HYDROMETEOROLOGICAL RISKS AND THE INSTITUTIONAL MAP FOR CLIMATE CHANGE IN MEXICO

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ABSTRACT

Talking about climate change is talking about a global concern, where international organizations set the guidelines for its treatment. However, each country has its own legislation and organization that create mechanisms outlined towards the adaptation, mitigation or monitoring of risks associated to climate change in vulnerable areas. For the case of hydrometeorological risks, it is necessary to identify which are the main government agencies associated with climate change in Mexico to observe what exists and how it works in order to identify instruments, policies and laws that affect the areas of action of adaptation, mitigation and monitoring of this type of risk. Therefore, based on a search methodology in digital information sources on government websites and documents, the topics related to climate change were classified into four categories: (1) Units responsible for the management, administration and execution of these topics; (2) Systems associated with such dependencies; (3) Laws and guidelines that regulate climate change in Mexico; and (4) Instruments that derive from such dependencies that support the main areas of action regarding adaptation, mitigation and monitoring of disaster risk. It was found that the analysis of the information is viable at three levels: national, state and municipal, where it is observed an inequitable production between levels of programs, instruments, strategies and funds. The government agencies have similarities between the objectives outlined for climate change. However, it is difficult to down-scale the information to the municipal level, where a higher promotion of adaptation and mitigation is observed more in terms of management rather than in operative actions. In addition, in the laws that govern these dependencies there are disconnections between the three levels so that efforts are duplicated, or objectives are not concluded, and most of the laws do not present clear references to international frameworks. The results could be useful to understand and formulate strategies and policy recommendations to reduce risks associated to climate change in Mexico.
Keywords: climate change, institutional map, disaster risk management.

1 INTRODUCTION

In the various societies of the world, in order to influence climate change, participation of all those involved in the issue is necessary and the joint cooperation of the various public and private sectors is essential, from the highest levels of government to neighborhood organizations and the population itself for the mitigation, adaptation and monitoring of risks derived from environmental changes, specifically to reduce hydrometeorological risks.

Due to its geography, Mexico has coastal areas that are at high risk due to extreme phenomena of landslides, droughts, cyclones and dry seasons that impact in the volume of precipitation [1], which can make climate change management more complex. Between 2012 and 2018, Mexico participated in six Conferences of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC), as well as in workshops, negotiation sessions and activities [2]. With this, the Mexican government has launched actions to reduce the emission of compounds and greenhouse gases [3]. Despite the participation in international conventions, there is a disconnection with the legal mechanisms in terms of

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regulations, since there have not been enough actions that integrate systems and structures that achieve the sequential interaction of permanent activities for that purpose.

Taking into account actions that go beyond the emergency attention would mean a transition from a reactive to a preventive risk reduction framework that has been highlighted as a need in the National Civil Protection System in Mexico [4]. Nevertheless, the coordination of such actions and implementation of appropriate mitigation and adaptation measures in the context of climate change is difficult to achieve due to different factors that involve complex socio-economic, political, and institutional processes, not just for Mexico but for many other Latin American cities [5]. From those factors, coordination between city and local-level governments and integration across sectors and government levels remain as a challenge [4], [5]. In this context, a first step to understand and visualize synergies, coherence or overlaps within a national system to tackle hydrometeorological climate change associated risks, is the construction of an institutional map, which is the primary objective of this paper.

At a global scale, as stated by Widerberg et al. [6] *Mapping the Institutional Architecture of Global Climate Change Governance* may involve several dimensions and attributes that "fall within a specific architecture because they share an identifiable governance goal which addresses the issue at hand". For the case of Mexico, this institutional map will focus on the goal of identifying the departments and governmental actions in charge of monitoring, mitigating, and adapting for climate change, providing also an initial quantitative description that may be useful for further investigations in this field.

