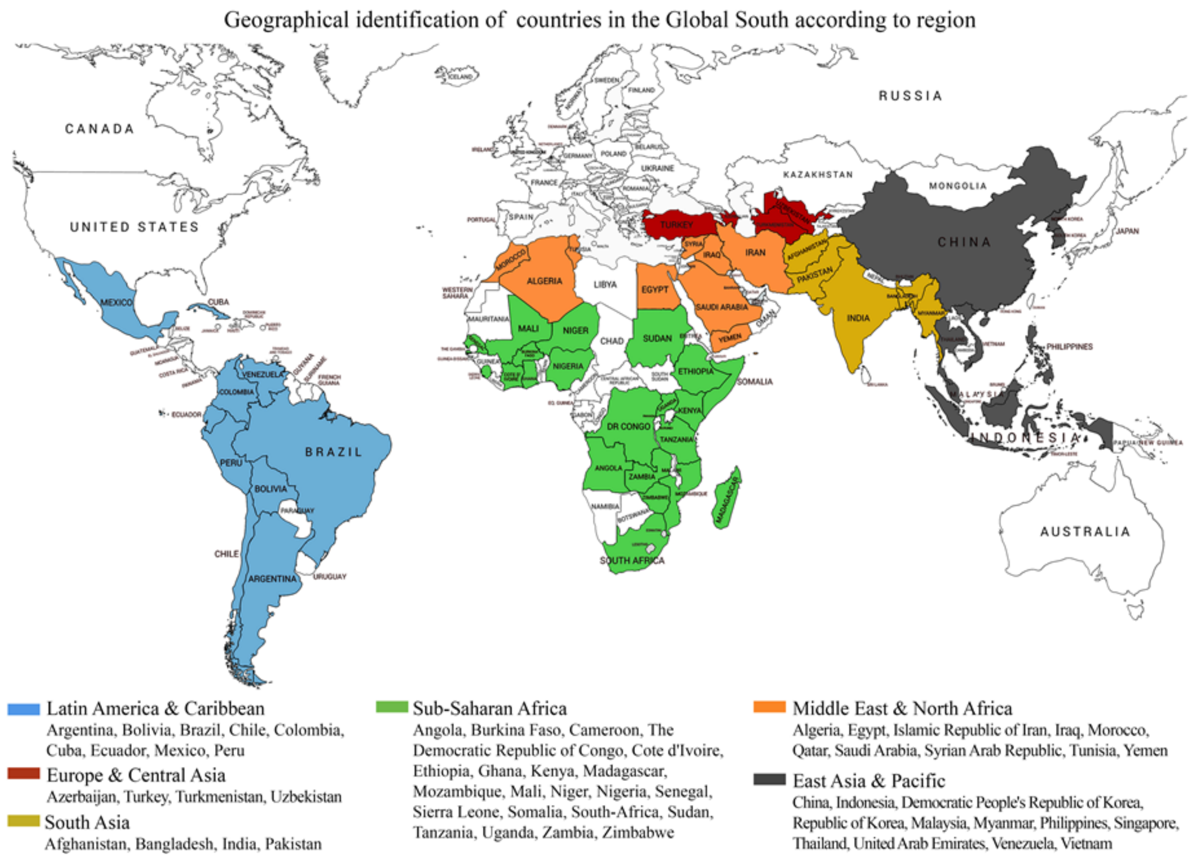

Figure 4 The final nominated countries in the Global South by region (Author, 2021)

The research methodology employed to source relevant information on the energy efficient building regulations of the 61 Global South Countries, included:

- Extensive library searches and various web engines were used find publically available data.
- Architectural associations, organisations and related government institutions from each country were listed and contacted to obtain documents not available to the public.
- Individual Architectural firms were contacted for further assistance on countries where information or documentation was still outstanding.
- The relevant regulations, policies or energy efficient strategies were grouped into the following 4 categories: Mandatory, Voluntary, non-existent and no information available.
- The official language of each country posed significant challenges and required many of the documents to be translated. However, this was made possible with the assistance of google translate, fellow colleagues and foreign students from the institution

After analysing the documentation obtained on building energy codes of the 61 countries, the data was categorised accordingly. This process identified countries without building energy codes, whether voluntary or mandatory. The existing building energy codes were further analysed to arrive at a final number of Global South countries with and without building energy codes. Ultimately defining the current implementation status of building energy codes on the Global South. The information was collated in different charts with graphical illustrations.

