

INTEGRATING ENVIRONMENTAL SUSTAINABILITY AND DISASTER RESILIENCE IN BUILDING CODES

Naveed Anwar,

Executive Director, AIT Consulting, Asian Institute of Technology

E-mail: nanwar@ait.asia

Adnan H Aliani,

Chief, Sustainable Urban Development Section

United Nations Economic and Social Commission for Asia and the Pacific

E-mail: aliani.unescap@un.org

Wathanyu Amatyakul

Researcher, Asian Institute of Technology

E-mail: wathanyu@ait.asia

Abstract

The planning, design, construction and operation of buildings are governed by building codes. Not all countries in Asia and the Pacific have a native building code and countries that do have a code often struggle with low compliance rates. Improving building code quality and enforcement could help cities improve their environmental sustainability and disaster resilience. To address this issue, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the Asian Institute of Technology (AIT) conducted a joint study to gain an overview of the current status of integration of disaster resilience and environmental sustainability in building codes in the Asia-Pacific region and to document a series of good practices, showing a range of incentives for building code stakeholders in this region to further integrate these elements in their work. The findings of the study reveal that environmental design is a relatively new element in building codes in developing countries and is therefore often not well integrated. With regards to disaster resilience, some hazards have been addressed reasonably well. Resistance against earthquakes, storms and typhoons, for example, has been integrated in many codes analyzed. Some of the incentives to integrate environmental design and disaster resilience in building codes includes fiscal, financial and zoning. Three methods have been identified through which building codes can be implemented effectively. Improving the building code is going to have a greater impact as building growth is expected to be higher in this region.

Keywords: Environmental Design, Disaster Resilience, Resilient Buildings, Enforcement of Building Codes, Good Practices of Building Code Enforcement

1. Introduction

1.1 Background

Buildings constructed today are likely to dictate city and town development and consumption patterns for the next 20 to 30 years. The way we design, build and maintain our buildings will influence the sustainability of a city and the health and safety of its inhabitants for decades to come. Therefore, a lot of problems cities are coping with can be addressed by using and enforcing building codes. Disaster resilience, energy efficiency and prevention of diseases are all issues that are influenced by building codes.

Resilience to earthquakes, for example, is very much linked to construction. In earthquakes of approx. the same strength, 2 people died in California (USA, 2003), while 41,000 people lost their lives in Bam (Iran, 2004). Experts agree that most of this difference is attributable to the high standards of earthquake safety that California sets in its building code. In other words, many lives could have been saved by implementing and enforcing better building codes. The same is true for extreme weather events like cyclones and hurricanes, which are likely to occur more often with climate change; much of the destruction this will cause can be prevented by constructing safer buildings.

For environmental issues, buildings are extremely important, too. Buildings consume energy in all phases of their lifecycle. Designing and constructing buildings that use resources efficiently is one of the best ways to address sustainability in a city. By incorporating disaster resilience and environmental design in the building codes, buildings in the future can be more people and environment friendly. This will decrease the carbon-footprint of cities and their impact on the environment, while increasing people's quality of life.

Most of the cities in the Asia-Pacific region are experiencing rapid urbanization. To accommodate these people many buildings will be built in these cities in the coming years. Building growth is expected to be higher in the developing cities in Asia as it is less developed compared to developed cities in the world. In many of these developing Asia-Pacific countries, buildings are not built in an environmental friendly manner as building codes do not take into account environmental issues and some of these countries don't also have a building code, or have codes with very low compliance rates. Therefore, improving the building codes of these developing countries will have a greater impact as more building growth is expected to be higher in this region.

1.2 Research Objectives

The overall research objective is to identify elements of environmental sustainability and disaster resilience both vertically (across government levels) and horizontally (across construction sectors) in codes that govern planning, design and construction of buildings in urban areas that can be integrated into building codes in developing countries in the Asia-Pacific region. The specific objective of this research is to gain an overview of current integration of

environmental sustainability and disaster resilience in building codes and building code compliance in the Asia-Pacific region, challenges and strategies in building code enforcement and to identify good practices in enforcing building codes.