As a point of departure, it is known that the formulation, evaluation and follow-up of the measures to manage climate change effects continue to be concentrated only in a few unrelated agencies at the national level [7], which in its structure makes impossible to down-scale the information to other levels of government and to the population. In this sense, various questions arise: What are the government agencies that are in charge of climate change actions in Mexico? To what extent are actions coordinated to manage adaptation, mitigation and monitoring? Are there mechanisms that allow the integration of the population in particular actions of hydrometeorological risks? This document is made up of three sections. The first exposes the methodology used to evaluate adaptation, mitigation and direct and indirect monitoring actions on which government agencies focus through their laws and strategic programs; The second part shows the analysis of results and a third part points to the discussion that we face in terms of the legal framework regarding climate change in Mexico.

2 METHODOLOGY

An online search and documents of the institutional organizations in charge of climate change in Mexico were carried out at the end of 2021: 27 web pages of government agencies at the National level were reviewed, 20 web sites of government agencies at the State level corresponding to Mexico City, 12 web sites of agencies of government at the municipal level corresponding to a sample of the 16 municipalities (Iztapalapa Mayor's office), as well as official newspapers and gazettes, in addition to the web sites corresponding to decentralized organizations and programs and instruments, leading to the review of more than 100 internet web sites, as well as review of literature, books and articles. Said information was classified in analysis tables in Excel software, with the secretaries, associated systems, associated laws, commissions, councils, institutions, programs, funds and instruments, policies and documents and recommendations that are in charge of regulating climate change in Mexico. Based on this classification, government agencies were identified in Mexico that are responsible for organizing, managing, creating laws, strategies and documents aimed at

regulating adaptation to climate change, mitigation and direct and indirect monitoring of risks. These units were classified into three levels: national, state and municipal. Likewise, percentages of the regulation were analyzed observing the most worked areas, as well as those that are unprotected with respect to these issues, this analysis was given at the three levels mentioned. With the above, the main connections and disconnections between ministries, institutions and potential central organizations to work on climate change were identified. In the same way, the laws derived from these organisms were observed in the same sense of connection and disconnection.

3 INSTRUMENTS FOR CLIMATE CHANGE IN THE MEXICAN GOVERNMENT SYSTEM AT THE NATIONAL, STATE AND MUNICIPAL LEVEL

Based on the above, five secretariats were identified at the national level and an institute that promote, manage and act in relation to climate change and the issues associated such as risks, vulnerability and disasters. Also the decentralized organizations that are an indispensable part of this process were identified, as well as the most important laws from which action programs are derived, and also those laws that would enable an institutional coordination.

The Secretariat of the Environment and Natural Resources (SEMARNAT) [8], [9], in collaboration with the National Water Commission (CONAGUA) [10] have joined forces to regulate the protection of the environment in order to reduce deterioration and even at some point reverse it through its main laws: The General Law of Ecological Balance and Environmental Protection (LGEEPA) [11], the General Law of Climate Change (LGCC) [12] and the Law of National Waters (LAN) [13] (see Fig. 1).

SEMARNAT is directly and partially linked to other secretariats through the General Law of Ecological Balance and Environmental Protection (LGEEPA) and directly linked to the Secretariat of Agrarian, Territorial and Urban Development (SEDATU) [14] through its General Law of Human Settlements, Land Management and Urban Development [15]. Such Law refers to the fact that all development plans must comply with the environmental statutes of the LGEEPA. Likewise, these two laws are directly linked with the Ministry of the Interior (SEGOB) [16] through the National Coordination of Civil Protection and the National Civil Protection System (SINAPROC) [17] and its decentralized Department: The National Centre for Disaster Prevention (CENADRED) [18], through the General Law of Civil Protection (LGPC) [19].

The Secretary of National Defense (SEDENA) and the Secretary of the Navy (SEMAR) [20], maintains a direct link with SINAPROC through the Marine Plan (Navy Plan) and with SEMARNAT through its laws with the Ministry of Communications, Infrastructure and Transportation (SCT) [21] through its Civil Protection Manual, which is regulated by the General Law of Ecological Balance and Environmental Protection (LGEEPA) and with the General Civil Protection Law of SINAPROC.

The National Institute of Ecology and Climate Change (INECC) [22] is another actor, who is governed by the General Law of Ecological Balance and Environmental Protection (LGEEPA) and the General Law of Climate Change (LGCC); it is based on international statutes, which in turn link it to the SEMARNAT and SINAPROC with the General Law of Civil Protection. The National Waters Law also governs SEMARNAT and maintains a link between laws with the LGEEPA and together with the LGPC are those that link the national level with the state level.

