UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
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"GOBIERNOS LOCALES COMO AGENTES CLAVE EN LA ADAPTACIÓN AL CAMBIO CLIMÁTICO EN MÉXICO"

TESIS
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Presente

Me permito informar a usted, que el Comité Académico del Programa de Posgrado en Ciencias de la Sostenibilidad, en su sesión 89 del 14 de marzo del presente año, aprobó el jurado para la presentación del examen para obtener el grado de **DOCTORA EN CIENCIAS DE LA SOSTENIBILIDAD**, de la alumna **Cid Salinas Abril** con número de cuenta **300090714,** con la tesis titulada "Gobiernos locales como agentes clave en la adaptación al cambio climático en México", bajo la dirección de la Dra. Amy Michelle Lerner..

PRESIDENTA:	DRA. NAXHELLI RUIZ RIVERA
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Sin más por el momento me permito enviarle un cordial saludo.

ATENTAMENTE,

"POR MI RAZA HABLARA EL ESPIRITU"
Cd. Universitaria, Cd. Mx., 29 de septiembre de 2023.

Dr. Alonso Aguilar Ibarra
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Resumen

La dimensión institucional es un elemento determinante en la distribución social de la vulnerabilidad y habilitante de la capacidad de adaptación de los sistemas socioambientales al cambio climático a escala local. La capacidad institucional influye en el potencial de los países para responder, en el corto plazo, y adaptarse, en el mediano plazo, a los efectos del cambio climático (Moss et al., 2001). La capacidad adaptativa supone procesos de aprendizaje y cambios en los arreglos de gobernanza e institucionales de manera tal que se generen los medios para adaptarse a condiciones cambiantes (IPCC, 2012, 2014). Pese a que la dimensión institucional es clave para transitar de la planeación a la implementación de la adaptación al cambio climático, la falta de articulación en sistemas de gobernanza multi-nivel es una de las principales barreras para que las instituciones puedan implementar acciones de adaptación al cambio climático (Phuong et al., 2018). En sistemas de gobernanza multinivel, los gobiernos locales juegan un papel clave en la implementación de acciones de adaptación, además de que son los principales interlocutores con la población vulnerable (Mimura et al., 2014). No obstante, existen diversos retos estructurales que dificultan el papel de los gobiernos locales en la adaptación al cambio climático (Noble et al., 2014). La mayoría de los estudios empíricos en capacidad adaptativa se enfocan en casos únicos, cuyos resultados no permiten discriminar determinantes de capacidad adaptativa que son dependientes de la escala y aquellos que podrían presentarse a través de múltiples escalas (Siders, 2019). En este proyecto de investigación se plantea un enfoque teórico-metodológico de análisis de las capacidades institucionales que considere tanto las capacidades como los determinantes para movilizarlas, así como las condiciones reales de procesos de decisión en la escala de implementación local de la adaptación al cambio climático. A partir de la aplicación del enfoque metodológico propuesto, se examinaron las condiciones que inciden en el desarrollo, fortalecimiento y movilización de capacidades latentes de gobiernos locales en sistemas de gobernanza multi-nivel. En particular se plantea la pregunta central de *¿cómo las capacidades institucionales de gobiernos locales se pueden movilizar en acciones de adaptación al cambio climático?* Y de esta pregunta surgen las siguientes preguntas de investigación: (a) ¿Cómo se puede analizar la capacidad institucional de gobiernos locales bajo un enfoque de capacidades que permita articular el bienestar humano como parte de estrategias de adaptación al cambio climático?; (b) ¿Cuáles son las principales barreras y oportunidades para el fortalecimiento de capacidades institucionales de gobiernos locales para la adaptación al cambio climático?; y (c) ¿Cómo movilizan los gobiernos locales sus recursos de colaboración en acciones dirigidas a múltiples riesgos? y ¿cuáles son las implicaciones para sistemas de gobernanza multinivel? En el capítulo I de esta tesis se presentan las bases teóricas de la dimensión institucional en la adaptación al cambio climático. En el capítulo II se describen las herramientas analíticas que se emplearon en la tesis, junto con sus alcances y limitaciones. En el capítulo III se desarrolla el enfoque teórico-metodológico para analizar la capacidad institucional de los gobiernos locales en 2,454 municipios de México. En el capítulo IV se examinan las implicaciones de los resultados del capítulo III, se determinan grupos de capacidad institucional a nivel nacional, así como las principales barreras, retos y oportunidades para fortalecer la capacidad institucional de los grupos de municipios

identificados. En el capítulo V se abordan los retos de integrar elementos determinantes en la movilización de capacidades en la aplicación del enfoque de análisis del manuscrito 1 mediante estrategias de mapeo participativo de redes de colaboración y acciones con alcaldías de la Ciudad de México (manuscrito 3). En el capítulo VI se discuten los alcances teórico-metodológicos y principales hallazgos de los capítulos III, IV y V.

Palabras clave: capacidad institucional, capacidad adaptativa, movilización de capacidades adaptativas, gestión integrada de riesgo, sistemas de gobernanza multinivel

Abstract

The institutional dimension is a key determinant of the social distribution of vulnerability and an enabler of the adaptive capacity of socio-environmental systems to climate change at the local scale. Institutional capacity influences the potential of countries or communities to respond, in the short term, and adapt, in the medium term, to the effects of climate change (Moss et al., 2001). Adaptive capacity entails learning processes and changes in governance and institutional arrangements in such a way as to generate the means to adapt to changing conditions (IPCC, 2012, 2014). Even though the institutional dimension is key to move from planning to implementation of climate change adaptation, the lack of articulation in multilevel governance systems is one of the main barriers for institutions to implement climate change adaptation actions (Phuong et al., 2018). In multilevel governance systems, local governments play a key role in the implementation of adaptation, in addition to being the main contact with the vulnerable population (Mimura et al., 2014). However, there are several structural challenges that hinder the role of local governments in climate change adaptation (Noble et al., 2014). Most of the empirical studies in adaptive capacity focus on single cases, which prevents the identification of adaptive capacity determinants that are scale-dependent from those that could occur across multiple scales (Siders, 2019). This research project proposes a theoretical-analytical approach to the assessment of institutional capacities that considers both the capacities and the determinants for mobilizing them, as well as the actual conditions of decision-making processes at the scale of local implementation of climate change adaptation. Based on the application of the proposed analytical approach, the conditions affecting the development, strengthening and mobilization of latent capacities of local governments in multilevel governance systems were examined. In particular, the following research questions were addressed: a) how can the institutional capacity of local governments be analyzed under an approach that integrates human well-being as part of climate change adaptation strategies; (b) what are the main barriers and opportunities for strengthening institutional capacities of local governments for climate change adaptation; and (c) how do local governments mobilize their collaborative resources in actions aimed to address multiple risks? and what are the implications for multilevel governance systems? Chapter I of this thesis presents the theoretical basis of the institutional dimension of climate change adaptation. Chapter II describes the analytical tools used in the thesis, along with their scope and limitations. Chapter III develops the theoretical-methodological approach to analyze the institutional capacity of local governments in 2,454 municipalities in Mexico. Chapter IV examines the implications of the results of Chapter III,

identifies groups of institutional capacity at the national level as well as the main barriers, challenges and opportunities for strengthening the institutional capacity of the groups of local governments that were determined. Chapter V addresses the challenges of integrating determinants of capacity mobilization in the application of the analysis approach of manuscript 1 through participatory mapping of collaboration networks and actions using Mexico City as a case study (manuscript 3). Chapter VI discusses the theoretical-methodological scopes and main findings of chapters III to V.