2. Research Design

2.1 Methodology

The methodology used for this study is briefly mentioned below.

1. Identify Reference and Target Country

The main objective is to review building codes of countries that are known to have integrated environmental sustainability and disaster resilience in their building codes and to identify elements of environmental sustainability and disaster resilience in these codes that can be integrated in building codes in developing countries in the Asia-Pacific region. Thus, the first step involves identifying countries that are known to have integrated environmental sustainability and disaster resilience in their building codes. These countries will serve as the reference countries. In addition, developing countries in the Asia-Pacific region was identified that are known to have poor building codes; these will serve as the target countries.

2. Develop Analytical Framework

The building codes of the reference and target countries were reviewed to determine the elements of environmental sustainability and disaster resilience. An analytical framework was developed that will determine the integration of the elements of environment sustainability and disaster resilience for the reference and target countries.

3. Analyze the Building Codes

The building codes of the reference and target countries were analyzed based on the analytical framework that was developed in the previous step.

4. Integrate Environmental Sustainability and Disaster Resilience in Building Codes

Based on the analysis, the element of environmental sustainability and disaster resilience that has been integrated in the building codes was compared among the reference and target countries. The elements of the building codes from the reference countries that can be integrated into the building codes of the target countries were identified.

5. Organize Expert Group Meeting to Identify Challenges and Strategies in Building Code Enforcement

Even though there are building codes, in some of the developing countries, the building code is not having any value in the ground reality as developers and designers are not complying with the codes. To make the building code effective, the code has to be enforced. To identify the challenges and strategies in enforcing building code the researchers organized an expert group meeting.

6. Identify Good Practices in Enforcing Building Codes

To make the building codes effective, it has to be enforced. Through literature review and through the Expert Group Meeting good practices were identified in enforcing building codes.

2.2 Analytical Framework

Building codes can be used to regulate many different aspects: structural strength, accessibility, health, safety, etc. These regulations are integrated in technical provisions, which are grouped in categories. Categories used differ from country to country; for the purposes of this research, the following categorization was used:

1. Structural Design
2. Building Materials
3. Buildings and Services (including building envelope, lighting, ventilation, heating, air-conditioning, and electrical, mechanical and energy systems)
4. Plumbing (including sanitary, water and waste treatment)
5. Fire Prevention
6. Landscaping
7. Construction practices

For the scope of this research project, the only prescriptions that will be analyzed are those that address environmental sustainability and disaster resilience. These can be grouped under any of the above categories. For environmental sustainability for example, prescriptions minimizing water loss may appear under 'plumbing', while rules prohibiting the use of energy intensive appliances would be grouped under 'buildings and services'. For this research the six categories were identified for environmental sustainability.

1. Material Conservation & Resource Efficiency

This element deals with the need to minimize the amount of resources used, to increase the use of environmentally friendly materials.

2. Energy Conservation & Efficiency

This element includes regulations aiming to minimize energy use and maximize the use of renewable energy sources.

3. Water Conservation

This element includes prescriptions that minimize water use both within (e.g. water conserving fixtures) and around the house (e.g. water retention facilities)

4. Soil & Land Conservation

Regulations related to this element include those trying to avoid wind erosion of the land surrounding the building.

5. Solid Waste Reduction

Building codes can address solid waste reduction both during construction (construction waste) and during use (household waste).

6. Air Pollution Control

This element deals with the potential of buildings to minimize air pollution, for example by using environmentally friendly building materials or by building green roofs and using plants around the building.

For a building code to have integrated environmental sustainability well, it should address all six categories. However, some issues may be more important than others, depending on the local context. Similar to environmental sustainability six categories has been identified for disaster resilience.

1. Wind Load Resistance

This element addresses factors such as mean roof height, design pressure, wind velocity and connections between roofing felt and sheet metal.

2. Snow Load Resistance

This includes prescriptions for strength of roofs and other structural elements.

