Chapter 8

Climate change adaptation and mitigation in ports

Advances in Colombia

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1 Context

Colombia is the second most biodiverse country in the world and borders on the Pacific Ocean and Caribbean Sea. The country's marine-coastal zones display a great variety of strategic ecosystems coral reefs, mangroves, sea grass areas, and beaches, among others. These landscapes and ecosystem present a key role in Colombia's exposure to climate change, as they provide protection against sea-level change, climate regulation and climate change hydrology, and erosion control (UNDP, 2014). However, these ecosystems have been subject of degradation due to unplanned development of economic activities. This has resulted that erosive processes are affecting a quarter of the Colombian coastline. Coastal areas on the Caribbean Sea (23%) and the Pacific (25%) have been categorized as critical, where erosion is affecting coastal ecosystems and infrastructure.

This chapter describes the relevance of climate change adaption and mitigation for the Colombian port system and discusses the identified threats and general adaptation and mitigation needs in the national port climate change action plan. Colombia's climate action plan, or Intended Nationally Determined Contribution (INDC), includes the goal to reduce its greenhouse gas emissions by 20% by 2030, as compared to a projected business-as-usual scenario. Colombia's INDC document stresses that climate action is fundamentally a development issue (Colombian Government, 2015). Thus, innovative and strong development in the various sectors of the economy will support efforts to reach this goal. Therefore, the second part of this chapter focuses on mitigation efforts by presenting results for current baseline measures for implementing and monitoring mitigation matters in the port sector.

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2 Climate change impacts and ports

An analysis of INVEMAR-MADs (2016) revealed that Colombia's seaports are exposed to a variety of threats associated with the climate variability and change. The analysis identified 13 threats for the 12 coastal regions. All coastal regions are affected by gales, floods, erosion, and sea surge. Four regions are at least exposed to 10 of the threats. The least affected regions Cordoba and Sucre are still affected by 6 and 5 threats, respectively (see Table 1).

Studies have also estimated the aggregate or macroeconomic and sectoral impacts of climate change in the General Equilibrium Model Climate Change Computable (MEG4C) developed by the National Planning Department (DNP). The model, applying IDEAM's future climate scenarios, finds a negative aggregate impact of climate change on the economy. Taking only the impacts on a number of sectors between 2011 and 2100, the average impact would be annual GDP loss of 0.49%. This means that each year GDP would be 0.49% lower than in a macroeconomic scenario without climate change. It is important to bear in mind that the analysis was only carried out on subsectors of the economy which together account for 4.3% of total GDP (BID-CEPAL-DNP, 2014).

TABLE 1 Exposure to threats from climate variability and change by coastal department in Colombia.

Threat	Bolívar	Antioquia	Chocó	Magdalena	S. Andrés	Atlántico	Guajira	Nariño	Cauca	V. Del Cauca	Córdoba	Sucre	Total number of coastal departments affected by threat
Gale													12
Flood													12
Erosion													12
Cam sea													12
Tropical storm													10
Earthquake													10
Slip													9
Hurricane													8
Drought													6
Sea level rise													5
Salinization													4
Tsunami													3
Tornado													3
Number of threats per coastal department	12	11	10	9	10	9	8	9	7	7	6	5	

Source: author based on Invemar-MADS 2016.

The sum of the losses, not considering inflation, would be equivalent between 3.6 and 3.7 times the GDP value of 2010. However, despite this exemplified impact for the country as a whole, the identified impacts by sectors and regions are very heterogeneous. In general, forestry could be one of the sectors that could actually benefit from climate change as an increase in temperature in combination with higher precipitation in some regions could have a positive effect on the growth of certain species, while livestock, agriculture, aquacultures, and fisheries can be expected to present losses in their production (BID-CEPAL-DNP, 2014).

Turning toward the transport sector, this sector contributes 4.07% to the national GDP, a figure that has remained relatively constant over the last 15 years (Mintransport, 2018). Across all modes the greatest contribution remains with the road transport sector (69%, considering constant prices) of the whole transport sector. While the contribution of the maritime sector to GDP does not seem of high relevance in terms of direct contribution to the country's GDP, over 93% of Colombia's trade in terms of volume are moved via the maritime mode. In 2017 the Colombian port system transferred 205 million tons, a volume that doubled in comparison to 2006. 178 million tons of the total cargo handled in ports correspond to international trade.