Key words: institutional capacity, adaptive capacity, mobilization of adaptive capacities, integrated risk management, integrated risk management, multilevel governance systems

I. Introducción

Los efectos del cambio climático ya se están experimentando en gran parte del Sur Global, incluido México, donde la temperatura de la superficie aumentó casi 0.85ºC por encima de la media en los últimos 50 años y persiste la variación de los patrones de precipitación (periodos de lluvia y fenómenos extremos). Estos efectos, junto con la desigualdad de ingresos y las deficiencias en las necesidades humanas básicas, determinan la vulnerabilidad diferencial al cambio climático observada en México. En su recientemente actualizada Contribución Nacionalmente Determinada (NDC, por sus siglas en inglés), México requiere implementar acciones climáticas en el 50% de los municipios más vulnerables, particularmente en aquellos con mayores carencias de desarrollo (SEMARNAT, 2020). Este compromiso ilustra el reto para los gobiernos locales de crear capacidades para movilizar sus recursos para la acción contra el cambio climático en condiciones de subdesarrollo y exposición diferencial a las amenazas climáticas. En este contexto, se requiere de una adecuada capacidad institucional para que las instituciones locales puedan ser efectivas para la acción climática a través de la construcción de consenso entre diversos intereses, de promover la coordinación e informar la formulación de estrategias de adaptación (IPCC, 2023). A continuación, se describen las bases teóricas para avanzar en el entendimiento del papel de la capacidad institucional en la adaptación al cambio climático.

I.1. Antecedentes teóricos y conceptuales

Los antecedentes teóricos de esta tesis abordan la capacidad adaptativa de los sistemas socioambientales y la capacidad institucional como uno de los determinantes o condiciones habilitantes de la capacidad adaptativa. El análisis de la capacidad institucional se basa en enfoques de capacidades y su movilización, así como de capacidades genéricas para atender deficiencias en condiciones de desarrollo y capacidades específicas para la atención de riesgos. Finalmente, se abordan los sistemas de gobernanza multinivel como un enfoque clave para entender el papel que juegan los gobiernos locales para la acción climática a través de redes de colaboración.

1. Capacidad adaptativa

En general, la *capacidad adaptativa* se refiere a una propiedad o capacidad de los sistemas socioambientales para responder, ajustarse, aprender y/o adaptarse a perturbaciones, disturbios y/o sorpresas (Turner, 2010; Gallopín, 2006; Turner *et al.,* 2003; Folke *et al.,* 2002; Carpenter *et al.*, 2001). En esta investigación se retoma la conceptualización de la capacidad respuesta separada de la capacidad adaptativa (Gallopín, 2006). La primera involucra ajustes ―incidentales o deliberados― que dependen de recursos disponibles para manejar y sobreponerse a condiciones adversas para asegurar un funcionamiento básico en el corto plazo (IPCC, 2012; Kates, 2000; Nelson et al., 2007). La segunda se relaciona a acciones de largo plazo dirigidas a anticipar cambios y abordarlos de forma proactiva, por lo que involucra procesos de aprendizaje y cambios en la exposición del sistema, en los sistemas de reglas y en las formas de gobernanza (Gallopín, 2006; IPCC, 2014). Además, la capacidad adaptativa de un sistema se relaciona con la "…gestión

y gobernanza que tiene el sistema para mitigar las amenazas y mejorar la relación con el ambiente" (p.183 en Calderón-Contreras, 2017).

2. Capacidad institucional

En el contexto de la adaptación al cambio climático, la capacidad institucional juega un papel clave al proporcionar una masa crítica de recursos humanos, físicos, financieros y administrativos para consolidar las instituciones públicas y los instrumentos políticos asociados a la capacidad de adaptación (Aall & Norland, 2005). Además, la capacidad institucional definida a partir de un enfoque de gobernanza integra las estructuras y procesos sociales que permiten a la sociedad compartir el poder con el gobierno e integrar acciones colectivas e individuales entre instituciones formales e informales (Lebel et al., 2006). Un enfoque de gobernanza considera la contribución de diversas comunidades de práctica a la gestión de los asuntos públicos, a la cooperación y participación pública en los procesos de decisión, y a la distribución de responsabilidades colectivas (Carrera-Hernández et al., 2010).

Las principales barreras y oportunidades que enfrentan las instituciones en la planeación de la adaptación son: (a) la coordinación entre diferentes niveles políticos y administrativos en la sociedad; (b) la presencia de actores clave, partidarios, y defensores (campeones) que inician, establecen y mantienen el *momentum* para la adaptación al cambio climático; (c) las interacciones transversales entre sectores, actores, y políticas que operan en niveles administrativos similares; (d) las dimensiones políticas en la planeación e implementación; y, (e) la coordinación entre agencias gubernamentales administrativas, sectores privados y tomadores de decisiones que incrementan la eficiencia, representación y apoyo a las medidas de adaptación al cambio climático (Mimura et al., 2014).

De acuerdo con Noble y colaboradores (2014), los elementos críticos de diseño para entender las necesidades institucionales en materia de adaptación al cambio climático son el: (1) grado de flexibilidad a través, y al interior, de las instituciones para evaluarse y reorganizarse; (2) grado en que la adaptación puede ser transversalizada en el proceso de toma de decisiones, a corto y largo plazo; (3) potencial para la coordinación, comunicación y cooperación efectiva a través de diferentes órdenes de gobierno y sectores; y (4) grado en que las instituciones son lo suficientemente robustas para atender las necesidades de los tomadores de decisión e involucrarlos en las decisiones y acciones de adaptación.

Con respecto a los antecedentes teóricos sobre capacidad institucional en materia de adaptación al cambio climático, Gupta y colaboradores (2010) mencionan que no hay marcos para evaluar la capacidad de adaptación creada por las instituciones y que la mayoría de la literatura se refiere a pasos a seguir en lugar de criterios a cumplir. En atención a ello surge el marco conceptual-metodológico Rueda de Capacidad Adaptativa (ACW, por sus siglas en inglés).

3. Enfoques para el análisis de la capacidad institucional en el contexto del cambio climático

3.1. Enfoque de capacidades o capitales

En el contexto del cambio climático, el concepto de *capacidades* abarca las condiciones y características que permiten a la sociedad acceder a recursos sociales, económicos, psicológicos, culturales, informáticos y asociados a hogares e instituciones para reducir la vulnerabilidad y afrontar las consecuencias de las amenazas del cambio climático (IPCC, 2012). La consideración del concepto de capacidades retoma tanto la composición de los capitales de los que disponen las comunidades, como las fuentes de influencia y movilización de dichas capacidades (Eakin, 2015).

La capacidad adaptativa se ha evaluado tradicionalmente bajo el enfoque de capacidades de la teoría de Amartya Sen y de las evaluaciones de los modos de vida, que se desarrollaron en las décadas de los 1980's y 1990's. No obstante, no existe un método estandarizado para operacionalizar este enfoque. Generalmente se evalúan los cinco capitales definidos en el enfoque de modos de vida sostenibles: natural, físico, financiero, social y humano. Estos capitales conforman lo que se denomina capacidad genérica, junto con las dimensiones institucionales, de gobernanza y acceso a conocimiento. El reto de operacionalizar este enfoque es la aplicación en múltiples escalas y riesgos, debido a que ha sido exitosamente aplicado a nivel de hogar, pero pierde capacidad de explicación a nivel de escalas mayores, como a nivel de país (Mortreux & Barnett, 2017).

El uso de enfoque de capacidades genéricas ha recibido las mismas críticas que el Índice de Desarrollo Humano (IDH), particularmente en lo que concierne al uso de criterios subjetivos para la ponderación de los determinantes, la redundancia entre variables y la falta de datos y estrategia para asegurar que dichas métricas puedan informar y evaluar políticas públicas. El uso de índices agregados conlleva que los resultados puedan no ser sensibles a la naturaleza diferencial y contexto-dependiente de la adaptación. Lo que podría enmascarar diferencias relevantes entre sitios y comunidades (Mortreux & Barnett, 2017).