3. Seismic Load resistance

To withstand earthquakes, a building should use a certain minimum quality of building materials, and have a strong structure.

4. Rain & Flood Load Resistance

Examples of prescriptions under this category are raising the ground floor above average flood levels or re-siting buildings outside flood-prone areas.

5. Wildfire & Bushfire Resistance

Prescriptions under this heading help to prevent the spread of bushfires and minimize the impact by e.g. prescribing fire resistant materials.

6. Landslide Resistance

This includes prescriptions detailing how to minimize damage when the ground under the house would move.

As opposed to environmental sustainability, a building code doesn't need to address all of these six categories in order to have disaster resilience 'well implemented' – it depends on the relevance of the disaster to a country. In tropical countries, snow load resistance is usually not an issue, while in dry countries, floods are not likely to happen.

Some of the above elements of environmental sustainability and disaster resilience can only be addressed under one building code category; others should be dealt with in more categories. The

diagram in Figure 1 shows how this could be done. This figure was used as the analytical framework.

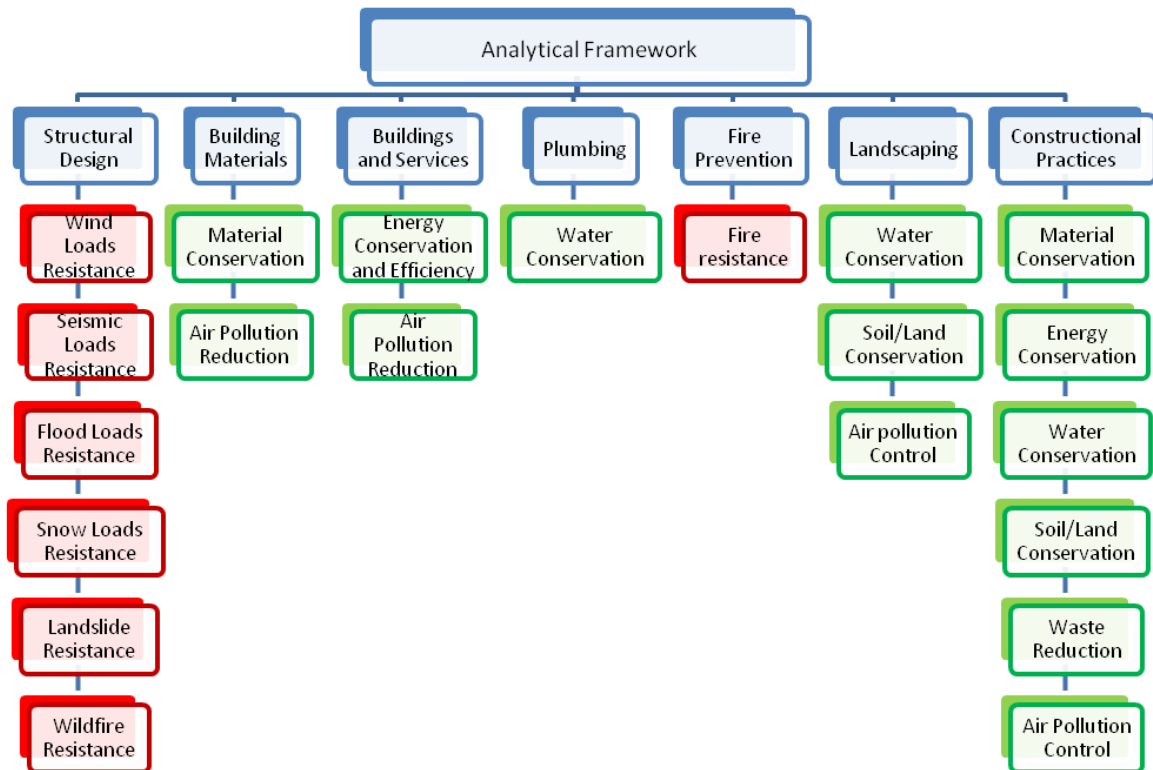


Figure 1: Analytical framework. The six elements of disaster resilience (red) and the six elements of environmental sustainability (green) should ideally be integrated under above categories.