The transport sector has two strategic priorities: the improvement and development of logistics and infrastructure; and the consolidation of transport systems in cities. However, the level of progress in meeting these objectives may be affected by climate effects. Climate variability and change in precipitation patterns can have negative effects on the assets and operation of the transport sector. Floods and droughts can cause damage to roads and ports, and increase closures and disruptions in land, rail, sea, and air traffic leading to increases in freight rates, reduced reliability, shortages, and damming of cargo with impacts on the rest of the economy. On the other hand, rising sea levels along with storm surges can cause flooding of transport infrastructure, causing costly damage and closures for the sector (BID-CEPAL-DNP, 2014).

3 Climate change, national strategies and ports

An analysis of the literature also reveals that a "first wave" of climate change risk studies in ports was realized around 2010 (e.g., Scott et al, 2013; UNFCC, 2007). Relevant impact on the awareness of port authorities and increased visibility of this topic probably relates back to the survey of Becker et al. (2011) and continued efforts of international institutions such as UNCTAD (UNCTAD, 2018) and associations, e.g., IAPH and the World Ports Sustainability Programme, set up in 2017 following the World Ports Climate Initiative from 2008.

In 2017 Colombia published the "Plan de Gestión del Cambio Climatico para los Puertos Marítimos de Colombia" [Climate change plan for maritime ports in Colombia]. As numerous similar reports, the work presents a first stocktaking and guide how to assess climate risks and vulnerability assessments. At the same time risk assessment in Colombian ports has a certain tradition. One of the first risk assessments of climate changes was realized by the IFC for the Terminal Maritimo Muelles el Bosque in Cartagena. This analysis included legal, financial, environmental, local community, operational, health and safety, reputational and external stakeholder criteria (Stenek et al., 2011). Furthermore, in 2015 the City of Cartagena was one of the pioneers to develop a climate change action plan (inveMAr-MAds-Alcaldía Mayor de Cartagena de indias-CdKn, 2012).

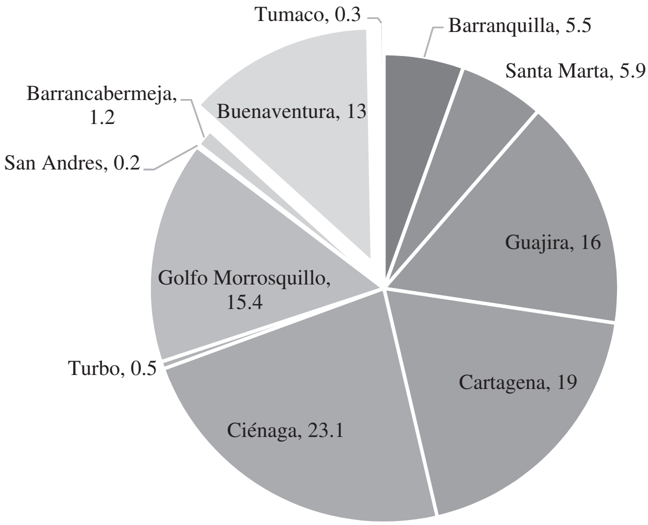
What can be found in the Colombian national report as in similar local, regional, or other works are guidelines and risk assessment frameworks based on other national or individual experiences. Therefore, this case like others leads to the invariable first question: what are the most appropriate actions a port should be taking now to deal with climate change. Second, what of the plans has been put into reality? In the case of the Cartagena plan advances toward implementation have been very limited until today (Ortiz, 2017).

4 The Colombian port system

There are nine main port management zones defined by the Integrated Port Management Plan—PIOP and port expansion plans (INVEMAR, 2016; Conpes 3611 of 2009 and 3744), of which seven are located on the Caribbean Coast (La Guajira, Santa Marta, Ciénaga, Barranquilla, Cartagena, Golfo de Morrosquillo, Urabá, and San Andrés) and two in the Pacific (Buenaventura and Tumaco). Overall more than 85% of all cargo in terms of volume is moved on the Caribbean coast. In 2018 43% of all cargo in terms of volume was coal, liquid bulk (25%), dry bulk (not coal) 8%, general cargo 3%, and containerized cargo 20%. Santa Marta-Ciénaga, Morrosquillo, and Guajira are the ones in which more volume is handled. These mobilize 65% of the total cargo entering or leaving the country in terms of volume (Fig. 1).