At the state level, with the case of Mexico City, three Secretariats were identified that promote, manage and act with regard to climate change and the issues that affect it such as

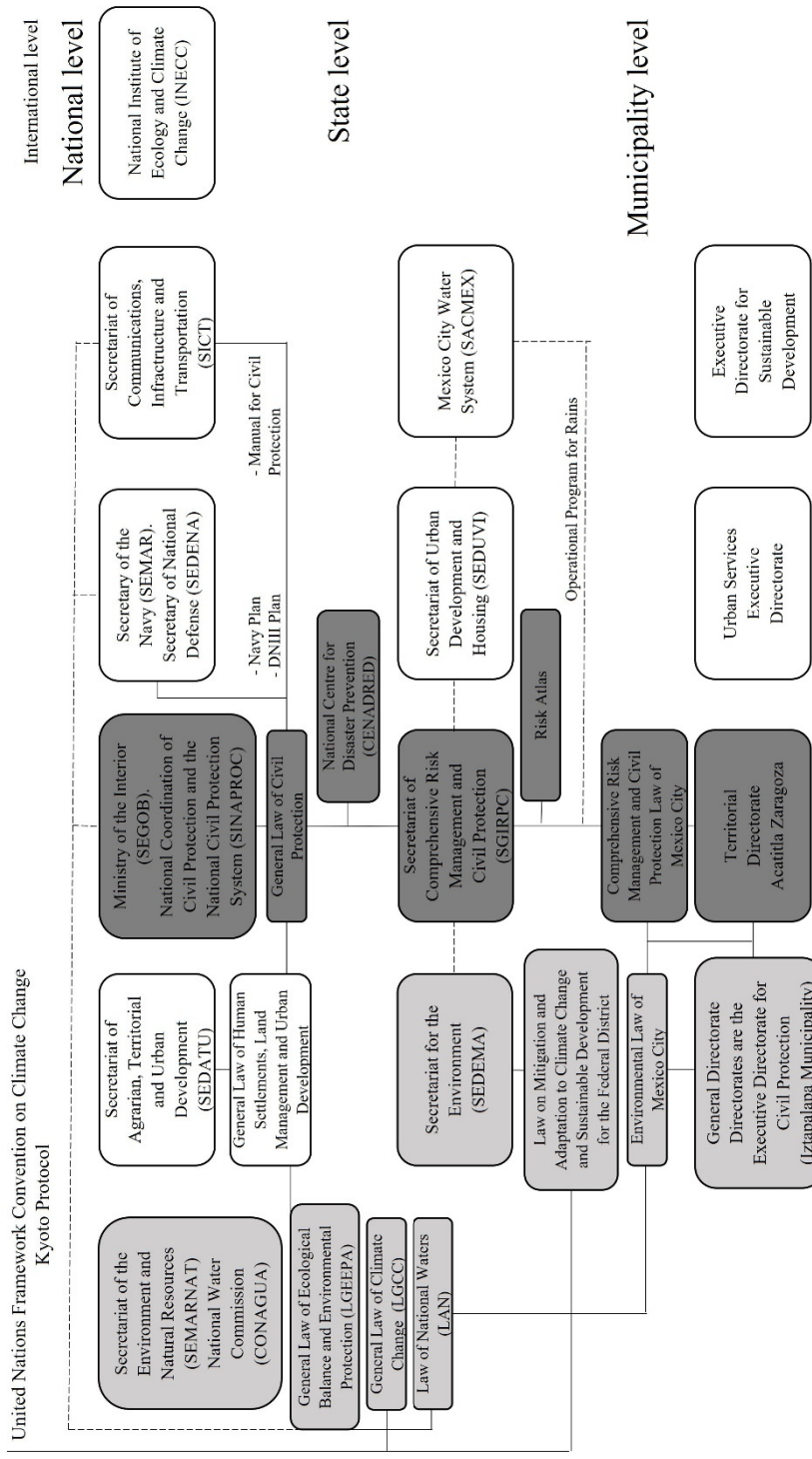

Figure 1: Institutional map associated to climate change actions in Mexico. Vertical axis of coordinated governmental levels for environment and disaster risk management fields are marked in light grey and dark grey respectively.

risks, vulnerability and disasters, among others, as well as the Water System of Mexico City (SACMEX) [23], which are an indispensable part of this process and the most important laws from which action programs emerge, but also those laws that would allow, at any given time, a close coordination.

