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Improving Sustainability Concept in Developing Countries

# Planning Coastal Areas and Waterfronts for Adaptation to Climate Change in Developing Countries

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## Abstract

Most of developing countries suffer from climate change impacts. Scenarios projected increase intensity and frequency of climate hazards especially sea level rise and storm surge. Coastal areas in developing countries already suffer coastal erosion in developing countries situation of coastal areas is the worst due to human-induced pressures on environmental and absence of sustainable development. The inevitability of climate change highlights the importance of adaptation. Climate change adaptation through land use planning strategies increase the resilience to risks, enhance economic and social conditions of community and safeguarding resources for next generations. Mainstreaming the UN millennium development goals in climate change adaptation process through sustainable planning of coastal areas will maximize the benefits of the adaptation process. Land use planning adapt with sea level rise risks through use some strategies ranging between official or local plans, zoning, land subdivision and development controls, design guidelines, environmental review of development projects.

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**Keywords:** climate change impacts; climate change adaptation; planning Coastal Areas; Coastal Areas and Waterfronts; Developing Countries, land use; urban development; costal development; development plans vulnerability; coastal vulnerability; adaptation strategy; mainstreaming development into climate change adaptation framework.

## 1. Introduction

Coastal areas attract a lot of people in developing countries due to availability of economic activities such as marine transportation, resource extraction, fish cultivation, recreation and tourism, also availability of species and habitats

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that provide many benefits to society and natural ecosystems.[1] Population densities in coastal regions are about three times higher than the global average, nearly a quarter of the world's population lives both within 100 km distance of the coast less than 100 m above sea level, 60% of the world's 39 metropolises with a population of over 5 million are located within 100 km of the coast.[2] Low elevation coastal zones that altitude less than 10 meters account for 2% of the world's land but are home to 10% of the world's population.[3]

## 2. Assess coastal vulnerability

Assess the current vulnerability of social, economic and environmental condition of the community to determine the objectives that development plans failed to address them also project the development challenges that will be faced in the future.[4] Assess current and future climate change impact on environmental and socio-economic conditions, direct impact of climate change impact on coastal areas include sea level rise, storm surge and heavy precipitation, raise water temperatures and ocean acidification, this factors generate indirect threats on public health and safety, drinking water. Identify the linkage between unmet development goals and vulnerability to climate change for underlying factors that cause vulnerability, identify the objective and capacity of adaptation process, build up and specify scenarios of vulnerability in the future and mutual influence between climate change and development to putting climate change adaptation into development context to enhance climate change adaption and sustainable development and avoid maladaptation in developing countries.[5] Convert this amount of information maps into maps to be handled by planners.

### 1.1. Assess development plans vulnerability

The major direct factors development plan failed to address them in coastal regions and have indirect effect on climate change adaption in developing countries include heavy use of resources, pollution of industry and agriculture activities, uncontrolled rapid urbanism, change land use, unsustainable management of coastal regions, deterioration of services and spread of poverty, illiteracy and health problems. Pressure on natural resources such as fishing by destructive harvesting methods shattering coral, damage habitats and remove seaweed. Industry and agriculture activities discharge sewage, fertilizers and heavy metals into coastal waters which have long-term toxic effects due to accumulate within fish tissues also extractive activities such as sand mining and hydrocarbon cause coastal erosion and oil spills that cause water contamination.[6] Rapid urbanism with high population density along coastlines pressure on natural resources, the average population density in global coastal areas is about 80 persons per square kilometer but at coastal areas in northern Africa reaches 500 to 1,000 people per square kilometer[7]. Change land use of waterfronts or fill wetlands such as mangroves deforestation to reclamation or expand industrial and urban development. Urban sewage discharge into sea without being treated cause infections and transmit diseases and reduces the amount of dissolved oxygen in the water body and impaired growth and reproduction of ecosystems, In some developing countries, more than 90 percent of domestic wastewater are discharged in coastal waters without being treated cause in die of 3 million people every year due to water-related diseases.[8] Engineering structures such as dams and recreational structures on coastal regions maybe change circulation patterns of freshwater, sediment and nutrient delivery to ecosystems on the sea. Unsustainable management that focus only on economic development with neglect environmental issues and absence of Integrated coastal management of economic sectors including tourism, fishing, agriculture, aquaculture, forestry, manufacturing, oil and gas extraction, waste disposal, marine transportation, and real estate development in coastal zones. [9] Most of developing countries suffer from deterioration of services and the spread of poverty, illiteracy and health problems. 17 % of people in the developing world lived at or below \$1.25 a day in 2011, [10] more than 50 percent of Africans suffer from water-related diseases such as cholera and infant diarrhea, every 3.6 seconds another person dies of starvation, over 40 percent of the world's population do not have basic sanitation and more than one billion people still use unsafe sources of drinking water,[11] 38 % of African adults are illiterate, two-thirds of these are women.[12] Unmet development redouble the climate change impacts, increase vulnerability of coastal regions to climate change and hinder adaptation and development process.