However, given the Colombian cargo structure this picture is somewhat skewed due to the dominance of bulk cargo on the Caribbean coast. Therefore, it is necessary to take a separate look at geographical distribution of the container port activity, which reached around 4 million TEU in 2018. The two principal container port activity zones are Cartagena (58.5%) and Buenaventura (34.3%). These are followed in distance by Barranquilla (4.0%), Santa Marta (2.6%), San Andres (0.4%), and Guajira (0.1%) (Superintendencia de Puertos y Transporte, 2019). About 1 million containers were transshipped in Colombia, 267 thousand in Buenaventura, and 802 thousand in Cartagena.

Figures from the National Infrastructure Agency (ANI) show that between 2010 and 2018 the investment made in the country's public port terminals reached 2558 billion dollars. According to the ANI, these investments have increased the installed port capacity by 55%. The capacity in 2010 was approximately 286 million tons per year; by 2018 it reached 444 million tons per



Source: Superintendencia de Transporte, 2019

FIG. 1 Share of port activity in tons by Colombian port region.

year of installed capacity. According to projections of the entity, the installed capacity of the Colombia's port infrastructure could reach 514 million tons per year by 2021. No figures exist on the volume of investment considering or preparing the port system for climate change impacts.

In this sense, given the volume of coal exports the respective capacity in specialized ports (in addition to Puerto Bolivar de Cerrejón the direct loading ports of Drummond and Prodeco were opened) increased from 69 million tons per year in 2010 to 157 million tons in 2018, and by 2021 it is expected to reach 201 million tons.

Further, estimations indicate that the capacity of 124 million tons per year for petrochemical products will remain stable, container capacity is planned to increase from 164 million tons per year in 2018 to 189 million tons in 2021, which implies an increase of 89% over the 2010 capacity level, which was 100 million tons per year.

In terms of the regional port system Cartagena and Buenaventura aim to develop their role as transshipment and logistics hubs. Beyond the pure transshipment activity, the expansion of the two ports as regional logistics centers is part of this strategy, thus capturing value-added services and using the attractiveness of an emerging national market of 49 million inhabitants, the second largest in South America. Example, of first successes, is the establishment of Cartagena as the Latin American distribution center for Decathlon (La Semana, 2018). On the Pacific coast, the development of the Centro Logístico del Pacífico (CELPA) has made the port of Buenaventura attractive for international companies as a distribution center for the West Coast of South America; at the same time the development of national distribution centers in adjacency to the port becomes a more attractive option (CELPA, 2019; Calivia, 2016). The strategies are accompanied by increased expectations in the functioning and reliability of the Colombian port and logistics infrastructure as these will lead to a greater integration of the country in global and regional value chains. Given the identified climate change-related risks, infrastructure adaptation and mitigation move up in the level of importance.

5 Climate change adaptation

Climate change poses new challenges to infrastructure. On the one hand, customers demand reduction of greenhouse gases due to corporate environmental goals (carbon neutrality) or national targets in the countries where they operate. On the other hand, the effects of the climate change are impacting the port infrastructure and its functioning, requiring the development of higher investments for maintenance and generating incident losses. Given this situation ports need to implement measures to mitigate their emissions and to adapt to climate change.

Adaptation measures must include indicators to assess their impact on the environment and on the determinants of vulnerability. In Colombia IDEAM developed indicators and models for this purpose and across all sectors. IDEAM also is responsible for the upcoming National System of Adaptation Indicators, developed by the National Government, and led by the Ministry of Environment and Sustainable Development. Colombia's commitment to GHG emission reductions by 2030 is approximately equivalent to 670 million tons of CO_2 equivalent over the period 2015–30.

Regarding GHG mitigation, the measures considered must be formulated with methodologies validated by the Intergovernmental Panel on Climate Change (IPCC), such as the GHG Protocol or ISO 14064.

The figure below shows GHG adaptation and mitigation measures suggested in Colombia's Port climate change management plan, based on national and international case studies. These are proposed as guidance for decision-makers (Ministry of the Environment and Sustainable Development, 2017) (Fig. 2).

The Colombian government has identified key adaptation, mitigation, and transversal actions (see Tables 2 and 3) to lead the country's port sector in the fight against climate change impacts and to depict possibilities to contribute to the set targets of greenhouse gas emissions.

In the key actions for adaptation and mitigation the relevance of the mangroves as coastal protection becomes evident. Thus, the protection of the current mangroves and reforestation of damaged areas are a central part of the strategy. The listing also shows that the identified actions apply for the Caribbean as for the Pacific coast of the country.