The Ministry for the Environment (SEDEMA) [24] works at the state level and manages environmental issues in a sustainable sense, is mainly governed by two laws: the Law on Mitigation and Adaptation to Climate Change and Sustainable Development for the Federal District [25] (linked to international frameworks) and the Environmental Law of Mexico City [26], which is linked at the national level with the National Water Law and with the Secretariat of Comprehensive Risk Management and Civil Protection (SGIRPC) [27] at the state level through its Comprehensive Risk Management and Civil Protection Law of Mexico City [28].

SGIRPC is the only Secretariat that has a direct link with the other ones. Those that interact with each other are SEDEMA and the Secretariat of Urban Development and Housing (SEDUVI) [29], nevertheless in an indirect way. The Mexico City Water System (SACMEX) interacts with the SGIRPC due to the Operational Program for Rains regulated by the Comprehensive Risk Management and Civil Protection Law of Mexico City, which in turn is the one that is connected to the Municipal level.

In the case of the municipal level, four Directorates work with issues related to the environment. These Directorates are the Executive Directorate for Civil Protection, the Urban Services Executive Directorate, the Executive Directorate for Sustainable Development and the Territorial Directorate, which, as mentioned before, for the case of the Iztapalapa Mayor's office it is divided into 13 territorial Directorates. In this case we are exemplifying with the Ermita Zaragoza Territorial Directorate [30].

At the Municipal level, with the example of the Iztapalapa Mayor's office, a General Directorate of the Mayor's Office was identified, and four Executive Directorates should act on risks associated to climate change, however, only the General Directorate of the Mayor's Office is linked to two of the Executive Directorates.

The General Directorate of the Mayor's Office is directly linked to the Executive Directorate for Civil Protection and the Territorial Directorate (it is important to mention that Iztapalapa currently has 13 territorial Directorates, as its geographical territory as has been divided due to its geographical extension, more than 116 km^2), Said Directorates are regulated mainly by the Law of Comprehensive Management of Risks and Civil Protection of Mexico City and the Environmental Law of Mexico City, which are laws at the State level. However, the Executive Directorate of Urban Services and the Executive Directorate of Sustainable Development are seemingly administratively disconnected and apparently with no direct or indirect link with citizens [30].

Fig. 1 shows the three levels of government, above the national level; the state level is exemplified with Mexico City and below the municipal level exemplified with one of the municipalities (the Iztapalapa Mayor's office). At the state level, a horizontal link between secretariats is still very diffuse due to its recent creation through an Agreement for the reorganization of the legal framework in environmental matters, urban development, mobility, water and civil protection of 2019.

At the national level is where the regulatory instruments in the field of laws that influence mitigation and adaptation to climate change are more developed. At the state level, these instruments decrease, and the lower the level they disappear, as occurs in the municipal case where there are no regulatory elements. It is identified that there are similarities between the objectives of the different agencies or even between laws, however, it is difficult to down-scale the information. There are two vertical axes that link the national level to the municipal

one: the axis of the environment issues and the axis of disaster risk management (see Fig. 1 in light grey and dark grey respectively).

3.1 Detailed incidence of adaptation, mitigation, direct and in-direct monitoring through the system of government in Mexico

3.1.1 National level

Each of the secretariats at the national level that affect climate change, consider among their instruments laws and programs with a different level of incidence and elements to promote adaptation, mitigation, direct monitoring and indirect monitoring (see Table 1). SEMARNAT promotes actions and instrumentation strategies for adaptation and mitigation with 30% and 31% respectively. One the instruments is the Climate Change Law or the Climate Change Program, but also the National System of Climate Change (SINACC) [31], the Federal Commission for the Protection against Sanitary Risks (COFEPRIS) [32] and the Inter-secretarial Commission of Climate Change.