3. Analysis

3.1 Analysis of Building Codes

All of the target and reference countries have some type of rules governing building. In most countries analyzed, these rules are included in a proper building code issued under one single law, but in Thailand, the regulations are scattered over various ministries and therefore less coherent. In Sri Lanka, the same is true, but moreover, these regulations only apply to the city of Colombo.

Another difference between the countries is that some countries have a prescriptive building code, outlining exactly which materials and which techniques can be used (USA-California, India, Bangladesh, Thailand, Sri Lanka and the Philippines), while others have a performance-based building code, which only states the minimum or maximum values a building design has to live up to, leaving it to the owner, developer and/or designer to decide how to make sure that happens (Singapore, Australia and the UK). Although performance-based building codes allow

for more flexibility and innovations, it is harder for developing countries to implement them: it requires a lot of capacity from architects, engineers and local government staff to make and check such calculations.

3.2 Integration of Environmental Sustainability and Disaster Resilience in the Building Codes

Originally, building codes were adopted to improve safety and health in and around buildings. The concept of using a building code to address environmental concerns is relatively new to developing countries in the Asia-Pacific region. This is why not all environmental sustainability aspects have been dealt with sufficiently in their building codes.

There are just a few countries that have integrated all aspects of environmental sustainability: USA-California, Singapore and India. In the case of California and Singapore, these requirements are followed, but in India, compliance is generally low. Other reference countries (Australia and the UK) have only integrated a few elements.

The most well integrated element is energy efficiency. All countries either already have requirements for energy efficiency or are working on it. All building codes and regulations discussed have been updated recently (Australia's code is even updated annually), except for those of Bangladesh and Sri Lanka, who are both currently in the process of updating.

Water conservation is another element that is relatively well implemented, especially in reference countries. There are, however, also many elements that hardly any country addresses: land and soil conservation, air pollution and solid waste reduction. Only the building codes of Singapore, California and India take care of the environment around the house by including landscaping regulations, e.g. to minimize air pollution and to improve water and soil conservation.

Interestingly, all reference countries have integrated energy efficiency and water efficiency with the other chapters of the code (e.g. energy in the sections dealing with appliances and constructional practices, water in the section on plumbing), but all other elements of environmental sustainability are generally dealt with in a separate 'green code' (such as the California Green Building Code or the Code of Environmental Sustainability in Singapore) and not integrated with the other requirements.

Target countries have similarly isolated energy efficiency, which is usually addressed in a separate building code which is not mandatory or not enforced, while most other elements of environmental sustainability are not addressed at all. Apparently, prescriptions relating to environmental sustainability are usually first included in voluntary guidelines, and then transferred to mandatory, but separate building codes, before they are mainstreamed into the 'normal' chapters of the main building code.

Environmental Sustainability	USA	Singapore	Australia	UK	Thailand	India	Bangladesh	Philippines	Sri Lanka
Material conservation & Resource efficiency	◆	◆	●	●	●	◆	●	●	●
Energy conservation & efficiency	◆	◆	◆	◆	◆	◆	updating	voluntary	updating
Water conservation	◆	◆	◆	◆	●	◆	updating	●	●
Land and soil conservation	◆	◆	●	●	●	◆	●	●	●
Soil waste reduction	◆	◆	●	●	●	◆	●	●	●
Air pollution control	◆	◆	●	●	●	◆	●	●	●

Figure 2: Integration of Environmental Sustainability in Building Codes and Regulations.

◆ = integrated, ● = not integrated.

Not all countries are equally prone to all disasters, and therefore, some disaster resilience elements are not applicable everywhere. Almost all the disaster resilience prescriptions have been included in the building code chapters on structural design. The only exception is fire resistance: in India and California, there is a separate code for fire safety, while the Philippines have requirements for fire-resistant construction materials.