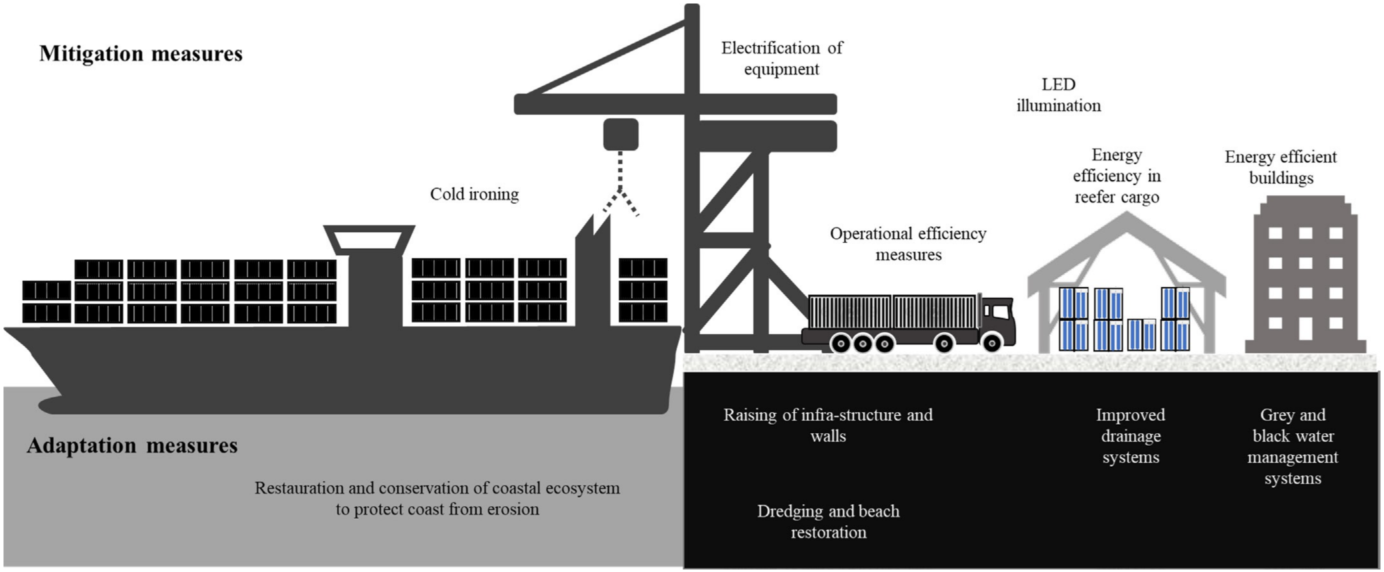


FIG. 2 Proposed mitigation measures in Colombia's port climate change strategy.

TABLE 2 Key actions for climate change adaptation in Colombian seaports.

Threat	Action	Port zone
Sea level rise, flooding, erosion	Protection through management of coastal ecosystems, e.g., mangrove plantation	Gulf of Morrosquillo, Cartagena, Turbo, Buenaventura and Tumaco
	Adaptation of port facilities to minimize impacts from floods, droughts, and coastal erosion, e.g., protective walls, elevation of infrastructure	All
	Articulation of actions of the Road-CC Plan with climate change strategies for seaports in order to reduce vulnerability of ports in terms of connectivity, e.g., consider results of pilot studies of the Road-CC Plan on port access roads	
	Use of the dredging material in accordance with the guidelines of the National Dredging Plan, e.g., beach landfills	
Rainfall increase, temperature increase	Maintenance planning and rehabilitation of port infrastructure taking into account the effects of climate variability and climate change, e.g., with IDEAM climate forecasts	All
	Planning and design of new works considering the risks derived from climate variability and climate change, e.g., guide to incorporate climate change in projects, works or activities of the Ministry of Environment and Sustainable Development	
	Integration of climate change variables into port operating procedures or plans, e.g., ships, terminals, and depots, may require more efficient refrigeration systems in drought seasons, relocation of port facilities to areas not susceptible to sea level rise	
	Reforestation of mangroves and riparian forest and revegetation of areas adjacent to the terminal and in terminal buildings to reduce temperature increase	

TABLE 2 Key actions for climate change adaptation in Colombian seaports.—cont'd

Threat	Action	Port zone
Sedimentation	Planning of dredging activities according to the guidelines of the National Plan	Barranquilla, Dragados Cartagena, Urabá, Buenaventura, Tumaco
Floods and droughts	Implement rainwater capture, management, and storage systems, e.g., rainwater gardens, bio-infiltration or plant trenches, and permeable pavement to infiltrate as much runoff water as possible	All
	Technologies to reduce water consumption, e.g., improved irrigation systems for bulk solids, water recycling systems for carbon wetting	
All	Review and update of standards, codes, and regulations applicable to infrastructure to incorporate the effects of climate variability and change	All
	Identification of future climate change maintenance needs (e.g., tools, plans)	

Source: Ministry of the Environment and Sustainable Development., 2017. Plan de Gestión del Cambio Climático para los Puertos Marítimos de Colombia. Documento de Trabajo. http://www.minambiente.gov.co/images/cambioclimatico/pdf/Plan_nacional_de_adaptacion/Plan_CC_Puertos_version_trabajo.pdf (accessed May 2019).