Direct monitoring represents 17% with meteorological station networks or radio sensors, and indirect monitoring (22%) with instruments such as the National Strategy for Climate Change. CONAGUA stands for direct and indirect monitoring, having an important role, as well as the Meteorological Service (SMN) [33] and the Mexican Institute of Water Technology (IMTA) [34] with direct monitoring.

The Ministry of the Interior (SEGOB) promotes adaptation (28%) either through the Natural Disaster Fund Trust (FONDEN) [35] or the Fund for the Prevention of Natural Disasters (FOPREDEN) [36] and almost with the same percentage the promotion of indirect monitoring (29%), the latter can be undertaken through the Civil Protection Program, followed by direct monitoring, which represents 24%, mainly with the Early Warning Systems and the Risk Atlas. Promotion of mitigation is lower with 19%, and the same can be observed with the Ministry of the Interior trough the promotion of mitigation with the National System of Civil Protection (SINAPROC) and the National Centre for Disaster Prevention (CENAPRED) [37].

The National Institute of Ecology and Climate Change (INECC), also attends climate change through its instruments and documents. From the entirety of its strategies, the most important promotion of indirect monitoring is the National Emission Inventory (14%). While the promotion of adaptation is 28% with actions for climate change, likewise mitigation with 29% and direct monitoring with emissions records with 14%, that are inputs for the Inventory. The Secretariat of Agrarian, Territorial and Urban Development (SEDATU), through the General Law of Human Settlements and Territorial Planning, contemplates the promotion of adaptation and mitigation by 50%, while the Secretariat of the Navy (SEMAR) and the Secretariat for Communications and Transport (SICT) only promote direct monitoring through forecasts of waves and the network of observations based on sea buoys respectively.

3.1.2 State level

Each of the secretariats and the Mexico City Water System (SACMEX) at the state level have influence on climate change actions through instruments, laws and programs with a different level of incidence, regarding the promotion of adaptation, mitigation, direct monitoring and indirect monitoring. In the case of the Secretariat for the Environment (SEDEMA), it contemplates the said types of actions in a different percentage. It mainly promotes mitigation with 52% of its total, especially with plans such as the *Barter Market* or *Solid Waste* Programs, followed by the adaptation promotion with 30% through strategies such as the Environmental Fund for Climate Change [38] or the Climate Change Program itself. To a

Table 1: Number of actions and programs for adaptation, mitigation and monitoring at the three levels of government in Mexico.

Government office	Number of actions and programs (total/percentage)						
	Promotes adaptation	Promotes mitigation	Direct monitoring	Indirect monitoring	Attention to emergencies	Subtotal	Total
National level	20/50 = 40%	18/60 = 30%	15/25 = 60%	16/22 = 72.7%	0		69 (43%)
SEMARNAT	11 (30%)	11 (31%)	6 (17%)	8 (22%)	0 (0%)	36 (100%)	36 (52.2%)
SEDATU	1 (50%)	1 (50%)	0 (0%)	0 (0%)	0 (0%)	2 (100%)	2 (2.9%)
SEGOB	6 (28%)	4 (19%)	5 (24%)	6 (29%)	0 (0%)	21 (100%)	21 (30.4%)
SEMAR	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1 (100%	1 (1.5%)
SICT	0 (0%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)	2 (100%)	2 (2.9%)
INECC	2 (28%)	2 (29%)	1 (14%)	2 (29%)	0 (0%)	7 (100%)	7 (10.1%)
					Subtotal of actions	69 (100%)	
State level	23/50 = 46%	33/60 = 55%	7/25 = 28%	4/22 = 18.2%	0		67 (42%)
SEDEMA	14 (30%)	24 (52%)	5 (11%)	3 (7%)	0 (0%)	46 (100%)	46 (68.6%)
SGIRPC	8 (44%)	8 (44%)	1 (6%)	1 (6%)	0 (0%)	18 (100%)	18 (26.9%)
SEDUVI	1 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	1 (1.5%)
SACMEX	0%	1 (50%)	1 (50%)	0 (0%)	0 (0%)	2 (100%)	2 (3%)
					Subtotal of actions	67 (100%)	
Municipal level	7/50 = 14%	9/60 = 15%	3/25 = 12%	2/22 = 9.1%	3/3 = 100		24 (15%)
Civil protection	1 (8%)	4 (33%)	3 (25%)	2 (17%)	2 (17%)	12 (100%)	12 (50%)
Territorial directorate (1 of 13)	3 (75%)	0 (0%)	0 (0%)	0 (0%)	1 (25%)	4 (100%)	4 (16.6%)
Urban services	3 (43%)	4 (57%)	0 (0%)	0 (0%)	0 (0%)	7 (100%)	7 (29.2%)
Sustainable development	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	1 (4.2%)
					Subtotal of actions	24 (100%)	
Total of actions at the national, state and municipal level	50 (31%)	60 (37%)	25 (16%)	22 (14%)	3 (2%)		160 (100%)