The data was processed using Microsoft Excel® (Microsoft Office® Professional Plus 2016) software program to present the statistical graphics. The Geographical Maps were created to add perspective to the countries locations by using the online platform *MapChart* and Adobe Photoshop Pro.

6. Findings and Discussion

This section of the article presents the analysis and discussion of the findings of the study.

6.1 Implementation status of building energy practices in 61 Global South countries

This section of the article focuses on the results obtained from the 61 Global South countries, implementation status of their respective energy efficiency building codes or standards and the contribution to alleviating global climate change impacts.

The primary objective is to identify countries in the Global South with mandatory building energy codes and highlight countries that do not implement energy efficiency building regulations. Table 3 below indicates the status of energy efficiency regulatory building practices in the 61 Global South countries, including the possibility of passive design principles and whether enforcement of building energy codes take place on a mandatory, voluntary or non-existent basis.

Table 3 Status of Energy Efficiency Building Codes for the top 10 African countries (Author, 2021)

No	Country	Energy Efficiency Building Code (EEBC)	EEBC Status		Passive Principles	Voluntary
			Mandatory	None		
1	Afghanistan	None	–	✓	–	–
2	Algeria	Technical Regulations Document (DTR C 3-2)	✓	–	✓	
3	Angola	None	–	✓	–	–
4	Argentina	National Programme for Rational Use of Energy and Energy Efficiency (Decree 140/2007)	–	✓	✓	✓
5	Azerbaijan	Town Planning and Construction Code of the Republic of Azerbaijan 2012	✓	–	✓	–
6	Bangladesh	Bangladesh National Building Code 2015	✓	–	✓	–
7	Bolivia	Bolivian Construction Regulations 2012	–	✓	✓	–
8	Brazil	Quality Technical Regulation for the Energy Efficiency Level of Buildings commercial, Services and Public 2010	✓	–	✓	✓
9	Burkina Faso	Burkina Faso Code of urban planning and construction, Law No. 017-2006	–	✓	–	–
10	Cameroon	None	–	✓	–	–
11	Chile	General Ordinance of Urbanism and Construction 2017	✓	–	✓	–
12	China	GB-50189:2014	✓	–	✓	–
13	Colombia	Colombian Construction Regulations for Earthquake resistance 2010	–	✓	✓	–
14	Congo (DRC)	No Information				
15	Cote d'lvoire	None	–	✓	–	–
16	Cuba	Caribbean Uniform Building Code 1985(CUBiC)	–	✓	–	–
17	Ecuador	Ecuadorian Standard of Construction energy efficiency in residential buildings 2018	✓	–	✓	–
18	Egypt	Residential Energy Efficiency Building Code 2011 (EEBC)	✓	–	✓	–
19	Ethiopia	Ethiopian Building Code Standard 2013	–	✓	✓	–
20	Ghana	Ghana Building Code (GS1207: 2018)	✓	–	✓	–
21	India	Energy Conservation Building Code 2016 - 2017	✓	–	✓	–
22	Indonesia	Indonesian National Standards *(SNI 03-6389-201; SNI 03-6390-2011; SNI 03-6197-2011;SNI 03-6196-2011)*	✓	–	✓	–
23	Iran, Islamic Rep	Code Number 19 - 2001	✓	–	✓	–
24	Iraq	None	–	✓	–	–
25	Kenya	Building Code of the Republic of Kenya 2009	–	✓	✓	–
26	Korea (North)	No Information				
27	Korea (South)	Building Design Criteria for Energy Saving 2008(BDCES)	✓	–	✓	
28	Madagascar	All Building Works of Madagascar	–	✓	–	–
29	Malaysia	Code of Practice on Energy Efficiency for non-residential Buildings 2014 (MS1525)	✓	–	✓	–
30	Mali	None	–	✓	–	–
31	Mexico	Energy conservation code for Buildings of Mexico 2016	✓	–	✓	–
32	Morocco	General Construction Regulations 2014	✓	–	✓	–
33	Mozambique	General Regulations 1976	–	✓	–	–
34	Myanmar	Myanmar National Building Code 2016	✓	–	✓	–