TABLE 3 Key CO_2 mitigation actions in Colombian seaports.

		Port zones
CO_2 capture	Protection or restoration of ecosystems with CO_2 capture functions, e.g., Mangroves (highest capacity), seagrasses, coral reefs	Golfo de Morrosquillo, Cartagena, Urabá, La Guajira, Buenaventura and Tumaco
Renewable energies	Use of the wind season to generate and supply alternative energy	La Guajira, Santa Marta—Ciénaga, Cartagena, Barranquilla, San Andres
	Installation of photovoltaic panels to energize small infrastructure units (e.g., bathrooms, to gradually increase its capacity. participation	All

Continued

TABLE 3 Key CO_2 mitigation actions in Colombian seaports.—cont'd

		Port zones
Energy efficiency	Adaptation of port facilities to optimize energy and water consumption, e.g., reuse of gray water, and maximize the use of energy and natural lighting	All
	Cold ironing	
	Replacement of technologies by more efficient ones, e.g., reconversion of cranes, forklifts, vehicles, and other equipment to electrical systems	
	Replacement of light bulbs and luminaires in the entire port/terminal	
	Switching off light sensors in buildings	
Transport	Encourage employees to use active travel modes (bicycle, walking), public transport, or car pooling	All
	Establish a policy for minimizing idling tines in port facilities: vehicles turn off engines (eco driving)	
	Promotion of renovation or reconversion of the vehicle fleet to electric, hybrid, or natural gas vehicles	

Source: Ministry of the Environment and Sustainable Development., 2017. Plan de Gestión del Cambio Climático para los Puertos Marítimos de Colombia. Documento de Trabajo. http://www.minambiente.gov.co/images/cambioclimatico/pdf/Plan_nacional_de_adaptacion/Plan_CC_Puertos_version_trabajo.pdf (accessed May 2019).

In terms of mitigation actions, the report focuses on actions that can directly be employed by the sector in the country, renewable energy and energy efficiency building a central axis.

The transversal actions (Table 4) go beyond the "traditional" adaptation and mitigation actions. Here the focus lies on seizing competitive advantage by implementing environmental standards and optimization of the port and logistics system. A crucial element is the development of financing strategies and leveraging public and private investment resources. Further capacity building and constructing of information systems are seen as essential to visualize progress and raise the awareness of the climate change actions in the port sector. The success

TABLE 4 Key transversal actions in the Colombian port sector.

Competitive advantage	• Promoting and transforming of traditional to more efficient ports through optimization and certified environmental management systems, e.g., Ecoports
Adaptation and mitigation in buildings	• Adopting of sustainable construction and renovation guides or standards to increase adaptive capacity and mitigation
Financing	• Developing of financingstrategies that leverage resources to develop climate change actions, e.g., public and private climate funds (through the Climate Change Committee)
Information	• Complementing port information systems with information on climate change to develop vulnerability analysis and greenhous gas inventories and effects • Indicators for evaluating adaptation and mitigation actions in port areas. • Exchange between public and private actors on climate change management
Education and communication	• Training on climate change for port personnel and operators • Dissemination of information on vulnerability and reduction of emissions to the community in the area of influence of the port

Source: Ministry of the Environment and Sustainable Development (2017).

of the implementation of the latter is directly related with the possible success in the search for climate finance, as donors will request for clear success and progress indicators.

5.1 Mitigation efforts and constructing energy consumption and emissions baseline data

Given the focus of mitigation key actions on changing energy sources, energy consumption, and efficiency this section presents and discusses efforts from the Colombian government to create a baseline for mitigation efforts in ports. In a first step the Colombian government has adopted and further developed the energy consumption measuring methodology described in Wilmsmeier and Spengler (2016), Wilmsmeier et al. (2014), and Spengler and Wilmsmeier (2019).