### 1.2. Assess vulnerability to climate change

Assess current and future vulnerability of climate change on environmental and socio-economic conditions. Climate

change impact on coastal areas include sea level rise, storm surge and heavy precipitation, raise water temperatures and ocean acidification. Global sea rose at a mean rate of 1.7 mm/yr between 1900 and 2010 the raise rate rapidly increase at a rate 3.2 mm/yr from 1993 to 2010, that's mean during the 20th century, global sea level rose by roughly 18 cm and projected to be 0.28 to 0.98 m by 2100 to threat a lot of coastal regions and low-lying areas also with regional variations and local factors sea level rise can be higher than that projected in regional or local.[13]Sea level rise due to global warming due to rising amount of greenhouse gases in the atmosphere by pollution, which absorb and emits heat that cause raise temperature, ice retreat and raise sea level. Sea level rise plays a role with human activity in coastal erosion that treats settlement, recreation facilities and infrastructure near the shores and waterfront also submerge wetlands that provide habitat of some plants and animals. Increase groundwater salinity push saltwater further upstream into underground aquifers which increase water stress in developing countries. Coastal areas are also vulnerable to increases in the intensity of storm surge and tropical cyclones as a result of sea level rise or heavy precipitations, storm surge effect zone ranging from 25 km to 500 km, damage settlement and infrastructure and cause annual loss estimated with billions of dollars, kill about 10,000 people and destroy habitat of coastal ecosystem.[14]Sea surface temperature has significantly warmed during the past 30 years along more than 70% of the world's coastlines, The average rate of raise is 0.18°C per decade these values are larger than in the global ocean where the average of change is 0.11 °C per decade in the upper 75 m of the ocean during the 1971–2010 period.[15]warming affects marine habitat such as mangroves and pressure species to migrate northward some of marine ecosystems which can't be tolerant with temperature will face extinction risks.[16]Increase water warming and ocean acidification due to rising concentration of carbon dioxide (CO<sub>2</sub>) in the atmosphere raise coastal waters and ocean CO<sub>2</sub> uptake which increase acidic of water and affect the health of many marine species and led to loss of critical habitat to marine ecosystem due to coral bleaching.[17]All of climate change impacts will effect on economic activities result in enormous economic loss, climate change caused economic losses estimated 700 billion dollars, close to 1% of global GDP and 7% of GDP in developing countries in 2010, by 2030 global economic losses close to 2.1% of global GDP, most affected regions are sub-Saharan Africa, Small Island, developing states and South Asia.[18]sea level rise will effect on marine transportation that satisfy 80% of the world's freight moves by ship due to submerging ports and harbors.[19] Rising ocean temperatures and ocean acidification will change fish distribution and the productivity of fisheries and aquaculture that providing a livelihood for about 35 million people most of whom live in developing countries.[20]Loss of recreational beach facilities and coral reef bleaching will threat tourism that provide foreign exchange in 46 of 49 least developed countries.[21]The Effect on availability of species and habitats such as coastal wetlands and mangroves that provide many benefits to society and natural ecosystems, maintain the ecological balance, create effective buffer zone to protect shoreline from erosion and represent habitat to a lot of species. Climate change impacts will effect urban and infrastructure due to loss of land, salt water intrusion, disruption of buildings due to floods and recession in real estate investment in coastal regions especially in developing countries due to infrastructure very vulnerable to climate change and decreased development rates.

### *1.3. Mapping land use vulnerability*

As land use change became a major element in accelerate climate change in developing countries also can play a role in mitigating the negative impacts of climate change. Mapping land use change and activities that play a role in vulnerability to climate change and undermine the development plans, for example rapid urbanism in waterfronts increase vulnerability to sea level rise and coastal erosion also led to deterioration of the services and increase pressure on infrastructure and natural resources, mapping of land use change will address how land use changes accelerate climate change or limit the development objective to tackle negatives in adaptation process of land use. Mapping vulnerability through data (maps & aerial photographs) and tools (Geographic Information Systems GIS, Remote Sensing and Global Positioning System GPS) are very crucial for effective and reliable assessment, Some of the key data required include historical maps, land use maps, tidal data and biophysical information in addition, data on climatic elements, shoreline recession rate, and geodetic information are also required to mapping the potential extent of inundation from sea level rise and storm surge under current and future climate change scenarios in 2050 and 2100 for defining areas that could become unstable under the vulnerability scenarios.[22]