Además, una de las mayores críticas a este enfoque es que se basa en el supuesto de que la existencia de capacidades se traduce automáticamente en acciones. Por lo tanto, existe la necesidad de entender cómo estos capitales/capacidades se movilizan para implementar acciones de adaptación. Por otra parte, existen estudios que han demostrado que la relación entre capacidad adaptativa y adaptación no siempre es directa y que existen casos de baja capacidad adaptativa en donde se observa mayor adaptación, que en casos con alta capacidad adaptativa (Mortreux & Barnett, 2017).

3.2. Enfoque de movilización de capacidades

Este enfoque aborda la capacidad adaptativa como atributos que permiten a los sistemas sociales y actores adaptarse. Los estudios desarrollados bajo este enfoque se caracterizan por una falta de evidencia de adaptación, lo que a su vez limita evaluar la relación entre la capacidad adaptativa y la adaptación. No obstante, provee de insumos para incorporar factores psicosociales en el análisis de la capacidad adaptativa. El avance en esta frontera de investigación sobre capacidad adaptativa se puede beneficiar de otras disciplinas, tales como estudios empíricos sobre reducción de desastres y ciencias del comportamiento. Estas necesidades de investigación se dirigen a entender

mejor los elementos que determinan que los sistemas sociales se preparen y respondan mejor a eventos extremos, pese a una aparente alta capacidad (Mortreux & Barnett, 2017).

Uno de los principales retos para entender la movilización de las capacidades hacia la acción es la falta de evidencia empírica de cómo la ciencia de la capacidad adaptativa está informando efectivamente a las diversas comunidades de práctica. Siders (2019) indica la necesidad de integrar los objetivos de los usuarios finales y sugiere que al abordar los beneficios y limitaciones relativos de un determinante específico de la capacidad adaptativa en diferentes circunstancias puede proporcionar un medio para comprender mejor las disyuntivas (*trade-offs*) entre los determinantes de la capacidad adaptativa.

La consideración del manejo del riesgo de desastres como una analogía a la adaptación al cambio climático permitiría avanzar en el entendimiento de la relación entre capacidad adaptativa y adaptación, particularmente para entender mejor las condiciones bajo las cuáles moviliza la capacidad adaptativa para responder a desastres. Entre los factores propuestos que explican la movilización de capacidades para responder a desastres se encuentran las percepciones de riesgos en el involucramiento de actores en la adaptación y reducción del riesgo de desastres; y la falta de confianza y expectativas en las autoridades, como una de las barreras institucionales para la adaptación (Mortreux & Barnett, 2017).

3.3. Enfoque de capacidades genéricas y específicas

La consideración del concepto de capacidades retoma tanto la composición de los capitales de los que disponen los sistemas sociales, como las fuentes de influencia y movilización de dichas capacidades (Eakin, 2015). En particular, se identifican las capacidades adaptativas, de tipo genérico y específico. Las primeras abordan las deficiencias estructurales en la atención a las necesidades básicas de desarrollo humano ―i.e. salud, educación, movilidad e ingreso― que permiten a los sistemas humanos responder a múltiples estresores. Las segundas se relacionan a las habilidades y herramientas que se requieren para anticipar y responder a amenazas específicas, como las que supone el cambio climático (Eakin et al., 2014). La creación y desarrollo de ambos tipos de capacidades no es necesariamente agregables, dado que puede suponer sinergias y disyuntivas entre ambos tipos (M. Lemos et al., 2013).

4. Métodos de análisis de la capacidad adaptativa

El análisis de la capacidad adaptativa se puede dividir en dos grupos generales: enfoques basados en indicadores y el uso de medidas indirectas (*proxy*) de la capacidad adaptativa. Los enfoques basados en indicadores se caracterizan por la identificación de un conjunto de determinantes de la entidad de interés, con base en juicio experto y en la revisión de la literatura, para posteriormente agregarlos en una evaluación general de la capacidad adaptativa. En contraste, el uso de proxies se dirige a identificar medidas indirectas de los determinantes de la capacidad adaptativa, para después evaluarlos mediante indicadores y comparar los resultados de la evaluación para identificar las medidas indirectas (proxy) que se correlacionan. El tipo de medida (proxy) más común es el resultado de un desastre, y se considera como una medida indirecta de los

determinantes de la vulnerabilidad. Otras medidas indirectas (proxy) incluyen la adopción de una práctica de adaptación específica, el resultado específico de una medida de adaptación o una medida social. El enfoque en medidas indirectas de capacidad adaptativa se basa en el supuesto de que los grupos o entidades con mayor capacidad son aquellos que probablemente adoptarían dichas medidas o prácticas (Siders, 2019).

Las limitaciones o retos de los enfoques basados en indicadores incluyen la falta de estandarización de los indicadores y la falta de elementos empíricos con respecto a los cuales se puedan validar los resultados de los indicadores. En el caso de los enfoques basados en medidas indirectas (proxy), las limitaciones o retos residen en basarse en el supuesto de que la evidencia de esfuerzos y capacidades pasadas son indicadores robustos de capacidad futura, y que la capacidad para implementar una acción específica de adaptación es evidencia de la capacidad para adaptarse de forma general. Además, el uso de correlaciones como evidencia de existencia de capacidad adaptativa puede ser incorrecta, dado que una falta de correlación puede estar más asociada a la selección de la medida indirecta (proxy) y del resultado analizado, que a la relación conceptual que se busca analizar (Siders, 2019).

5. Gobiernos locales y sistemas de gobernanza multinivel

Pese a que la dimensión institucional desempeña un papel clave en la transición de la planeación a la implementación de la adaptación, las instituciones se enfrentan a varias barreras para implementar medidas de adaptación (Phuong et al., 2018). La falta de coordinación horizontal -entre los sectores público, privado y social- y vertical -entre los niveles local, subnacional, nacional e internacional-, es una de las principales barreras que deben superar las instituciones para aplicar la adaptación al cambio climático.

La integración horizontal adquiere relevancia a partir de la necesidad de acuerdos y mecanismos institucionales que permitan a la sociedad compartir el poder e integrar las acciones individuales y colectivas, entre instituciones formales, p.ej. gubernamentales, y no formales, p.ej. ONG. Desde esta perspectiva, la participación civil, la transparencia y la rendición de cuentas, los marcos jurídicos apropiados, la estabilidad política y la calidad de la regulación se convierten en dimensiones institucionales relevantes que apoyan una mayor credibilidad de las políticas públicas en el contexto de la planificación y la implementación de la adaptación. La integración vertical requiere la existencia de acuerdos institucionales entre niveles de gobierno y un enfoque en el desarrollo de capacidades (Amend, 2019). Los gobiernos nacionales cumplen la función de (a) crear marcos normativos que promuevan la coordinación entre los gobiernos estatales y locales; (b) proteger a las poblaciones vulnerables; y (c) proporcionar apoyo financiero y técnico a los gobiernos subnacionales y locales. Mientras tanto, los gobiernos subnacionales desempeñan un papel complementario al de los gobiernos nacionales. Sin embargo, los gobiernos nacionales y subnacionales pueden limitar las iniciativas locales y crear dependencias negativas debido a la falta de inversión en el desarrollo de capacidades a escala local (Mimura et al., 2014).

Los gobiernos locales son el escenario ideal para abordar la necesidad de integración vertical y horizontal. Este tipo de gobiernos tiene la responsabilidad de implementar la adaptación al cambio

climático en coordinación con los gobiernos subnacionales y nacionales. Además, los gobiernos locales son el actor gubernamental inmediato que interactúa con las poblaciones vulnerables (Mimura et al., 2014). No obstante, los gobiernos locales se enfrentan a retos estructurales asociados a la escasez de recursos y capacidades (Noble et al., 2014). Por lo tanto, es necesario desarrollar la capacidad institucional de los gobiernos locales para abordar la integración vertical y horizontal para la planificación y ejecución de la adaptación.