The methodology establishes the system boundaries at terminal level in order to capture differences between terminal types (container, general cargo, dry and liquid bulk). The information has been collected regularly in a joint effort of the Transport Ministry and the School of Management of the Universidad de los Andes. The goal of the data collection is to establish and develop baseline data for climate change mitigation actions as described in Table 3. Beyond energy consumption the collected data include traditional productivity measures, emissions (if calculated by the terminal), water consumption, as well as energy and water costs used.

Given the complexity to capture full emission profiles, energy data are only collected for emissions calculation of scope 1 and scope 2. Thus, for scope 1 calculations, the data on fuels burned in equipment owned by the reporting organization are collected. In the case of scope 2, all electric energy consumption at equipment level as well as the overall purchased electricity is collected. Since the boundaries are set to the organizational boundaries of the terminal, conversion losses that occur in electric energy production in the conversion from fossil energy to electric energy are neglected. For the calculation of scope 2 emissions the form of electric energy production is of relevance. The databases of the International Energy Agency (IEA)[a] and the Latin American Energy Organization [Organización Latinoamericana de Energía] (OLADE) database provide the necessary information and aggregated data at country level.

The methodology allows to disaggregate defined process clusters to individual equipment level. The following equation exemplifies the energy process cluster for container terminals (Spengler and Wilmsmeier, 2019), which is adjusted for other terminal types, respectively:

$$TC_{ij} = \sum_{z=1}^{n} \left(QCC_{ij} + HOC_{ij} + CRC_{ij} + BC_{ij} * LC_{ij} + OC_{ij} + GEN_{ij} \right) + UC_{ij} \quad (1)$$

where z is the type of energy; TC_{ij} is the total energy consumption in terminal i in period j; QCC_{ij} is the energy consumption within the process cluster of quay cranes; HOC_{ij} is the energy consumption within the process cluster of horizontal operations; CRC_{ij} is the energy consumption within the process cluster of reefer cooling; BC_{ij} is the energy consumption within the process cluster of buildings; LC_{ij} is the energy consumption within the process cluster of lighting; OC_{ij} is the energy consumption within the process cluster of others; GEN_{ij} is the energy consumption within the process cluster of generators; and UC_{ij} is the undefined consumption.

Since individual energy consumption of different equipment types and activity clusters might not always be the same as the indicated total consumption, the category the "Undefined consumption" is introduced. This category captures the cases where the terminal's total consumption exceeds the sum of the individual activity clusters (Eq. 2). It has however rather to be understood as a mathematical necessity than a process cluster. The formula for undefined consumption can be seen in the equation below:

$$UC = TC - \left(QCC + HOC + CRC + BC + LC + OC + GEN \right) \quad (2)$$

where UC is the undefined consumption; TC is the total energy consumption from all sources; QCC is the energy consumption from all sources within

a. International Energy Agency: Colombia: Balances for 2012. (URL: http://www.iea.org/statistics/statisticssearch/report).

the process cluster of quay cranes; *HOC* is the energy consumption from all sources within the process cluster of horizontal operations; *CRC* is the energy consumption from all sources within the process cluster of reefer cooling; *BC* is the energy consumption from all sources within the process cluster of buildings; *LC* is the energy consumption from all sources within the process cluster of lighting; *OC* is the energy consumption from all sources within the process cluster of others; and *GEN* is the energy consumption from all sources within the process cluster of generators.

The baseline data are collected using a semistructured questionnaire that is sent to Colombian terminals. The process is iterative with the aim to improve data over time, since terminal operators still have relatively little knowledge about the subject of energy consumption as well as no experience in recording historic energy consumption data in their terminals. In several cases, specific energy consumption source monitoring is not installed. The latter is particularly present in smaller ports and terminals, as they are not acquainted with energy consumption measures. Therefore, some questionnaires are not filled out completely in a first round, but in personal discussion during follow-ups it was possible to obtain the required in most cases. This iterative process also aims to measure the awareness and knowledge of the topic in the sector. Since data on resource consumption (energy and water), productivity, as well as expenses in general are considered confidential, no terminal names or specific locations are published. Terminals receive individual feedback on their data in terms of completeness and quality, including a benchmark exercise to indicate them where they are positioned in comparison to their peers. The latter, however, is dependent on the availability of sufficient data.

In 2018 the database included 23 bulk, liquid bulk, general cargo, and container terminals. The data for a couple of terminals is far back as 2012. The latest data are available for 2017.