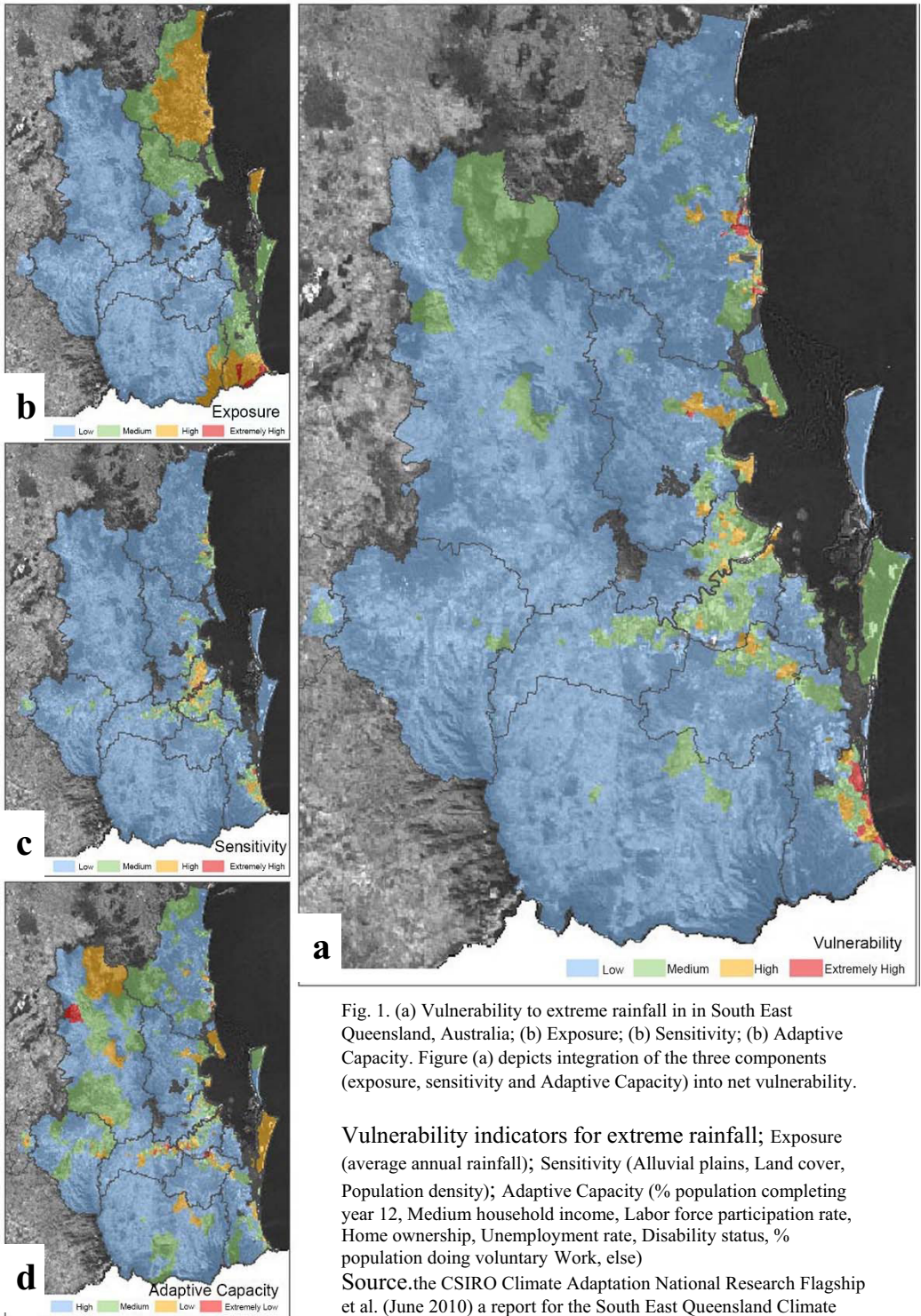


Fig. 1. (a) Vulnerability to extreme rainfall in in South East Queensland, Australia; (b) Exposure; (b) Sensitivity; (b) Adaptive Capacity. Figure (a) depicts integration of the three components (exposure, sensitivity and Adaptive Capacity) into net vulnerability.

Vulnerability indicators for extreme rainfall; Exposure (average annual rainfall); Sensitivity (Alluvial plains, Land cover, Population density); Adaptive Capacity (% population completing year 12, Medium household income, Labor force participation rate, Home ownership, Unemployment rate, Disability status, % population doing voluntary Work, else)

Source.the CSIRO Climate Adaptation National Research Flagship et al. (June 2010) a report for the South East Queensland Climate Adaptation Research Initiative.

**2. Developing an adaptation strategy**

Define adaptation strategies and measures that deal with land use planning then selecting and prioritizing adaptation by using multi-criteria analysis to select the best adaptation options that achieve adaptation and enhance sustainability through Implement and mainstreaming sustainable development with adaptation as part of a comprehensive plan conditioning then monitoring and evaluation to overcome the obstacles and keep track of progress in the in relation to the targets.