La capacidad institucional de los gobiernos locales puede fortalecerse a través de sistemas de gobernanza multinivel (IPCC, 2022). Las estrategias de gobierno jerárquicas y centradas en el Estado, basadas en enfoques tecnocráticos tradicionales descendentes (*top-down*), han demostrado ser inadecuadas para abordar múltiples riesgos que interactúan entre sí y son de corte transversal (Frey & Ramírez, 2019). Por el contrario, la gobernanza multinivel ofrece una forma de gobernanza basada en redes que operan tanto en un ámbito horizontal, con gobiernos locales vecinos, organizaciones de la sociedad civil y comunidades locales; como en entornos verticales, con autoridades gubernamentales de nivel superior y organizaciones internacionales (Fliervoet et al., 2016; Frey & Ramírez, 2019). La gobernanza multinivel puede habilitar o fortalecer la colaboración y mejorar el uso eficiente de recursos escasos a través de responsabilidades compartidas y la prevención de políticas contradictorias (Frey & Ramírez, 2019). También puede contribuir a la devolución de poder de los gobiernos centrales a los locales y aumentar el poder compartido entre el Estado y la sociedad civil (Di Gregorio et al., 2019). Los elementos exitosos en la atención de riesgos de desastres por parte de la gobernanza multinivel incluyen el papel protagónico de los gobiernos locales y su capacidad para involucrar a las comunidades locales y a los ciudadanos y para interactuar constantemente con las autoridades de nivel superior en los procesos de implementación (Frey & Ramírez, 2019). Además, existen respuestas a problemas asociados a escalas transversales (verticales u horizontales) que involucran: (a) la interacción entre sistemas de gestión situados en niveles adyacentes; y (b) el co-manejo, que involucra una serie de acuerdos que se basan en diversos grados de reparto de poderes y responsabilidades entre los gobiernos y las comunidades locales (Cash et al., 2006). Las principales barreras de los sistemas de gobernanza multinivel para la acción climática incluyen:

- Los límites jurisdiccionales que crean barreras a las interacciones entre niveles, reforzando los desajustes entre las respuestas institucionales y las realidades del cambio climático (Di Gregorio et al., 2019).
- Los gobiernos nacionales o subnacionales pueden mantener las asimetrías de poder con los gobiernos locales; por ejemplo, impidiendo el acceso a la información a otros actores políticos Las diferencias de poder entre niveles refuerzan los desajustes de escala entre las instituciones y los problemas perversos que supone el cambio climático (Di Gregorio et al., 2019).
- La inequidad política subyace al acceso diferencial a recursos críticos y la descentralización que se asocia a la provisión de nuevos recursos y poder a los responsables locales de la toma de decisiones (Ruiz-Rivera & Melgarejo-Rodríguez, 2017).

- La centralización de los sistemas políticos, que impide a los gobiernos subnacionales y locales compartir experiencias y cooperar (Solorio, 2021).
- Bajos niveles de legitimidad democrática, que previenen determinar mejor el papel de la sociedad en las redes de colaboración; es decir, cómo es representada y empoderada por los acuerdos de la red de colaboración o si son limitados por favorecer prácticas más tecnocráticas (Frey & Ramírez, 2019).

I.2. Preguntas de investigación y objetivos

La pregunta principal de este proyecto fue *¿Cómo las capacidades institucionales de gobiernos locales se pueden movilizar en acciones de adaptación?* De esta pregunta central surgieron las siguientes preguntas de investigación:

¿Cómo se puede analizar la capacidad institucional de gobiernos locales bajo un enfoque de capacidades que permita articular el bienestar humano como parte de estrategias de adaptación al cambio climático?

¿Cuáles son las principales barreras y oportunidades para el fortalecimiento de capacidades institucionales de gobiernos locales para la adaptación al cambio climático?

¿Cómo movilizan los gobiernos locales sus recursos de colaboración en acciones dirigidas a múltiples riesgos? y ¿cuáles son las implicaciones para sistemas de gobernanza multinivel?

Para responder a las preguntas de investigación, se desarrolló un proyecto de investigación con el objetivo de integrar un enfoque teórico-analítico de las capacidades institucionales que considere tanto las capacidades como los determinantes para movilizarlas, así como las condiciones reales de procesos de decisión en la escala de implementación local de la adaptación al cambio climático. A partir de la aplicación del enfoque teórico-analítico propuesto, se buscó examinar las condiciones que inciden en el desarrollo, fortalecimiento y movilización de capacidades latentes de gobiernos locales en sistemas de gobernanza multinivel. A partir de este objetivo general se atendieron los siguientes objetivos específicos: (a) integrar un enfoque teórico-metodológico para analizar las capacidades institucionales de gobiernos locales; (b) implementar el enfoque teórico-metodológico de capacidades institucionales en los gobiernos locales de México; (c) identificar los principales retos y oportunidades para fortalecer las capacidades institucionales de los gobiernos locales en México; y (d) identificar los principales recursos de colaboración en un caso de estudio de México, y determinar las acciones a través de las cuáles los movilizan.

Esta investigación se dirige a contribuir a la línea de investigación "Gobernanza, planeación colaborativa y aprendizaje social" del Programa de doctorado en Ciencias de la Sostenibilidad, UNAM, mediante la generación de conocimiento empírico sobre la capacidad institucional como condición habilitante de la adaptación en escalas locales.

A través de esta investigación se obtuvieron tres productos principales, que consisten en un capítulo de libro y dos artículos científicos centrales para esta tesis (y como primera autora) son:

- Cid A, Cano D, Montalvo V, Ruíz-Bedolla K, Romero-Cazares M, Monterroso-Rivas AI, et al. Insights for building institutional capacities for climate change adaptation: evidence from Mexico. In: Leal Filho W, Luetz JM, Yayeh Ayal D, editors. Handbook of Climate Change Management: Research, Leadership, Transformation. Switzerland: Springer Nature; 2020.
    - Este capítulo de libro presenta el enfoque teórico-analítico para evaluar las capacidades institucionales de gobiernos locales y su aplicación en 2,457 municipios en México. En este capítulo se atendió la primera pregunta de investigación: *¿Cómo se puede analizar la capacidad institucional de gobiernos locales bajo un enfoque de capacidades específicas y genéricas que permita dirigir los esfuerzos a articular el desarrollo y bienestar humano como parte de estrategias de atención del cambio climático y con ello, contribuir a abordar las causas estructurales de la vulnerabilidad?* Y los objetivos a y b (ver Capítulo III).
- Cid A, Lerner AM. Local governments as key agents in climate change adaptation: challenges and opportunities for institutional capacity-building in Mexico. Clim Policy. 2023; 1–13. doi:10.1080/14693062.2022.2163972.
    - Este artículo representa el manuscrito de requisito, en el cual se abordó la segunda pregunta de investigación y el objetivo c (ver Capítulo IV).
- Cid A, Siqueiros-García JM, Mazari-Hiriart M, Guerra A and Lerner AM. Mobilizing institutional capacities to adapt to climate change: local government collaboration networks for risk management in Mexico City. Clim Action (in prep).
    - Este artículo representa el segundo manuscrito de requisito y en él se atiende la última pregunta de investigación y el objetivo d. (ver Capítulo V).