The following calculations showcase the advances in Colombia and are based on data provided from six container terminals representing a throughput of 2.66 million containers in 2017. These terminals spent over 936 million current USD on energy sources, consuming 12.48 megaliters of diesel and 83.12 GWh of electricity, emitting an estimated 43.5 thousand tons of CO_2 (Table 5).

Diesel is the main energy source in container terminals across the globe (74% of overall energy consumption) (ECLAC and MTT, 2016; Gonçalves de Souza Viera et al., 2010). Colombia is no exception. In Colombia the share of electricity has been oscillating around 40% between 2014 and 2017. The current dependency on diesel marks a significant potential toward electrification.

The variation of consumption patterns across terminals depends significantly on the equipment configurations in each terminal. In the case of Colombia advances in electrification are not only dependent on the terminals but also requires significant improvement of electricity provision. The current network

TABLE 5 Container terminal climate change baseline data for Colombian container terminals, 2017.

2.66 million container throughput **

>938 thousand USD energy expenses **

12.48 Megalitres diesel consumption **

43.5 thousand tonnes CO_2**

75% full container

25% empty container

20.14 millions** worked hours

83.12 GWh electric energy consumption**

~2 million m^3 water consumption*

Source: Author based on Survey UniAndes Mintransporte 2018.
Notes: * Value based on estimations and data provided from five container terminals.
**Values based on six terminals, estimations based on historic energy data for three terminals.

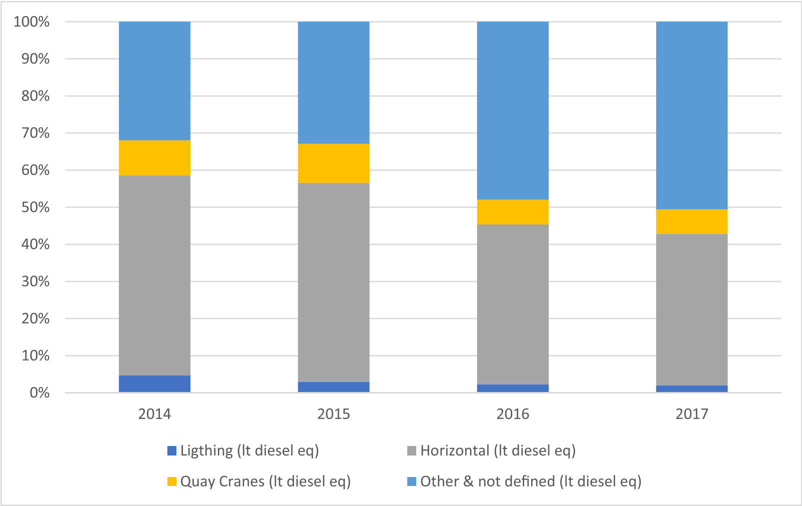
in certain regions does not provide the necessary energy security to make an investment in electric equipment.

The use of different energy sources also requires the transformation of the different energy types into one comparable unit to derive comparable indicators. In the following the different energy sources are converted into diesel liters equivalent to enable such comparison (Spengler and Wilmsmeier, 2019).

The results from the latest survey show that the greatest energy consumption continues to be related to horizontal movements in the terminals (Fig. 3). Further, despite concerted efforts to improve the knowledge and increase the relevance of the topic the share of "undefined consumption" remains relevant. This indicates that more concerted efforts will be necessary to explain the process cluster approach and to convince operators on the relevance in enabling measurement by activity clusters.

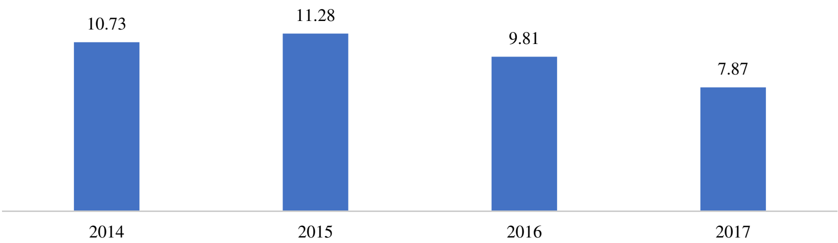
Spengler and Wilmsmeier (2019) show the variation in diesel liters equivalent used to handle a single dry container in different countries. The median consumption per dry container across their global benchmark was 10.4 L diesel equivalent. In the case of Colombia, the average energy used to move one container has improved significantly between 2014 and 2017. In 2014 the average consumption was 10.7 L of diesel equivalent. This value reduced to 7.9 L diesel equivalent by 2017. In Latin America and the Caribbean Spengler and Wilmsmeier (2019) calculated an average consumption of 8 L (Fig. 4).[b]

b. Based on 41 terminals in 17 countries with a total throughput of over 37 million TEU.