35	Niger	No Information				
36	Nigeria	National Building Energy Efficiency Code 2017	✓	–	✓	–
37	Pakistan	Building Energy Code of Pakistan 2011	✓	–	✓	–
38	Peru	National Building Regulations 2006	–	✓	–	–
39	Philippines	The Philippine Green Building Code 2015	✓	–	✓	–
40	Qatar	Qatar Construction Specification 2014	✓	–	✓	–
41	Saudi Arabia	Saudi Building Code Energy Conservation Requirements 2007 (SBC 601)	✓	–	✓	–
42	Senegal	No 2009-1450 the Regulatory Part of the Town Planning Act	–	✓	–	–
43	Sierra Leone	The National Building Control Regulations 2015	–	✓	✓	–
44	Singapore	Code for Environmental Sustainability of Buildings 2012	✓	–	✓	–
45	Somalia	No Information				
46	South Africa	South African National Standard (SANS) 10400:2011 & SANS 204:2011 Energy Efficiency	✓	–	✓	–
47	Sudan	General Building Regulations 2008		✓	✓	–
48	Syrian Arab Rep	New Arab Building Energy Code 2010	✓	–	✓	–
49	Tanzania	Urban Planning and Space Standards Regulations 2011; Urban Planning Act 2007	–	✓	–	–
50	Thailand	Building Energy Code 2009 *(Volume 126, Part 12A - Building's area from 2000 m²)*	✓	–	✓	–
51	Tunisia	Tunisia Thermal Building Regulation 2009	✓	–	✓	–
52	Turkey	Thermal Insulation for Building 2008 (TS 825) & Regulation of energy performance of buildings 2010 (Bep-TR)	✓	–	✓	–
53	Turkmenistan	SNT 3.04.03-94 Residential Buildings; SNT 2.03.10-2001 Roofs and Roofing; SNT 2.01.01-98 Building Climatology; SNT 2.01.03-98 Building Thermal Engineering	✓	–	✓	–
54	Uganda	Building Control Regulations 2012	–	✓	✓	–
55	United Arab Emirates	Abu Dhabi International Building Codes 2013	✓	–	✓	–
56	Uzbekistan	No Information				
57	Venezuela	General Specifications for Buildings		✓	–	–
58	Vietnam	National Technical Regulation on Energy Efficiency Buildings 2013	✓		✓	
59	Yemen	None	–	✓	–	–
60	Zambia	No Information				
61	Zimbabwe	Model Building By-Laws 1997	–	✓	–	–
		STATUS OF IMPLEMENTATION STRATEGIES	*31*	*24*	*39*	*2*

The following section explains the preliminary findings on the current status of building energy codes of the 61 countries in the Global South.

After analysing the respective building energy codes, research indicates that 51% (31 out of 61) of the selected countries in the Global South implement mandatory building energy codes and currently only 3% of the countries, namely; Argentina and Brazil have voluntary standards.

However, it is concerning that 39% of the countries do not have any form of building energy codes or policies. This while only 31 out of 61 Global South countries with the implementation of either mandatory (49%) or voluntary codes (3%) are working towards overcoming the effects of climate change by developing strategies to achieve a more resilient sustainable environment. This represents approximately half of the countries that are responsible for climate change, emitting 33% of the GHG emissions originating from the Global South.

After extensive research and various data collection methods employed, the lack of information on 6 out of 61 (10%), countries suggest the absence of building energy codes or related policies. This while it is most likely that voluntary building energy codes will eventually become standard practice as the necessary energy efficiency policies are already proposed is some of the documents. An example of this include the current energy efficiency regulations of Brazil that only partially covers federal public buildings with voluntary codes for the remaining commercial and residential sectors.

From the analysis it is evident that many of the countries do not have building energy codes. Though, it is noted that most of the countries implement standard building regulations and that 39 out of 61 (63%) countries recommend the use of passive principles. However, the implementation of passive strategies alone are not enough to fulfil 2050 climate change targets, the SDGs or the Paris Agreement objectives for the built environment.