Wind load resistance has been integrated in all countries. Only Sri Lanka has voluntary prescriptions, other countries have mandatory rules that should safeguard buildings from storms and typhoons. The same is true for seismic loads: all countries that are prone to earthquakes have addressed this in their building code. This is not surprising, since this is a common reason for countries to start drafting a building code in the first place. Snow loads have been addressed in each country that is vulnerable to it, except for the UK.

Less well addressed are rain & flood loads and landslide resistance. Out of the target countries, Bangladesh has the only Code that currently addresses floods. These requirements are very outdated, but Bangladesh is in the process of updating them. In 2011, many countries in South and South-East Asia were affected by major floods, leaving many homes damaged or even destroyed. With climate change, it is expected that such floods and the related loss of lives and goods, will happen more often, unless countries adapt.

Incorporating flood loads and landslide resistance in building codes and enforcing those is one good step in that direction. The reference building codes from the USA and Australia could serve as an example. Wildfire and bushfire resistance is another element that is not integrated in most building codes analyzed. The Philippines is the only country addressing it in their building code. Again, the building codes of the USA and Australia, and the regulations of the Philippines could be used as an example for integrating this element into other target country building codes as necessary. In India, the building code gives the local authorities directions on how to construct safe buildings in areas that are prone to more than one disaster.

Disaster Resilience	USA	Singapore	Australia	UK	Thailand	India	Bangladesh	Philippines	Sri Lanka
Wind Load	◆	◆	◆	◆	◆	◆	◆	◆	voluntary
Snow Load	◆	N/A	◆	●	N/A	◆	N/A	N/A	N/A
Seismic Load	◆	N/A	◆	N/A	N/A	◆	◆	◆	N/A
Rain and Flood	◆	N/A	◆	●	●	●	updating	●	●
Wildfire and Bushfire Resistance	◆	◆	◆	N/A	●	●	●	◆	N/A
Landslide Resistance	●	◆	◆	◆	●	●	●	●	●

Figure 3: Integration of Disaster Resilience in the Building Codes and Regulations.

◆ = integrated, ● = not integrated.

4. Building Code Enforcement

4.1 Challenges and Strategies in Building Code Enforcement

Even when countries have a building code that incorporates environmental sustainability and disaster resilience, it is often poorly enforced. In the Expert Group Meeting the participants identified the challenges which are provided in the table below.

Table 1: Challenges and Strategies in Building Code Enforcement

Challenges	Strategies to Overcome
Lack of Awareness	<ul style="list-style-type: none"> • Invest in education; both in the curriculum and in building strong school buildings as demonstration projects • Build linkages with academic institutions • Use the mass media and organize large-scale events such as ‘earthquake awareness day’ or ‘building code day’
Code-compliant buildings are more expensive to construct	<ul style="list-style-type: none"> • Establish different building codes for different buildings; complicated buildings should use a more sophisticated code than simple houses (e.g. Nepal). • The code documents should be affordable and easily accessible
Lack of Capacity and Knowledge	<ul style="list-style-type: none"> • Implement continuous training programmes to professionals, contractors and masons. Start with formal education curricula, but also use mobile training facilities and international development projects to build capacity • Use third party verification by government accredited agencies/firms/individuals (e.g. China, Republic of Korea) if local government doesn’t have the capacity to check building permit applications • Use South-South learning to exchange experiences

Challenges	Strategies to Overcome
Accountability and Enforcement Framework	<ul style="list-style-type: none"> • Implement financial, fiscal or zoning incentives (e.g. India, Republic of Korea, Japan) • Make housing loans dependent upon completion certificate • Establish a stronger penalty system for corruption and non-compliance, particularly for larger, more complex buildings
Lack of coordination between authorities	<ul style="list-style-type: none"> • Establish one regulatory body to coordinate enforcement • Set up an awareness raising program to inform stakeholders about their roles