Source: Survey UniAndes Mintransporte 2018
Notes: For the years 2014-15 values based on data provided from six container terminals. For the years 2016-17, values based on data provided from three container terminals and estimations based on partial energy data for three terminals

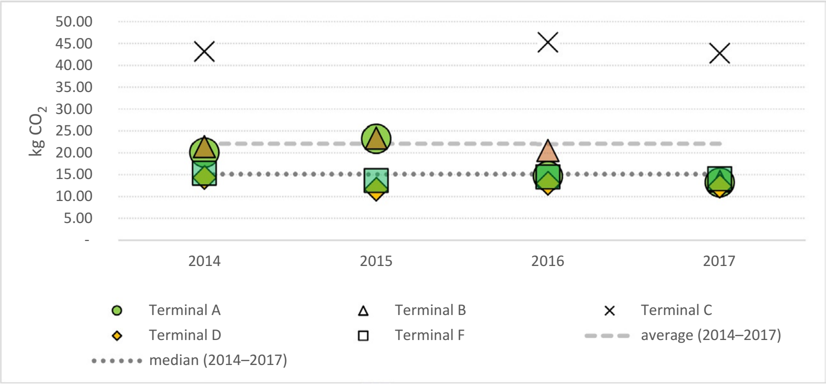
FIG. 3 Share of energy consumption by activity cluster in container terminals, Colombia 2014–17.



Source: Survey UniAndes Mintransporte 2018
Notes: For the years 2014-15 values based on data provided from six container terminals. For the years 2016-17, values based on data provided from three container terminals and estimations based on partial energy data for three terminals

FIG. 4 Average liters of diesel equivalent consumed for handling one dry box (excluding reefer consumption) in Colombia, 2014–17.

Considering the different energy sources, CO_2 emissions (scope 1 and scope 2) per container varied between 12.4 and 42.7 kg in 2017. This difference is significant and reveals the gap between terminals in the same country. It also sets the benchmark for the less efficient terminals. A key element to incentivize terminals, whether public or private, to invest in strategies to reduce emissions is the cost of energy. Thus, the data on energy expenses reveal the economic dimension of energy consumption in general, substituting energy sources, and potential challenges in the current energy tariff structure when implementing



Source: Survey UniAndes Mintransporte 2018.
Notes: For the years 2014–2017 values based on data and estimated data from four container terminals.

FIG. 5 Estimated CO_2 emissions (scope 1 and scope 2) per container and terminal in Colombia, 2014–17. *From Survey UniAndes Mintransporte, 2018. Notes: For the years 2014–2017 values based on data and estimated data from 5 container terminals.*

electrification strategies. In 2017 the average total energy costs for the terminal for moving a container through a Colombian container terminal are estimated to sum up to 37 current USD, 22 current USD for diesel, and 15 for electricity.[c] Consequently, any increase in energy efficiency will not only have a significant impact on the terminal's emissions but also improve its economic performance. The economic dimension in the climate change discussion should not be underestimated since it can bring key arguments for terminals to invest in new technology, change processes, or operating pattern (Fig. 5).

6 Conclusions

This chapter presents an overview of Colombia's strategy for adaptation and exemplifies the efforts to create and develop a baseline for CO_2 emissions in the country's port sector. While the country is clear on the identified actions for mitigation and adaptation (INVEMAR, 2016; INVEMAR-MADs, 2016), the financing of these actions and concrete implementation remain a major challenge. Further, agency to implement proposed actions or guidelines is not always clear. The role of government of private actor responsibilities remains fuzzy and no incentive of investment programs has been developed to incentivize change.

Nevertheless, Colombia shows clear advances in building baseline data for climate relevant indicators, which will facilitate monitoring progress of climate

c. Energy costs will vary by container type, e.g., reefer container as well as type of movement, e.g., transshipment, import, export as these require different handling operations in the terminal.

action in the future. Yet, existing results should not hide that data coverage focuses only on the largest terminals in the country. The current data base on sustainability and productivity of terminals includes 23 terminals. However, according to the Superintendencia de Puertos y Transporte (2016) at least 207 terminals exist in the country, of which 121 are maritime and 86 are inland waterway terminals. Continued efforts to increase the participating number and types of terminals and, thus, to also include a significant number of bulk and river terminals is required.

Acknowledgment

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