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lesser extent this Secretariat also promotes direct monitoring with 11% through the realization of environmental records and a 7% for indirect monitoring with inventories or derived documents.

SGIRCP focus more on the promotion of adaptation and mitigation which correspond to 44% of both. In the case of adaptation, actions for mitigation are observed such as the *Family Plan for Disaster Preparation* and derivatives. In the case of direct and indirect monitoring, its percentage coincides with 6% mainly through the *Risk Atlas of Mexico City*, although there are some instruments like this that are not defined with the intervention of a single unit. Regarding the Mexico City Water System (SACMEX), the focus is divided by 50% between mitigation actions such as preventive drainage works, infrastructure maintenance, and direct monitoring actions such as water distribution and pump monitoring. While in the case of SEDUVI (Housing and Urban Development Secretary), the totality of its actions are focused on adaptation through housing regulations.

3.1.3 Municipal level

It is important to mention that at this municipal level there is no longer a production of programs or funds beyond the civil protection protocols. For this reason, in the case of the promotion of adaptation, mitigation, direct monitoring and indirect monitoring, only the management part is considered at this level. However, an immediate reaction system appears as part of emergencies attention, so that some results are included. In the case of the Executive Directorate of Civil Protection it promotes to a different extent the five fields. Mainly it promotes mitigation through the Office for Prevention or Coordination of Training for Drills with a 33%. Followed by 25% direct monitoring through water monitoring records through technical coordination; a 17% for indirect monitoring with the coordination of urban incidents and with the same percentage the emergency actions.

As for the Territorial Directorate, it promotes mainly adaptation with 75% through the coordination of hydraulic services or citizen participation projects; 25% of the actions are dedicated to emergencies with the attention to soil cracks related risks. The Executive Directorate of Urban Services promotes mitigation through the solid waste collection or sanitation works with 57%, and a 43% is promoted to adaptation with the infrastructure rehabilitation or with the Department for the network drainage construction. The Executive Directorate for Sustainable Development promotes mitigation at a 100% through the actions of the Office for Environmental Impact.

If we look at the three levels of government together, it can be seen that in some way the three levels promote adaptation, mitigation, direct monitoring and indirect monitoring in addition to emergency attention at the municipal level, that is, with more direct actions. At the national level, the direct monitoring systems are the ones that predominate. At the state level a balance is observed except for indirect monitoring that decreases. At the municipal level emergency attentions emerges immediately, but the production of programs is absent.

4 THE GOVERNMENT SYSTEM AS AN OPPORTUNITY TO COORDINATE ACTIONS FOR HYDROMETHEOROLOGICAL RISK REDUCTION

In the case of hydrometeorological risks, one instrument was identified that can guide the coordination between the different government levels (see Fig. 2). We refer to the *Risk Atlas*, which is a "comprehensive information system on disturbing agents and expected damage; [it is] the result of a spatial and temporal analysis of the interaction between hazards, vulnerability and the degree of exposure of the affected agents" [37]. It is an inclusive monitoring instrument due to the integration of government, autonomous organizations and private institutions. This instrument is concentrated at a middle State level. However, it does