4.2 Good Practices of Building Code Enforcement

Almost all countries in the Asia-Pacific region have building codes. However, not all building codes incorporate elements of environmental sustainability and disaster resilience and not all codes are enforced strongly. ESCAP and AIT documented six practices in the Asia-Pacific region that were successful in increasing the share of green and/or resilient buildings. The success factors differed:

1. Keep it simple. Nepal didn't have a building code until 2003. That building code has four different levels: the simpler the building design, the simpler the rules set for the design in the code. But as Nepal doesn't have a tradition of strong building code enforcement, even the simplest building code isn't followed widely. The city of Dharan decided to make compliance even easier and start with five rules that all new construction should follow. By explaining these rules to all stakeholders involved, compliance has risen quickly.

2. Raise awareness. In central Viet Nam, the NGO Development Workshop France has set up a programme to strengthen existing housing against damage caused by typhoons. The basis of the programme are ten simple construction rules, but the strength of the programme lies in the extensive awareness raising programme, which includes cultural events, radio and television broadcasts and adapting local myths and lyrics of songs to explain the importance of disaster preparedness. When one strengthens one's house according to above-mentioned ten rules, one can apply for a special housing loan.

3. Provide incentives. Incentives, in whatever way, shape or form, can be a very effective means of encouraging compliance, as it can reduce the costs for the developer or buyer. Three major types of incentives were explored for this report:

a. Offer special housing loans. In India, the National Housing Bank, with support from the German KfW Development Bank, established a housing loan programme where availability of loans is made dependent upon energy savings. Only when a new building is expected to consume 30 per cent less energy than a reference building, the developer is eligible for this specific housing loan, and the buyers of the apartments are eligible for sub-loans. Although additional incentives haven't been implemented yet in India, the programme could be made more attractive for developers by offering lower interest rates or preferential tax treatment.

b. Relax zoning restrictions. Every building developer in the Republic of Korea must choose which energy saving measures he wants to implement from a list provided by the government. Every implemented measure is awarded with points. To receive a construction permit, one has to implement at least 60 points worth of measures. But if one manages to implement more than 70, 80 or even 90 points, zoning restrictions (e.g. maximum building height) are increasingly relaxed. In cities where space is scarce, developers can often earn back the extra investment in energy efficiency by renting out or selling this extra floor space, while it doesn't require any additional investment from the government.

c. Offer tax breaks. Japan has chosen to look at housing from several viewpoints: housing quality (quality of construction material and techniques), safety (seismic resistance), environmental sustainability (energy and water efficiency) and the ageing population (adaptability). Owners and developers who build or retrofit their houses according to certain quality standards set by the government can apply for a 'Long-life Quality Housing Certificate'. With this certificate, they are eligible for tax breaks on their income, real estate and individual inhabitant tax. Even though the programme has started less than three years ago, already around 25% of all newly built detached houses are certified.

4. Attack the issue from all sides. Singapore has made green building a national priority and has, for this purpose, drafted a green building master plan. Under this masterplan, a variety of incentives for greening new and existing buildings have been established: partly mandatory (the minimum requirements set in the building code are raised every few years and are enforced strongly), and partly voluntary (financial incentives, educational programmes, and awareness raising). Different instruments are geared towards different stakeholders: technicians, CEOs, project managers, etc. The programme wouldn't have been as successful as it is without the strong political backing shown by various government agencies.

5. Transfer responsibility to the private sector. With the economic boom, more and more complex buildings were constructed in Chinese cities. Many local governments found themselves incapable of checking compliance of such buildings. Now, certified Supervision Companies are charged with this task; only with their signature for compliance can building developers get a building permit. This reduces the need for capacity building in every single local government and also transfers the checking cost from the public to the private sector.

4.3 Methods to Implement Building Codes Effectively

Four methods have been identified to implement building codes effectively which are briefly discussed below.