II. Métodos

Preguntas	Objetivos	Métodos	Limitaciones
¿Cómo se puede analizar la capacidad institucional de gobiernos locales bajo un enfoque de capacidades específicas y genéricas que permita dirigir los esfuerzos a articular el desarrollo y bienestar humano como parte de estrategias de atención del cambio climático y con ello, contribuir a abordar las causas estructurales de la vulnerabilidad?	a) Integrar un enfoque teórico-metodológico para analizar las capacidades institucionales de gobiernos locales b) Implementar el enfoque teórico-metodológico de capacidades institucionales en los gobiernos locales de México	- Construcción de indicadores - Integración de índices - Análisis de clusters o grupos	La información base para poder evaluar al total municipios tenía que venir de fuentes oficiales y ser accesible para los 2,457 municipios evaluados. Por ello, se limitó a datos del Censo Nacional de Gobiernos Municipales y Demarcaciones Territoriales, por lo que hubo dimensiones institucionales que no se incorporaron y municipios que quedaron fuera
¿Cuáles son las principales barreras y oportunidades para el fortalecimiento de capacidades institucionales de gobiernos locales para la adaptación al cambio climático?	c) identificar los principales retos y oportunidades para fortalecer las capacidades institucionales de los gobiernos locales en México	- Construcción de indicadores - Análisis de correlaciones - Análisis de clusters - Residuales de Gower para el análisis de los grupos de capacidades institucionales	Idem caso anterior, pero con datos actualizados del censo
¿Cómo movilizan los gobiernos locales sus recursos de colaboración en acciones dirigidas a múltiples riesgos? y ¿cuáles son las implicaciones para sistemas de gobernanza multinivel?	d) identificar los principales recursos de colaboración en un caso de estudio de México, y determinar las acciones a través de las cuáles los movilizan	- Obtención de información base a partir de talleres participativos (presenciales y virtuales). - Análisis temático a partir de la codificación de una matriz de acciones con base en un enfoque deductivo - Análisis de redes sociales (redes de colaboración)	Debido a la pandemia COVID-19, una parte de los talleres se tuvo que llevar a cabo de forma virtual. Ello dio lugar a diferencias en la información recabada. Dado que no se pudo tener varias mesas de trabajo, la cantidad de riesgos abordados fue menor en los talleres virtuales.

III. Insights for building institutional capacities for climate change adaptation *(manuscrito 1)*.

Cid, A., Cano, D., Montalvo, V., Ruíz-Bedolla, K., Romero-Cazares, M., Monterroso-Rivas, A. I., Caso, M., & García-Meneses, P. M. (2020). Insights for building institutional capacities for climate change adaptation: evidence from Mexico. In W. Leal Filho, J. M. Luetz, & D. Yayeh Ayal (Eds.), *Handbook of Climate Change Management: Research, Leadership, Transformation*. Springer Nature. https://link.springer.com/referenceworkentry/10.1007%2F978-3-030-22759-3_246-1#DOI.

En este manuscrito se desarrolla el enfoque teórico-metodológico para analizar la capacidad institucional de los gobiernos locales (municipios) en 2,454 municipios de México. Este manuscrito es el resultado del trabajo colaborativo con instituciones gubernamentales federales (Instituto Nacional de Ecología y Cambio Climático), no gubernamentales mexicanas (Transparencia Mexicana, A.C.) y con organismos de cooperación internacional (Programa de las Naciones Unidas para el Desarrollo).

Abstract: Institutions play a key role in planning and implementing climate change adaptation in Latin America and the Caribbean. However, the absence of integration between different government levels and multiple sectors is one of the main barriers that institutions need to address to implement climate change adaptation. Local governments are the ideal arena to address the need for vertical and horizontal integration because they are the immediate government actor interacting with vulnerable populations. Yet, local governments are usually challenged by scarce resources and capacities to confront differential climate change exposure. This chapter describes an analytical approach to assess the institutional capacities of local governments for climate change adaptation in Mexico. This approach comprised the development of: (1) a conceptual model of institutional capacity of local governments; (2) institutional capacity indicators; (3) institutional capacity indices; and (4) institutional capacity clusters of local governments in Mexico. This approach was used to evaluate 2,454 local governments in Mexico using data from official government sources which are periodically updated on a national scale. The analytical approach follows a hybrid between top-down (national and subnational) and bottom-up (local) approaches. A hybrid approach has been recognized by the IPCC as the most efficient way to implement climate change adaptation because it integrates the robustness of a top-down approach with the flexibility of a bottom-up approach. The outcomes of this study can inform authorities how to allocate scarce resources for building local institutional capacities to foster climate change adaptation in Mexico.

Resumen: Las instituciones desempeñan un papel clave en la planificación e implementación de la adaptación al cambio climático en América Latina y el Caribe. Sin embargo, la ausencia de integración entre los diferentes niveles de gobierno y los múltiples sectores es una de las principales barreras que las instituciones deben abordar para implementar la adaptación al cambio climático. Los gobiernos locales son el escenario ideal para abordar la necesidad de integración vertical y horizontal, ya que son el actor gubernamental inmediato que interactúa con las

poblaciones vulnerables. Sin embargo, los gobiernos locales suelen enfrentarse al reto de la escasez de recursos y capacidades para hacer frente a la exposición diferencial al cambio climático. Este capítulo describe un enfoque analítico para evaluar las capacidades institucionales de los gobiernos locales para la adaptación al cambio climático en México. Este enfoque comprendió el desarrollo de: (1) un modelo conceptual de capacidad institucional de los gobiernos locales; (2) indicadores de capacidad institucional; (3) índices de capacidad institucional; y (4) conglomerados de capacidad institucional de los gobiernos locales en México. Este enfoque se utilizó para evaluar 2.454 gobiernos locales de México utilizando datos de fuentes gubernamentales oficiales que se actualizan periódicamente a escala nacional. El enfoque analítico sigue un híbrido entre los enfoques descendente (nacional y subnacional) y ascendente (local). Un enfoque híbrido ha sido reconocido por el IPCC como la forma más eficiente de implementar la adaptación al cambio climático porque integra la solidez de un enfoque descendente con la flexibilidad de un enfoque ascendente. Los resultados de este estudio pueden informar a las autoridades sobre cómo asignar los escasos recursos para crear capacidades institucionales locales que fomenten la adaptación al cambio climático en México.

Insights for Building Institutional Capacities for Climate Change Adaptation: Evidence from Mexico

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Abstract

Institutions play a key role in planning and implementing climate change adaptation in Latin America and the Caribbean. However, absence of integration between different government levels and multiple sectors is one of the main barriers that institutions need to address to implement climate change adaptation. Local governments are the ideal arena to address the need for vertical and horizontal integration, because they are the immediate government actor interacting with vulnerable populations. Yet, local governments are usually challenged by scarce resources and capacities under differential climate change exposure. This chapter describes an analytical approach to assess the institutional capacities of local governments for climate change adaptation in Mexico. This approach comprised the development of (1) a conceptual model of institutional capacity of local governments; (2) institutional capacity indicators; (3) institutional capacity indices; and (4) institutional capacity clusters of local governments in Mexico. It was used this approach to evaluate 2454 local governments in Mexico using data from government official sources that is periodically updated on a national scale. The analytical approach follows a hybrid between top-down (national and subnational) and bottom-up (local) approaches. A hybrid approach has been recognized as the most efficient way to implement climate change adaptation, because it integrates the robustness of a top-down approach with the flexibility of a bottom-up approach. The outcomes of this study aim to inform authorities in allocating scarce resources for building local capacities to foster climate change adaptation in Mexico.

Keywords

Institutions · Adaptive capacity · Local governments · Specific and generic capacity

Introduction

Institutions play a key role in planning and implementing climate change adaptation. Institutional elements influence the social distribution of vulnerability and shape adaptive capacities (IPCC 2012). Institutional development and capacities influence the potential of countries to cope and adapt to the effects of climate change (Moss et al. 2001). Although the institutional dimension plays a key role in the transition from adaptation planning to implementation, institutions face several barriers for implementing adaptation measures (Phuong et al. 2018). The lack of horizontal –

between public, private, and social sectors – and vertical – between local, subnational, national, and international levels – integration is one of the main barriers that institutions need to address to implement climate change adaptation.