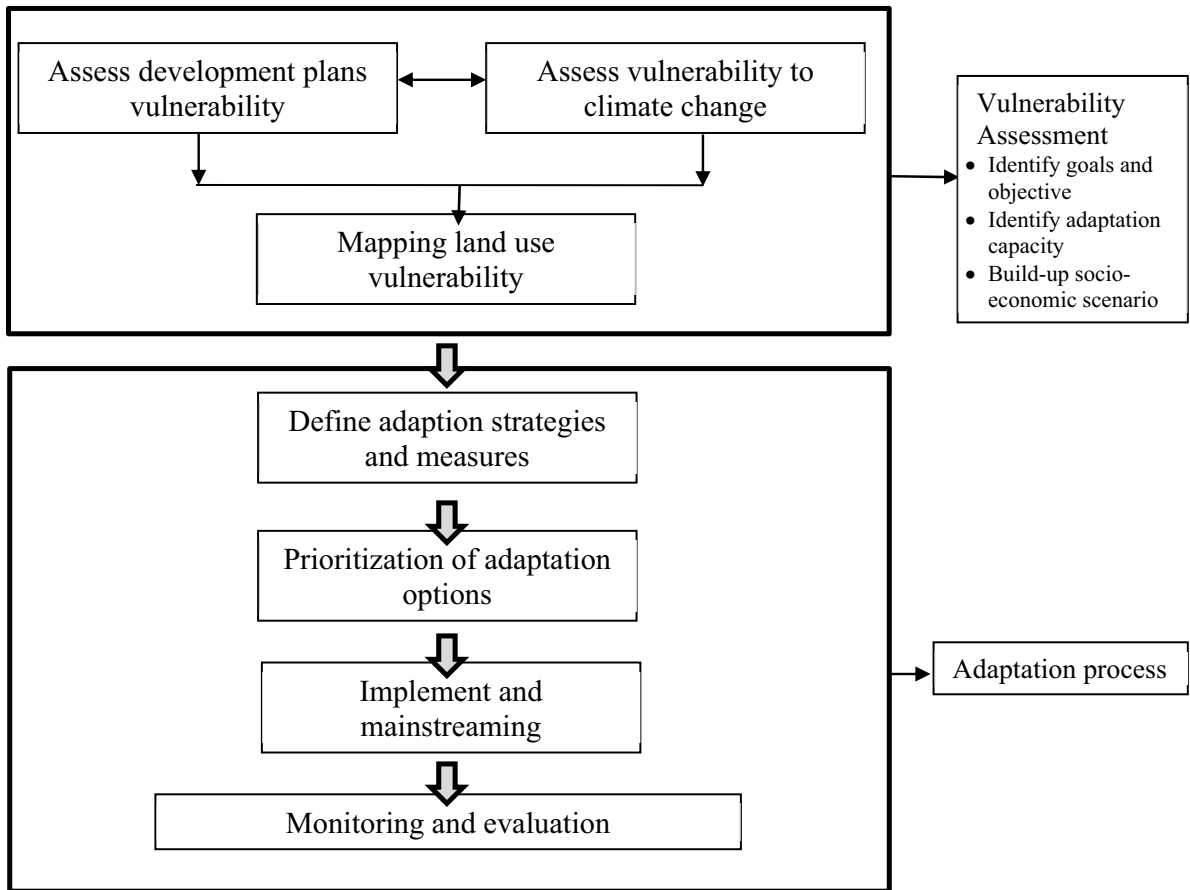


Fig. 2. Sustainable Climate change adaption frame work  
Source. Author

### 2.1. Define adaption strategies and measures

Land use planning is use of the land and natural resources in effective and efficient way by select the best land use options in order to enhance economic and social conditions of community and safeguarding resources for the future and plays a critical role in climate change adaptation. Many of the key strategies for adapting with climate change and enhancing sustainable development are linked to land use planning through development and conservation strategies that help protect the natural environment and make communities more attractive, economically stronger and more socially diverse in coastal zones in developing countries. Consider climate change adaptation into the management of activities that exist within the waterfront such as fisheries, tourism and marine transportation, Integrated coastal management and maritime spatial planning to ensure that the growth of increasing maritime activities at sea and the use of resources at sea and on coasts remain sustainable and ensure resilience to climate change.[23]Protection of the coastal ecosystem through sustainable management of the marine and terrestrial natural resources that consider threat of climate change on coastal zones, provide appropriate and ecologically responsible coastal protection of coastal settlements and their natural or cultural heritage and provide sustainable economic opportunities and employment options to support local communities. Planning of costal zones should take into account a broad overall perspective (thematic and geographic) about natural systems and human activities on coastal and engage stakeholder and respecting the carrying capacity of ecosystems, which will make human activities more environmentally friendly, socially responsible and economically sound in the long run.[24]Integrating climate change adaptation strategies in national development policies governments can provide transitional pathways to green growth and protect and improve the livelihoods in developing countries. Planner should encourage low-cost climate adaptation actions to improve the health and ecosystems and build community capacity to sustainably manage ecosystems for example in Mozambique, an investment of US\$120 per person per year to maintain mangroves generated significant gains in ecosystem protection, livelihood improvement and increased climate change resilience.[25]

Current trends in unsustainable land use allow humans to increase supplies of material goods from biosphere's but also diminishing the capacity of global ecosystems to sustain food production, maintain freshwater and forest resources, regulate climate and air quality and mediate infectious diseases in the long run so land use planning must trade-offs between meeting human needs and maintaining the capacity of ecosystems by recognize that land use provides social and economic benefits also preserve ecosystems.[26]Strengthening measures to ensure that ecological buffers such as wetlands and mangroves are protected should be a priority in planning by create buffer zone around protected areas and prevent filling wetlands, damming rivers, mining coral and beach sands and cutting of mangroves and encourage coastal wetland protection to preserve ecosystems and mitigate the impacts of sea level rise on coastal infrastructure and land uses.[27]Green infrastructure in cities such as parks and gardens, wetlands and green roofs are essential tool to reduce storm water runoff, mitigate the urban heat island effect , improve public health , maintain habitat , flood protection and deal with groundwater salinity in coastal zones.[28]