not consider local monitoring, so that a gap opportunity there is evident. This instrument is monitored at the State level through the Secretariat for Comprehensive Risk Management and Civil Protection (SGIRPC) and is powered by different agencies and institutions, including the private sector through the National Laboratory of Earth Observation (LANOT) [37] by satellite. This laboratory is directed by the Geography Institute of the National Autonomous University (UNAM) and by The National Council of Science and Technology (CONACYT). The Mexico City Water System (SACMEX) also participates through the use of the meteorological radar. The Risk Atlas inputs are also produced by the National Centre for Disaster Prevention (CENAPRED) through the monitoring center of the volcano (VM) that makes daily reports. The Ministry of the Environment (SEDEMA) also takes part with inputs for information on air quality that is obtained through sensors. The National Water Commission (CONAGUA) also sends information on accumulated precipitation data collected by the automatic stations of the meteorological service. Also the National Seismological Service (SSN) [39], that belongs to UNAM, participates with the registration of earthquakes as well as the National Commission for the Knowledge and Use of Biodiversity (CONABIO) [40] with the heat spots analysis; and finally the information of Waze which is a real-time transit application that belongs to Google.

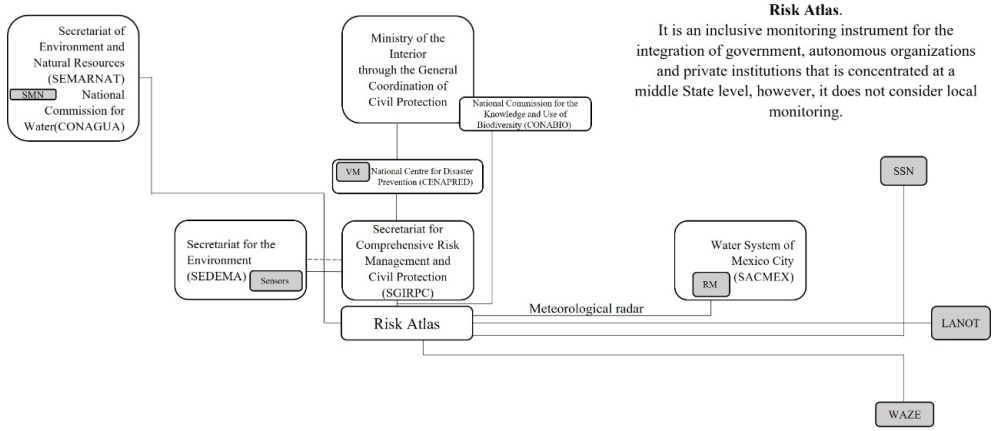

Figure 2: Institutions involved in the functioning of the Risk Atlas in Mexico City.

5 CONCLUSIONS

The analysis of the institutions by levels is feasible with regard to the implementation of regulations focused on climate change. In this way it can be identified the areas of opportunity to integrate the laws, but also the opportunities to integrate community actions. At the national level the instruments and documents for mitigation and adaptation to climate change supported by laws are more developed than the local ones: the lower the level, the fewer elements are available.

There is an unequal production of programs, instruments, strategies and funds between levels but at the lowest level there is an absence of such production. In spite the fact that the organisms have similarities between the objectives, it is difficult to down-scale the information and duplication of efforts is detected due to the disconnection between levels. On the other side, most laws do not present clear references to international frameworks.

The general climate change law does present clear international references but is disconnected from other levels. The Law on Mitigation and Adaptation to Climate Change and Sustainable Development for the Federal District does not present connections to national laws, but it does have clear references to international frameworks.

The federal government agencies that have influence at the lowest levels are the Ministry of the Environment and Natural Resources (SEMARNAT) and the National Civil Protection Coordination. In the case of the Secretariat for Comprehensive Risk Management and Civil Protection (SGIRPC) in Mexico City, it could function as an integration node between the secretariats and their directorates if some mechanisms such as the recent agreement are established. At the municipal level, a higher promotion of adaptation and mitigation is observed in administrative works rather than in operative actions. On the other side, the *Risk Atlas* is an inclusive monitoring instrument due to the integration of the government with autonomous organisms and private institutions that are found at a middle State level, however it does not consider local monitoring, which may represent an opportunity for action.

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