Horizontal integration gains relevance from the need of the institutional arrangements and mechanisms that enable society to share power and to integrate individual and collective actions, between formal – i.e., government – and nonformal – i.e., NGOs – institutions. From this perspective, civil participation, transparency and accountability, appropriate legal frameworks, political stability, and regulatory quality become relevant institutional dimensions that support higher credibility to public policy in the context of adaptation planning and implementation.

Vertical integration requires the existence of institutional arrangements among government levels and a focus on capacity building (Amend 2019). National governments fulfill the role of (a) creating normative frameworks that promote coordination between state and local governments; (b) protecting vulnerable populations; and (c) providing financial and technical support to subnational and local governments. Meanwhile, subnational governments play a complementary role to national governments. However, national and subnational governments can constraint local initiatives and create negative dependencies due to the lack of investment in capacity building at a local scale (Mimura et al. 2014).

Local governments are the ideal arena to address the need for vertical and horizontal integration. Local governments have the responsibility of implementing climate change adaptation in coordination with the subnational and national governments. Also, local governments are the immediate government actor interacting with vulnerable populations, either from the social or private sector (Mimura et al. 2014). However, local governments face structural challenges associated with scarce resources and capacities (Noble et al. 2014). Hence, there is a need for building the institutional capacity of local governments to address the vertical and horizontal integration for adaptation planning and implementation.

Capacities for climate change adaptation involve social, political, legal, institutional, technological, financial, innovation, and capacity for scaling (Iza 2019). These capacities are part of the adaptive capacity defined as "the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC 2014a, p.2). Usually, adaptive capacity is considered the counterweight of the other two vulnerability determinants: exposure and sensitivity. In the context of climate change, research on capacity has focused on the material and immaterial resources and assets, that are susceptible to being measured and observed, but harder to be empirically linked to a vulnerability reduction (Eakin et al. 2014). Even though the approach to institutional capacity used here is based on a constitutive perspective, it considers what is needed and mobilized to foster adaptive capacity in a particular context and region.

In particular, Mexico was the first developing country to submit its own NDC and also the first NDC to include commitments regarding adaptation (SRE 2016). Mexico undertook the challenge of increasing the adaptive capacity of at least 50% of the most vulnerable municipalities (Magnan and Ribera 2016). To do this,

Mexico relies on a national climate change policy comprised of general law and several public policy instruments, such as the Climate Change State Programs and the Climate Change Municipal Policies (SEMARNAT and INECC 2014). However, Mexican authorities – at national, state, and local levels – face differential exposure to climate change hazards and multiple challenges in development, such as pervasive poverty. These conditions translate into varying degrees of institutional capacities – i.e. budget, organizational structures, and technical capacities – that can hinder their ability to implement adaptation measures. In this context, we developed an analytical approach to assess the institutional capacities of 2454 local governments in Mexico for climate change adaptation, built as a collaboration between the National Institute of Ecology and Climate Change (INECC), the United Nations Environment Programme (UNDP) and Transparencia Mexicana, the national chapter of Transparency International.

Theoretical Basis on Institutional Capacity for Climate Change Adaptation

In the climate change literature, adaptation focuses on the moderation or avoidance of damages associated with climate change (IPCC 2014a) . Adaptation actions, however, may contribute to maintaining social-ecological systems in maladaptive pathways by increasing environmental degradation, generating negative socioeconomic externalities, or reducing the preconditions to sustainable development (Juhola et al. 2016). These causes of maladaptation relate to an independent treatment of climate change adaptation and sustainable development (Eriksen and Brown 2011).

Vulnerability can be conceptualized by allocating the risk either in the hazard or in the social system. The former holds on the assumption that climate change effects are independent of underlying social conditions, which overlooks the heterogeneous social contexts where vulnerability is produced and distributed. The latter bears the assumption that vulnerability relates to a lack of means to act and protect oneself at the risk of climate change effects (Ribot 2014). Vulnerability has been assessed mainly under the first approach, which has overlooked the underlying causes of risk. Consequently, adaptation focuses on technical solutions concerned only on what is to be preserved (Pelling 2011). Hence, interventions posed by adaptation may reproduce risk and lead to an accumulation of vulnerability as development fails, such as poverty and exclusion (Matyas and Pelling 2012). There is empirical evidence that illustrates how vulnerability has the potential to affect development and increase poverty in the long term, such as the positive feedback between vulnerability and poverty (Hallegatte et al. 2017). In this context, vulnerability cannot be addressed without accounting for sustainable development that involves the interests of future generations, nonhuman entities, and the marginalized (Pelling 2011; Pelling et al. 2015). On that basis, adaptation to climate change can be regarded as a social process contingent on ethics, knowledge, and attitudes towards risk and culture (Adger et al. 2009). Adaptation to climate change also means that the

design and implementation of adaptation actions are mediated by social and political relations, which may respond to other causes apart from climate change (Pelling et al. 2015). Smit and Wandel (2006) argue that adaptation actions are rarely discrete, stand-alone, and exclusively related to climate change measures. Instead, the authors argue that revisiting land-use planning legislation or improving the application of building standards regulations are examples of adaptations that are neither discrete nor exclusive for climate change (Pelling et al. 2015). Therefore, climate change adaptation can be used to challenge the development pathways that generate social inequity, poverty, and environmental problems.

Sustainable adaptation arises in response to unintended adverse effects on humans and the environment generated by maladaptation, related to trade-offs and negative externalities in social and environmental settings. This type of adaptation comprises a set of actions that contribute to, or at least, do not erode, social justice, and environmental integrity, and can be implemented through adaptive capacities (Eriksen and Brown 2011). Adaptive capacity entails learning processes and changes in governance and institutional arrangements that provide the means to adapt to changing conditions (IPCC 2012, 2014a). This capacity includes available resources and abilities that secure a basic performance in the short term, and the generation of new abilities or resources focused on anticipating changes in order to adapt in the long term (Gallopín 2006; Smit and Wandel 2006). Two dimensions of adaptive capacity become relevant in the context of climate-related risks and underdeveloped conditions: specific capacities, that comprise abilities and resources to manage specific risks; and, generic capacities, which involve actions focused on addressing basic human needs. Due to the multiple scales of decision-making, where these types of capacities may reside or be generated, one of the main challenges to address is the trade-off that emerges between the building of one type of capacity at the expense of another type in other places or scales. The two dimensions of adaptive capacity can be addressed at a governance level that refers to the socio-institutional arrangements. Sustainable adaptation comprises high generic and specific capacities, which characterizes by positive feedback between adaptation and development that reduces the overall vulnerability (Eakin et al. 2014). There is a need for empirical research on the building of generic and specific capacities, and how these can contribute to sustainable adaptation.