Enforce land use regulation to choose areas that are less vulnerable to climate change risks and reduce dependencies on transportation and energy in urban. Enhance resilience of urban areas by land-use planning and land protection tools such as soft and hard engineering protections that used to save important zones when retreat strategies can't be available due to high population densities. Engineering protections such as multipurpose artificial coral reefs, beach nourishment and green belts to form a buffer zone, it is relatively low-cost and eco-friendly, and can be provided by wetland restoration or planning waterfront parks. engineering protections such as building a sea wall, groynes and boulder barriers to block the inflow of sea water and protects facilities and critical infrastructure that would be difficult to move or relocate, but it's expensive and may has negative impact on ecosystems.[29]Accommodation strategies include promote building codes and retrofitting vulnerable buildings by elevate structures or use stronger connections or enhance storm water drainage to ensure that new buildings are built to better withstand wind and

flooding. Retreat strategies such as impose restrictions to limit development generally in low-lying coastal floodplains and high hazard areas include buffers and setback regulations by relocate structures behind setback line in vulnerable areas ,zoning regulation by impose specific land uses on vulnerable areas such as recreation or change land use to more resilience activities. Restrictions require compensation for coastal property owners, regulations that prohibit construction, conversion of land ownership to long-term, conditional leases that expire when the sea reaches a particular level or when the property owner dies. [30]

Increase resilience of vulnerable communities to mitigate negative impact of floods, storm surges, and extreme tides by raise awareness of community and enhance their adaptive capacity and mapping vulnerable areas to improve their adaptive capacity. Spatial planning should consider ways to increase awareness of dangers of exposure, carefully locate new facilities away from medium and high-risk flood areas, relocation or retrofitting for poorly located existing facilities, ensure the resilience of the building in case of emergency and extreme danger to assist in reducing risk, locate facilities such as waste disposal sites outside of flood-prone areas.[31] Redevelopment of brownfield sites to be green spaces for recreational uses and ensure coverage of disaster response services facilities into spatial planning such as fire stations, health and rescue services facilities would also assist in reducing risk. Develop performance measures for site and building design, covering energy and water efficiency, air and water quality, ecological services and solid waste management and apply the standards on the regular inspection process, new development approval subject to zoning and site plan controls. [32]

Develop land use controls to reducing water supply leakage, mobilizing non-conventional sources of water and maintaining and restoring key wetland functions of wetlands and watersheds.[33]Strategies aim to reduce gap between water supply and demand by Protect groundwater, Improve water use efficiency in agriculture and urban and increasing storage capacity.[34]Considering extreme weather events in evaluating water infrastructure safety and retrofit water and sewage to mitigate water runoffs and flooding and build systems to recycle wastewater and water storage.[35]Integrated storm water management plan to adapt with flooding by decreasing the leakage of storm water through apply storm water management techniques and increase storm sewer capacity through Separate storm sewer from sanitary infrastructure.[36] Promote green infrastructure and watershed management to reduce storm water runoff, improve rain water retention, mitigate the urban heat island effect and improve public health and rehabilitate coastal mangroves to provide habitat and flood protection and reduce groundwater salinity in coastal zones.[37]

Urban produce enormous amount of wastes that produce a high amount of co2 emissions also have a toxicant effect on nature and human therefore adaptation must be considered with extreme hazard events into siting, design, and operation of landfills for the disposal of municipal solid waste, special wastes construction or demolition debris, land clearing debris, and wood wastes to prevent transfer of contaminants off-site[38]also enhance reduce, recycle and reuse waste measures in planning through depend on recycled materials aim to proper treatment and disposal of hazardous waste protect the environment from harmful contamination.

## 2.2. Prioritization of adaptation options

Selecting and prioritizing adaptation policies and measures by using one or more criteria and prioritization methods such as cost-benefit analysis, cost-effectiveness analysis, expert judgment or multi-criteria analysis, the output will be a ranked list of adaptation options, results accuracy depend on accuracy of determining the scores of each criterion. Multi-criteria analysis suitable to developing countries because its deal with uncertainty by using different methods to get extensive evaluation, methods such as analysis of social and financial benefits, Implementation costs and expert judgment and key linkages with sustainable development,[39] sustainable criteria such as economy, social and environmental, economic sustainability; growth, development and productivity ,social sustainability; equity, empowerment, accessibility, Participation, Sharing, cultural identity and institutional stability, environmental sustainability; ecosystem integrity, carrying capacity, biodiversity ) and ability to integrate in development plans of developing countries and usability by individuals, communities and organizations as community participation tool to enhance development objective and mitigate climate change. Weigh objectives and evaluate trade-offs by comparisons between the performance of different strategies in meeting these objectives and integration with national sustainable development plans. [40]