1. Flexibility vs. simplicity: introduce a building code with various levels. National governments are often the main driver for developing or reviewing a building code. A proper building code needs to be laid down in a law, such as the Building Act, to make enforcement possible. A basic precondition for any code development process is good

cooperation between all relevant stakeholders, including national and local governments, architects, engineers and developers. This is important to avoid problems at the local level with implementing complex or impractical building codes developed at the national level. To resolve the issue of implementing complex building codes separate building codes for different types of buildings can be developed.

2. Low capacity in local governments: introduce private sector supervision. Building plans have to be checked for compliance by local government staff but some local governments may lack the technical capacity to review complex plans. In such cases compliance checking of technically complex plans can be outsourced to private ‘supervision companies.

3. Low awareness: incentivizing developers and owners. This has already been discussed in the good practices section. National and local governments are important stakeholders to increase building code compliance, but owners and developers play a major role, too. They are the ones who will have to invest their time and money in building a construction with higher quality, while it is usually easier and cheaper in the short term to construct a non-compliant building. When considering incentives to persuade them, it is important to recognize the difference between smaller low-cost housing projects and big commercial projects; the people paying for construction have different motives to invest and should therefore be incentivized in different ways.

5. Conclusion

Cities in the Asia-Pacific region are experiencing rapid urbanization as urban areas in this region are producing the bulk of the GDP of the respective countries. This influx of people is increasing the demand of buildings in cities especially in the developing countries in the Asia-Pacific region. To accommodate the people migrating to the city many buildings needs to be built in the coming years. Building growth is expected to be higher in the cities in the developing countries in this region as the land is less developed compared to developed cities in the world. In many of these developing Asia-Pacific countries, buildings are not environmental friendly as building codes in these countries do not take into account the environmental issues. Some of these countries don't also have a building code or have codes with very low compliance rates. Therefore, improving the building codes of these developing countries will have a greater impact as building growth is expected to be higher in this region.

Originally, building codes in the Asia – Pacific region were aimed at improving health and safety in and around buildings. The concept of using building codes to further environmental design is something relatively new in the region. This is mainly why, in Asian building codes, disaster resilience is usually better covered than environmental design.

Building codes of nine countries were analyzed in this study. Four out of the nine countries were considered as reference countries or countries that are known to have integrated environmental sustainability and disaster resilience in their building codes. The other five

countries were considered as reference countries or countries. There are developing countries in the Asia-Pacific region that are known to have poor building codes. The analysis of the building codes of the nine countries demonstrated that out of all the target developing countries, India is the only country that has addressed all six elements of environmental design. However, most of the building codes are voluntary and the parts that are mandatory are usually not much complied with.

Other target countries only address energy efficiency, although also mostly in a voluntary way and in a less comprehensive way than the reference developed countries have done. Solid waste management, air pollution control and land & soil conservation are items that are relatively new, even to reference country building codes.

The conclusions with regards to disaster resilience are slightly more positive. Resistance against storms and typhoons has been integrated in all building codes analyzed – in most countries in mandatory prescriptions, in Sri Lanka in voluntary guidelines. Resistance against earthquakes is also well integrated. All countries that lie in or close to seismically active areas have sections on seismic loads. There are, however, other important elements of disaster resilience that some countries have not been dealing with well. Floods, landslides and wildfires are hazards overlooked in most building codes.

It's not easy to formulate a building code, but enforcing it once it's in place is a challenge on its own. Since governments (both national and local) play a key role in building code enforcement, most of the challenges can and should be overcome within this stakeholder. Lack of capacity and awareness, lack of coordination between authorities and corruption are all issues that can be solved by improving the quality of governance.

The documented good practices show that this can start both from the national and the local level. Starting from the local level, it may be easier to raise awareness, because there are simply less people who need to be educated. When a strong regulatory system is in place, starting enforcement from the national level may be more effective, for example by implementing nation-wide fiscal, financial or zoning incentives.

To ensure a sustainable and disaster resilient city, national and local governments should focus on integrating environmental sustainability and disaster resilience in building codes and also focus on enforcing the building codes in practice. To encourage developers and designers to build environmental friendly and disaster resilient buildings, governments may provide them incentives.

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