Adaptive Capacity Analytical Approach

There are several analytical approaches for addressing climate change adaptation, which can be clustered in three types: bottom-up, top-down, and a hybrid approach between the two. A bottom-up approach is mainly used at local scales by municipal or local governments and communities (Mimura et al. 2014). A bottom-up approach is essential to foster climate change adaptation at the local scale because adaptation is context-dependent (Eakin et al. 2014). Consequently, local governments and communities are involved at the closest level of implementation of adaptation (Mimura et al. 2014). The challenges of a bottom-up approach include restrictions relating to the

transfer of results to higher scales and difficulties coordinating the allocation of scarce resources (Noble et al. 2014). The top-down approach is the most widely used in national and subnational scales (Mimura et al. 2014). In this approach, national governments coordinate adaptation actions at subnational and local levels, through (a) the development of regulatory frameworks to normalize decisions at subnational and local levels; (b) motivating and coordinating the creation of legal frameworks to regulate the actions of productive sectors and resource management; (c) protection of vulnerable groups; and (d) provision of financial support to other government levels. Subnational governments play a complementary role to national levels in a top-down approach in adaptation planning. The main challenges to a top-down approach include the restrictions of local initiatives and the generation of negative dependencies in local governments and communities due to the lack of investment in capacity building (Mimura et al. 2014). A hybrid approach between top-down and bottom-up approaches has been recognized as the most efficient way to implement climate change adaptation measures. Through this hybrid approach, national governments play the role of coordinators in the implementation of adaptation at regional and local levels. Coordination between institutions at multiple scales among different sectors and actors is fundamental to reduce risk at regional levels (IPCC 2012). Therefore, a hybrid approach integrates the robustness of a top-down approach – i.e., institutional arrangements and accountability mechanisms – with the flexibility of a bottom-up approach – i.e., citizens' participation mechanisms (Smit and Wandel 2006; Mimura et al. 2014; Noble et al. 2014). It was used a hybrid approach to define the features of institutional capacity in the context of climate change adaptation in Mexico.

Institutional Capacity in the Context of Climate Change Adaptation

In the context of climate change adaptation, institutional capacity plays a key role by providing a critical mass on human, physical, financial, and administrative resources to consolidate the public institutions and policy instruments associated to adaptive capacity (Aall and Norland 2005). Furthermore, institutional capacity defined based on a governance approach integrates the social structures and processes that enable society to share power with the government and integrate collective and individual actions between formal and informal institutions (Lebel et al. 2006). A governance approach considers the contribution of diverse practice communities to the management of public affairs, to the cooperation and public participation in decision processes, and the distribution of collective responsibilities (Carrera-Hernández et al. 2010). In our analytical approach, the contributions of a governance lens consist in the integration of citizen participation, transparency and accountability dimensions in the operationalization of institutional capacity. Thus, the main determinants of institutional capacity in our study were: (a) human, physical, financial, and administrative resources and (b) the capacity to mobilize and manage them in different scales. The capacities to mobilize these resources comprise administrative,

public-services provision, accountability, legal framework, and financial capacities (Martínez-Pellégrini et al. 2008; Carrera-Hernández et al. 2010; López and Gómez-Álvarez 2010; Rosas-Huerta and Gil-Montes 2013).

Operationalizing the Hybrid Approach

The methods followed to assess the institutional capacity of the 2454 municipalities in Mexico are described in this section, along with the main results. The assessment of the institutional capacity of the municipalities in Mexico followed an indicators-based approach (Hinkel 2011). This procedure entailed four steps: (1) conceptualization of institutional capacity in terms of specific and generic capacities to adapt to climate change; (2) construction of institutional capacity indicators regarding the specific and generic capacities of municipalities; (3) integration of the indicators in institutional capacity indices; and (4) generation of institutional capacity clusters. Each step of this procedure was developed for the specific and generic capacities domains. The units of analysis for the multidimensional measurement of institutional capacity were the 2454 local governments (municipalities hereon), distributed in 32 states or subnational governments, in Mexico. The selection of data on a municipality scale responded the need to use reliable data that was systematically collected and compiled by official sources, mainly from the federal government. This scope also entails limitations, as the lack of available data for three municipalities that hindered the evaluation for their local governments. Hence, instead of analyzing the total of municipalities (2457), it was examined the 99% of the municipalities (2454) in Mexico, due to the lack of available data for three of them. Nevertheless, it provides a common baseline for most of the municipalities to be assessed and compared based on the same databases.

Conceptualization of Institutional Capacity in Terms of Specific and Generic Capacities for Climate Change Adaptation

The conceptual structure of institutional capacity was defined in terms of their specific and generic adaptive. The specific capacity was operatively defined as the adjustments composed by short-term actions focused on managing and overcoming the risks posed by the adverse effects of climate change (Kates 2000). Specific capacities aim to increase the ability of vulnerable populations to respond to specific climate risks, such as through the development of early warning systems (Eakin et al. 2014). The operative definition of generic capacity encompasses long-term actions that address future trends and resource availability, which have the potential to modify a social-ecological system's sensitivity or exposure to perturbations (Gallopín 2006; Smit and Wandel 2006). This operative definition has a focus on the role played by institutions in determining the development conditions of the vulnerable populations living within the territorial limits of the municipality. Overall, the specific capacity structure relates mainly to civil protection, while the generic

capacity structure comprises elements of land-use planning, urban development, environment and ecology, public services provision, and citizen participation. Although, both capacities can be regarded as complementary, there are also trade-offs between them. A focus on responses to climate change risks can undermine elements generating and reproducing climate change vulnerability (Eakin et al. 2014). Hence, specific and generic capacities must be addressed explicitly as both potentially complementary and detrimental to each other. An adequate approach to address this condition is a multidimensional approach, where each domain – specific and generic – constitutes a single analytical axis that can be examined in a matrix.

The institutional capacity structure for the specific capacity domain includes five dimensions: *planning instruments, administrative capacity, political and institutional coordination, transparency and accountability, and citizen participation* (Fig. 1a). The institutional capacity structure for generic capacity contains the same dimensions plus a *public services* dimension (Fig. 1b).

- *Planning instruments*: regulations with the potential to reduce risk and increase the generic capacity of vulnerable populations (Jones et al. 2014).
- *Administrative capacity*: (a) human, economic, and material resources and (b) technical and management abilities to implement climate change adaptation (Rosas Huerta 2008; Bojórquez-Carrillo et al. 2015).
- *Public services*: actions undertaken by local governments to secure the basic needs of the population (Carrera-Hernández et al. 2010) and can influence the social distribution of vulnerability (Mimura et al. 2014).
- *Political and institutional coordination*: institutional arrangements and mechanisms that enable cross-cutting coordination, and prevent duplicating efforts and conflicts among government actors (IPCC 2012).
- *Transparency and accountability*: monitoring and evaluation of the planning and implementation of climate change adaptation (Mimura et al. 2014); also mirrors the flexibility within and among institutional arrangements, enabling the evaluation and reorganization processes of institutions in the context of climate change (Noble et al. 2014).
- *Citizen participation*: mechanisms and instruments available for the citizens to engage in planning, implementing, and evaluating climate change adaptation actions. This dimension is essential to generate effective governance approaches that influence climate change adaptation in decision-making processes (Mimura et al. 2014).

Construction of Institutional Capacity Indicators Regarding Specific and Generic Capacities

Sixty variables were selected based on deductive arguments (Hinkel 2011) developed from a literature review. Variables were clustered in two levels of criteria – dimensions and subdimensions – in the specific and generic capacities domains. A database was constructed from administrative records and surveys from the 2014