Table 1. Prioritization of adaptation options (for example)

Source. Author

	Criteria of selecting	Adaptation options		
		Measure 1	Measure 2	Measure 3
Adaptation criteria	social benefits	5		
	financial benefits			
	Implementation costs			8
	expert judgment		7	
	usability			
Sustainability criteria	economic			
	growth			
	development			
	productivity			
	social			
	equity		5	
	accessibility			3
	participation	4		
	empowerment			
	Sharing			
environmental	cultural identity and institutional stability			
	ecosystem integrity			
	carrying capacity			
	biodiversity			
Weigh measures		9	12	11



Ranking	3	1	2
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### 2.3. Implement and mainstreaming

Wrong development policies not only increase vulnerability to climate change but also hinder development for example destroying mangrove forests to expand urban development increased coastal vulnerability to storm surge, sea level rise and coastal erosion that threat costal development on the opposite side poverty alleviation helps increase resilience to sea level rise and enabling investment in better land management. Implement and mainstreamed land use planning as climate change adaptation measure into national, local or sectorial development planning and into policy processes and decision-making increase effectiveness of the policy. Mainstreaming refers to the incorporation of measures and strategies to reduce vulnerability to sea level rise into existing policies, processes and structures regarding sustainable development plans of low-lying coastal areas and small island developing states by Implement “win adaptation - win sustainable development” policies.[41] Finding the entry points for mainstreaming by understanding the linkages between climate change climate policies, plans and programmes , development and poverty alleviation through analyze socio-economic impact and benefits of adaptation option then mainstreaming into an ongoing development policy process by mainstreaming into budgeting and financing, implementation and monitoring of national development priority issues relevant to climate change such as food ,water, energy security or public health and safety.[42] The expected benefits of mainstreaming adaptation into development planning include avoided policy conflicts, reduced risks and vulnerability, greater efficiency compared with managing adaptation separately and leveraging the much larger financial flows in sectors affected by climate chance than the amounts available for financing adaptation separately.[43]

### 2.4. Monitoring and evaluation

The purpose of monitoring is to keep track of progress in the implementation of climate change adaptation and its various components (policies, strategies, measures) in relation to the targets. This enables management to improve operational plans and to take timely corrective action in the case of shortfalls and constraints and gain learning experience by right and wrong way. Evaluation determining the relevance, efficiency, effectiveness and impact of an adaptation strategy in light of its objectives during implementation monitoring ( ongoing evaluation ) and at the completion of a project (final evaluation) and some years after completion (post evaluation).[44] The five main factors which can determine successful adaptation are: effectiveness; An effective adaptation intervention will achieve its stated objectives, be these to reduce vulnerability or risk, increase adaptive capacity, or achieve an enhanced level of protection. Flexibility ;how adaptation deal with climate change uncertainty about the future, flexibility in act with range of climate changes projected under different emissions scenarios also response to for the ‘worst case scenario’ will be safer but it is extremely expensive but reduces resources available for pressing development needs now so successful adaptation that building capacity to improve current climate resilience and to be in ‘no regret’ and ‘win-win’ interventions that allowing for better decisions downstream. Equity: what dimensions of Inequality in adaptation? Adaptation interventions that are inequitable will undermine the potential for welfare gains in the future and are unsustainable so adaptation should respect equity and vulnerability by considering equalities between sectors, regions and societies.[45] Efficiency: Efficiency or cost-effectiveness is typically used to compare the costs of alternative ways of producing the same or similar results to assess the least-cost path to reaching a given target and address agreed acceptable levels of risk. Sustainability; Sustainability of an adaptation is concerned with looking beyond the immediate sphere of the intervention’s impact. It considers the longer-term benefits and environmental, social and economic impacts. Sustainable adaptation includes strong elements of partnership-building, community engagement, education and awareness-raising, mainstreamed into existing development processes and mechanisms to offer ‘win-win’ solutions. [46] Stakeholder engagement by increase awareness among key stakeholders about the risk climate change poses to achievement of national development priorities and its potential economic costs, along with the near- and long-term

benefits achievable through adaptation measures. Involve a broad range of stakeholders from within different sectors, sub-national governments and civil society, to strengthen the design of policy instruments, build commitment to implement adaptation actions, and ensure that policies are informed by practical, ground-level experience.[47] Guidance and engaging stakeholders in all phases of adaptation process through "Lateral" collaborative arrangement in making a decisions; in vulnerability assessment, identify priority of adaptation options and indicators that monitor progress and success will increase adaptation capacity.[48]