The current global climate change crisis requires policy maker to address the need for extensive energy efficiency measures, supporting long-term sustainable building practises.

6.2 Summarised results

To simplify and summarise the status, extent and implementation of building energy codes the previous 4 categories were combined into 2 simple groups, namely; mandatory and non-existent.

Figure 5 is a graphical representation of the summarised results showing the extent of mandatory versus non-existent building energy codes. This represent the availability, implementation and lack of energy efficiency policies in the built environment and identify possible research gaps. This is followed by analysing and discussing the relevant results.

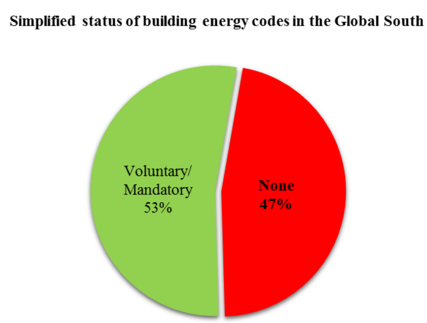

Figure 5 Graphic summary of the combined data from countries in the Global South (Author, 2021)

The combined data revealed 53% of the selected countries are implementing mandatory and/or voluntary building energy codes, while 47% of the selected countries do not implement or address energy efficiency through building energy codes.

Although more than half of the Global South countries implement some form of building energy code, it is clear from the chart that there is still a major gap in the implementation of codes and the overall knowledge regarding the effects of climate change on the built environment, regulations and its associated responsibilities. As a result the 30 developing countries, 47% forming part of the study are without instruments addressing energy consumption in the built environment and risk becoming more exposed to the effects of climate change.

6.3 Geographical results

The presentation of geographic data enables the reader to analyse and interpret data from a spatial perspective. Figure 6 illustrates the geographical implementation status of building energy codes in the selected 61 Global South countries.

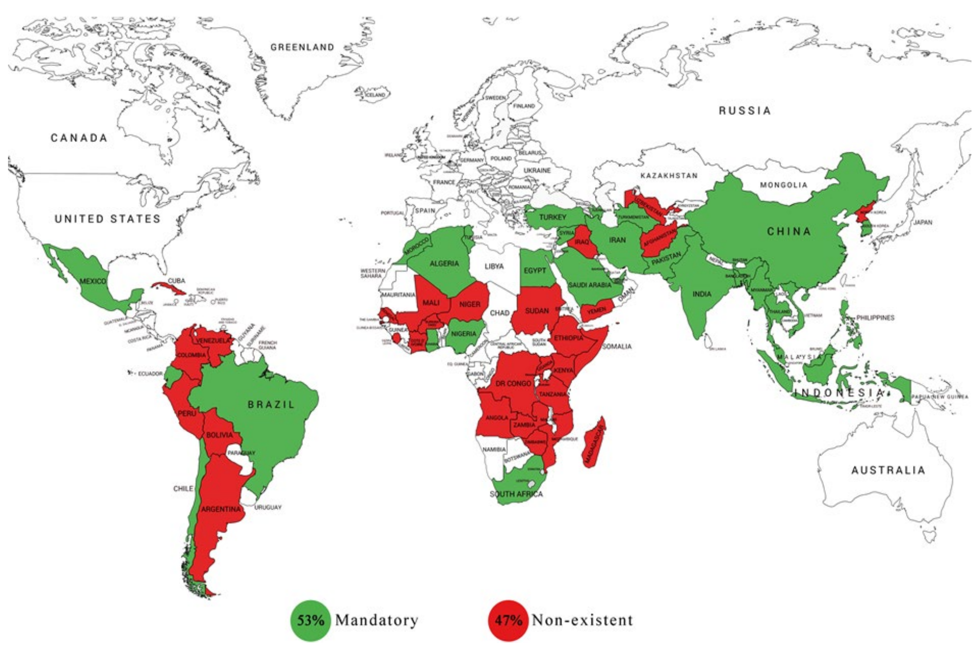

Figure 6 Combined status of building energy codes in the selected Global South countries (Author, 2021)

Further analysis on the geographical result from Figure 6 point towards a major lack of information or implementation of building energy codes on the African continent with the exception of Algeria, Egypt, Ghana, Morocco, Nigeria, South Africa and Tunisia. Currently 73% (19 out of 26) of African countries included in the study do not have any building energy codes or related information available. This could be due to African countries being more underdeveloped than the rest of the Global South. As stated earlier, countries in Africa are most at risk when facing the results of climate change, especially global warming.