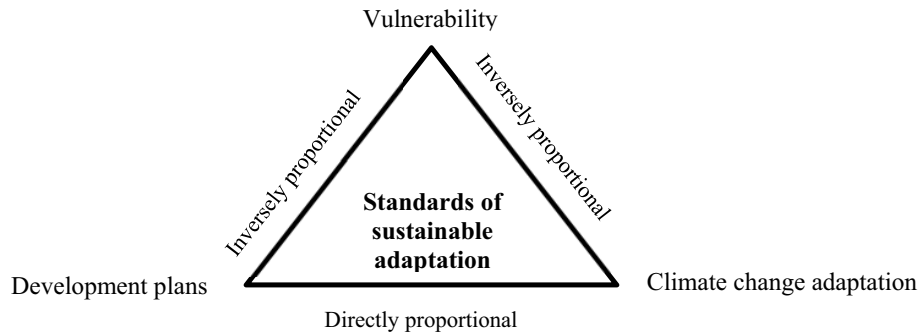


Fig. 3. Standards of sustainable adaptation  
Source. Author

### 3. Conclusion

climate change has enormous impact on city and infrastructure, the trends of impacts increase rapidly effect on environment, economic and social conditions, the unsustainable development increase vulnerability in developing countries especially in coastal zones so climate change adaptation is necessary to tackle with current and future at a range of scales. The major impact of climate change summarized in sea level rise, storm surge and erosion, the trends increase with high rates also unsustainable management increase the vulnerability so adaptation process should concern on win adaptation –win development strategies to reduce human-induced pressures on the environmental resources on costal zones by land use planning to use land and natural resources in effective and efficient way to enhance economic and social conditions of community and safeguarding resources for the future. Land use planning adapt with climate change risks through use some measure such as environmental standards, energy and water efficiency, modified building codes and changes in urban form to reduce dependencies on transportation and energy consumption and deal with climate risks, some of the adaptation measures to low lying areas on coastal zones such as preventing new permanent developments within risk areas, soft engineering protections and engineering protections. All of strategies consider into adaptation framework to define and assess vulnerability and adaptation strategy.

## References

1. US Environmental Protection Agency, Climate Impacts on Coastal Areas. Available at: <http://www3.epa.gov/climatechange/impacts/coasts.html> [Accessed September 2015].
2. Javier Sanchez-Reaza, André Carletto (June 2013) Resilient Coastal Cities, the Economic, Social and Environmental Dimensions of Risk. Caribbean Knowledge Series.
3. United Nations Department of Economic and Social Affairs (2011) Population Distribution, Urbanization, Internal Migration and Development: An International Perspective. United Nations
4. R. L. Wilby et al. (JAN 2009) A review of climate risk information for adaptation and development planning. *International Journal of Climatology*, Volume 29, Issue 9, pages.
5. W. Neil Adger et al. (December 2004) Successful adaptation to climate change across scales. *ScienceDirect*. 77–86, pages
6. Virginia Burkett, Jorge Codignotto, John Hay et al. (2007) Chapter 6: Coastal Systems and Low-Lying Areas. IPCC Fourth Assessment Report: Climate Change 2007. The Intergovernmental Panel on Climate Change (IPCC)
7. Liz Creel RIPPLE (September 2003) EFFECTS: POPULATION AND COASTAL REGIONS. Population Reference Bureau
8. The United Nations Environment Programme (2007) Global Environment Outlook GEO environment for development4
9. Liz Creel RIPPLE (September 2003) EFFECTS: POPULATION AND COASTAL REGIONS. Population Reference Bureau
10. The World Bank Poverty. Available at: <http://www.worldbank.org/en/topic/poverty/overview> [Accessed September 2015].
11. The United Nations, Fast Facts: The Faces of Poverty, The Millennium Project was commissioned by the United Nations
12. UNESCO, Literacy and non-formal education. Available at: <http://www.unesco.org/new/en/dakar/education/literacy/> [Accessed September 2015].
13. Jean Pierre al. (2014) Ch5: Coastal Systems and Low-Lying Areas in: Climate Change 2014: Impacts, Adaptation, and Vulnerability, the Intergovernmental Panel on Climate Change (IPCC).
14. ACAPS the Assessment Capacities Project (July 2011) Disaster Summary Sheet Tropical Cyclones
15. Jean Pierre al. (2014) Ch5: Coastal Systems and Low-Lying Areas in: Climate Change 2014: Impacts, Adaptation, and Vulnerability, the Intergovernmental Panel on Climate Change (IPCC).
16. San Francisco State University (May 2015) Climate change could cause cold-blooded animals' thermal tolerance to shrink. *Science Daily*
17. US Environmental Protection Agency, Climate Impacts on Coastal Areas. Available at: <http://www3.epa.gov/climatechange/impacts/coasts.html> [Accessed September 2015].
18. DARA and the Climate Vulnerable Forum (2012) Climate Vulnerability Monitor 2nd Edition, guide to the Cold Calculus of a Hot Planet. Fundación DARA Internacional
19. Austin becker, David newell, Martin fischer and Ben schwegler (March 2011) Will Ports Become Forts? Climate Change Impacts, Opportunities and Challenges. *Terra et Aqua journal* Number 122
20. The United Nations Environment Programme (2007) Global Environment Outlook GEO environment for development4
21. World Tourism Organization Network, FAQ - Climate Change and Tourism. Available at: <http://sdt.unwto.org/content/faq-climate-change-and-tourism> [Accessed September 2015].
22. Dr. Isaac Boateng (November 2010) Spatial Planning in Coastal Regions: Facing the Impact of Climate Change. Publication of FIG Commission 8 Working Group 8.4 – Urban Planning in Coastal Region. INTERNATIONAL FEDERATION OF SURVEYORS (FIG), Denmark
23. The European Commission (16.4.2013) Climate change adaptation, coastal and marine issues. The European Commission, Brussels
24. The European Parliament and The Council of The European Union (2002) concerning the implementation of integrated coastal zone management in Europe: Recommendation of the European parliament and of the council of 30 may 2002. Official Journal of the European Communities
25. United Nations Environment Programme (2014) keeping track of adaptation actions in Targeted Fiscal Stimulus Actions Making a Difference Africa, United Nations. Nairobi. Published 2014
26. Jonathan A. Foley et al. (2005) Global Consequences of Land Use, *Science* VOL 309 American Association for the Advancement of Science, 22 JULY 2005
27. Dr. Clement Lewsey et al. Climate Change Impacts on Land Use Planning and Coastal Infrastructure, the National Oceanic and Atmospheric Administration's National Ocean Service (NOS)
28. The City of North Vancouver (October 2013) City of North Vancouver Climate Change Adaptation Plan
29. Korea Yumi Lee (March 2014) Coastal Planning Strategies for Adaptation to Sea Level Rise: A Case Study of Mokpo. Scientific Research Publishing Inc
30. CHAIR S J. Gilbert, P. Vellinga et al. (April 1990) Coastal Zone Management, the Intergovernmental Panel on Climate Change (IPCC)
31. CEF consultant and CBCL limited (November 2005) A Guide for incorporating adaptation to climate change in land use, Version 1.1
32. Richardson, G.R.A. and Otero, J. (2012). Land use planning tools for local adaptation to climate change. Ottawa, Ont.: Government of Canada, 38 p.
33. Bergkamp, G., Orlando, B. and Burton, I. (2003). Change. Adaptation of Water Management to Climate Change. IUCN, Gland, Switzerland and Cambridge, UK. Ix + 53 pp.
34. Adaptation options in principle Table 3.5, Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability. [www.ipcc.ch/publications\\_and\\_data/ar4/wg2/en/ch3s3-6-2.html#table-3-5](http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch3s3-6-2.html#table-3-5) [Accessed September 2015].

35. Dr. Blair Feltmate Chair Dr. Jason Thistlethwaite (June 2012) Climate Change Adaptation: A Priorities Plan for Canada. Director Report of the Climate Change Adaptation Project (Canada)
36. City of Surrey (November 2013) Climate Adaptation Strategy, City of Surrey
37. The City of North Vancouver (October 2013) City of North Vancouver Climate Change Adaptation Plan
38. Maine Department of Environmental Protection in Augusta, Georgia, USA. Climate Preparation and Adaptation. Available at: <http://www.maine.gov/dep/sustainability/climate/preparation-adaptation.html#programs> [Accessed September 2015].
39. TIMOTHY CARTER. Technical Guidelines for Assessing Climate Change Impacts and Adaptations, TIMOTHY CARTER, University College London
40. Mohan Munasinghe and Rob Swart (2005) Primer on Climate Change and Sustainable Development: Facts, Policy Analysis, and Applications. Cambridge University Press
41. The Energy and Resources Institute (TERI), United Nations Department of Economic and Social Affairs Division for Sustainable Development Climate Change and Sustainable Development. Adaptation to Climate Change in the context of Sustainable Development: A Workshop to Strengthen Research and Understanding New Delhi, 7-8 April
42. United Nations Environment Programme (UNEP) (2011) Mainstreaming Climate Change Adaptation into Development Planning: A Guide for Practitioners, UNEP Poverty-Environment Initiative
43. Chinvarno, S. (2013) a holistic approach to climate change vulnerability and adaptation assessment: Pilot study in Thailand, Adaptation Knowledge Platform
44. ROSA T. PEREZ1 AND GARY YOHE2(2004) Continuing the Adaptation Process, UNDP 2004, published by the press syndicate of the University of Cambridge, United Kingdom
45. Rob D. van den Berg, Osvaldo N. Feinstein (2011) Evaluating Climate Change and Development, Transaction Publishers, 454 pages
46. MERYLYN MCKENZIE HEDGER, TOM MITCHELL, JENNIFER LEAVY, MARTIN GREELEY, ANNA DOWNIE (August 2008) DESK REVIEW: EVALUATION OF ADAPTATION TO CLIMATE CHANGE FROM A DEVELOPMENT PERSPECTIVE. A study commissioned by the GEF Evaluation Office and financed by DFID
47. Jo-Ellen Parry and Susan Taylor (August 2012) Mainstreaming Adaptation to Climate Change into National Policy: An overview for adaptation practitioners SECOND DRAFT, International Institute for Sustainable Development.
48. ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (2009) Integrating Climate Change Adaptation into Development Co-operation POLICY GUIDANCE.