In Latin America and the Caribbean, only 4 out of 10 countries (40%) have building energy codes. This indicates the disregard of more than halve of the continents countries to the impacts of climate change and their resultant consequences. The study suggests that Cuba, Peru, Bolivia and Argentina ungently adopt regulations from neighbouring countries as a foundation for draft policy implementation.

The graphical representation from Figure 6 clearly demonstrates the efforts from Asia and the Middle East in supporting sustainable building practices, with 80% of countries on the continent implementing mandatory building energy codes. Furthermore, studying recent trends in Asia suggest the rapid development of energy efficient building strategies for countries without mandatory energy codes are beyond doubt.

Although the majority, 53% of countries in the Global South are implementing some form of building energy code, it is evident that there is a general lack of implementation, enforcement and knowledge of such codes and their related practices. It is still concerning that nearly halve, 47% of the Global South countries have not made any efforts toward implementing energy efficiency strategies in the built environment.

7. Conclusions and recommendations

The effective implementation of building energy codes are essential mechanisms in creating sustainable, low-carbon and energy efficient built environments for the future. In light of the current global climate change crisis, this article set out to establish the implementation status of building energy codes in pertinent Global South countries to magnify the need for built environment mitigation strategies.

The literature review identified the selection criteria by identifying countries contributing significantly to climate change. The desk study included a detailed review of current CO_2 emissions, 2050 urban population figures and distinctive climate zones in the Global South, ultimately identifying 61 countries for inclusion in the study. Research commenced on the 61 Global South countries, identifying those with or without building energy codes in an attempt to magnify the lack of energy efficiency policies and provide a global perspective of the issue. The research established a large percentage, nearly half (47%) of Global South countries are not addressing the issues of climate change through the use and implementation of building energy codes. This situation is exacerbated on the African continent, where 73% of the selected African countries are not addressing energy efficiency through built environment regulatory policies. The resultant impacts causing irreversible climate damage, continuous rise of global average temperatures, increased poverty and the increase in droughts, floods and other extreme weather conditions. These findings are of great concern, seeing that Global South countries, specifically the African continent are most at risk when facing climate change impacts.

The uniqueness of this study lies in the contribution of new knowledge, addressing limited research on the theme and the limited information available on building energy codes in the Global South. This paper presents the first published evidence by identifying existing building energy codes in the Global South. This paper also attempts to create awareness on the lack of climate change policies in the built environment, thereby providing information to government organisations, relevant stakeholders and decision makers on the importance of achieving built environment climate change targets through the adaptation, implementation or development of building energy codes.

It is suggested that Global South countries develop some form of building energy code to reduce the impact of climate change globally. Countries without energy codes are encouraged to implement or adopt available building energy codes with associated climatic regions. On the African continent, the following countries; Mali, Niger and Sudan could consider the application of energy efficiency regulatory practices from Algeria and Egypt displaying similar climatic conditions. The use of draft polices derived from the Brazilian and Nigerian energy efficiency codes are also suggested for the Democratic Republic of the Congo, Uganda and Côte d'Ivoire.

However, further in-depth studies on policy adaptation is required to determine the accuracy of climate specifications, overall contribution to 2050 climate targets, the SDGs and alignment with global climate change initiatives.

8. Future Research Studies

Further research studies are recommended to identify the specific criteria necessary for the development and implementation of sufficient global best practices models by countries not currently implementing any energy efficient building regulations. It is also suggested that future studies investigate pledges made by individual governments and relevant stakeholders on the 2050 climate change targets, Paris agreement objectives and their probability of achieving the SDGs of 2030.

These studies could provide countries with the necessary information to develop, adapt or revise current built environment energy efficiency strategies to mitigate climate change and reach targets by 2050. Subsequently, this will assist with increased implementation of building energy codes globally, reducing CO_2 emissions and ultimately creating more sustainable building practices.

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