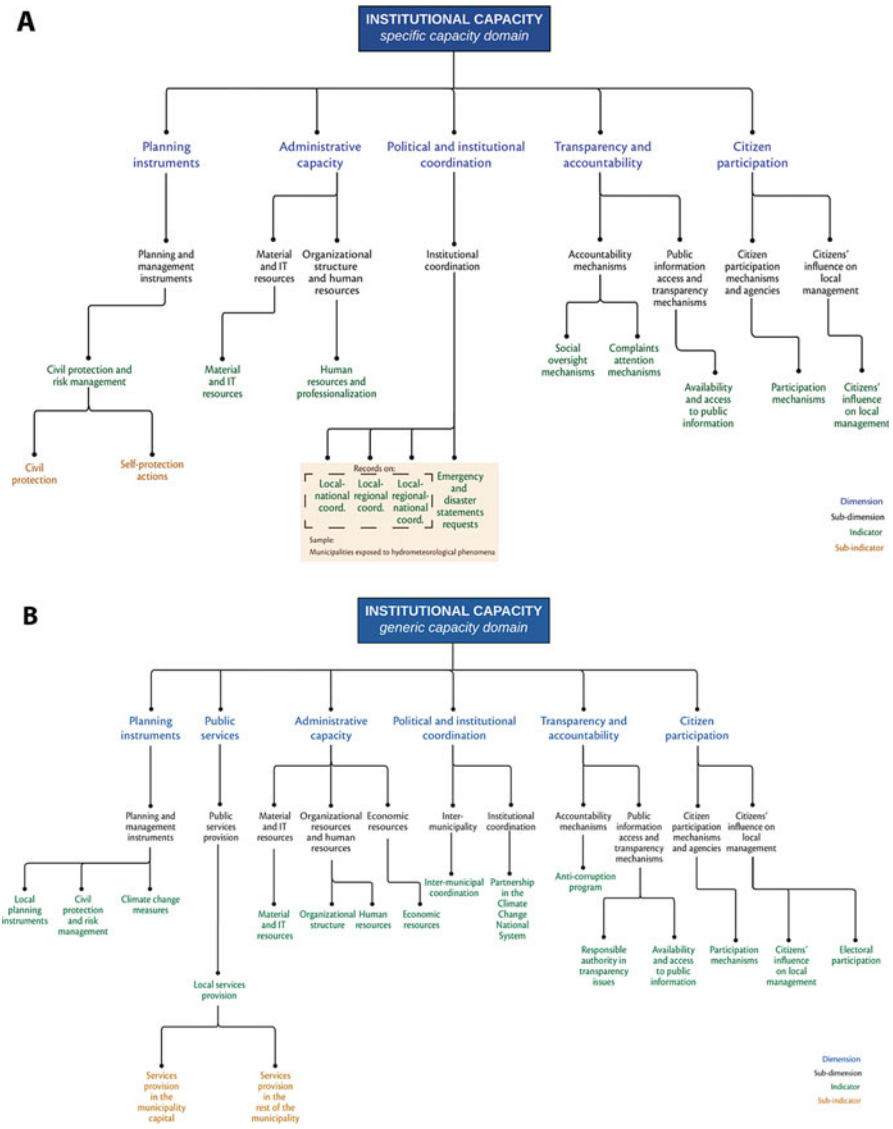

Fig. 1 Institutional capacity composition in the specific (**a**) and generic (**b**) capacities domains

National Census of Local Governments (CNGMD-INEGI 2015), the State and Local System Database (SIMBAD-INEGI 2014), Federal Elections Statistics System (INE 2015), Natural Protected Local Areas (CONABIO 2015), and the Local Ecological Ordinance Programs (SEMARNAT 2015). The variables were transformed into scalar and composed indicators for each dimension of the domains of specific and generic capacities. Scalar indicators consisted of the association of a theoretical

variable to a single observable variable (Hinkel 2011); for example, it was used the existence of the Partnership in the Climate Change National System (observable variable) as an indicator of the existence of institutional coordination (theoretical variable) in the municipality. Composed indicators related several observable variables to a theoretical variable; for example, it was used the presence of local planning instruments, civil protection, and risk management instruments and self-protection actions (observable variables) as indicators of the existence of planning and management instruments (theoretical variable). Twenty-eight indicators were constructed, 12 for the specific capacity domain and 16 for the generic capacity domain. Then, each indicator was evaluated in terms of a minimal baseline that local governments should display to enable climate change adaptation in the municipality. For example, it was considered the existence of local planning instruments in the municipality, such as Local Ordinance Ecological Programs and Urban Development Programs; still our databases did not provide us with enough information on the performance of these programs. Subsequently, nonparametric and parametric correlation tests were applied to indicators in order to determine very high correlations among them. The correlation tests used were: Goodman-Kruskal Gamma test, Somers' D test, Spearman's rank correlation coefficient, Cramer's V test, Cohen's d test, and Pearson's correlation coefficient. Due to the different value ranges of the indicators, the indicators were transformed to an interval scale through a min-max normalization (OECD 2008).

Within the specific capacity domain, most of the municipalities were concentrated around the highest values of the emergency and disaster statements request – from the *political and institutional coordination* dimension – and citizens' influence on local management – from the *citizen participation* dimension. In contrast, most of the municipalities lacked planning instruments, elements of administrative capacity, political and institutional coordination, and citizen participation regarding specific capacities. In the generic capacity domain, most of the municipalities lacked planning instruments, material and economic resources, and inter-municipal coordination.

Integration of Institutional Capacity Indices in Terms of Specific and Generic Capacities

The final set of indicators were aggregated into indices of institutional capacity in terms of specific (SC index here on) and generic (GC index here on) capacities by means of an equally weighted linear combination. The integration of the indices required the aggregation of the dimensions, subdimensions, and indicators on the basis of equal weights. However, it should be noted that an aggregation based on equal weights underlies the assumption that all indicators and criteria – dimensions and subdimensions in our case – are perfect substitutes, and that the low value of one indicator can be compensated by the high value in another (Hinkel 2011). To address this question, further research is required to determine the relative importance of the dimensions and subdimensions in specific contexts. To do so, there are some

analytical tools that can enable the comparison of heterogeneous indicators, such as multicriteria decision analysis (MCDA) (Bojórquez-Tapia et al. 2011). MCDA can integrate normative arguments (Hinkel 2011), such as experts judgment, from different practice communities (Bojórquez-Tapia et al. 2011). The indices were categorized into five classes: very low (0–0.2), low (0.2–0.4), moderate (0.4–0.6), high (0.6–0.8), and very high (0.8–1). A multidimensional measurement of institutional capacity (MMIC here on) was developed through the evaluation of the SC and GC indices in a matrix arrangement. The average value of both indices is very similar: 0.37 for specific capacity and 0.35 for generic capacity. However, the SC index displays greater differences between municipalities, with a standard deviation of 0.20, while the GC index exhibits a standard deviation of 0.12. The GC index concentrates most of the municipalities in a range of 0.2–0.6, while the SC index concentrates most municipalities in a wider range, between 0 and 0.6 (Fig. 3). Regarding very high values, 1% of the municipalities reach the very high class in the SC index and only one municipality falls into the same classification in the GC index.

Regarding the spatial distribution, the SC index (Fig. 2a) displays more heterogeneity than the generic capacity index (Fig. 2b). The municipalities that have the lowest value in the specific and generic capacities indices are in the state of Oaxaca. Meanwhile, the municipalities that have the highest value of specific and generic capacities indices locate in the states of Chiapas, Campeche, and Jalisco. This visualization provides elements to identify regions that completely lack institutional elements to adapt to climate change, while other regions concentrate in high classes of the SC index and at the same time distribute in lower classes of the GC index.

Multidimensional Measurement of Institutional Capacity MMIC

The MMIC comes from the simultaneous examination of the SC and GC indices in an *institutional capacity matrix*, where each axis represents one of the capacity domains (specific and generic capacities). The relation between the two indices can be perceived as positive, which means that higher values of specific capacity entail higher values of generic capacity and vice versa. However, in higher classes – i.e., very high and high – the variability of the specific capacity index increases (Fig. 3). The highest percentage of municipalities is concentrated in the combination of low SC and GC (23.8%). In contrast, the combination of high SC index and very high GC index had the lowest positive number, only one municipality.

Based on the heuristic proposed by Eakin et al. (2014), the municipalities that can be assumed to be in a poverty trap are the ones that ranked lower regarding specific and generic capacities are located in Oaxaca (Figs. 3 and 2a, b). It was not found evidence of a municipality in a sustainable adaptation condition. Instead, it was observed municipalities with high specific capacities, but no high generic capacities (safety-first); as well as municipalities with high generic capacities and no high specific capacities (safe development paradox). Safety-first conditions comprise a higher prioritization of present-day safety and security, involving weak safety nets at

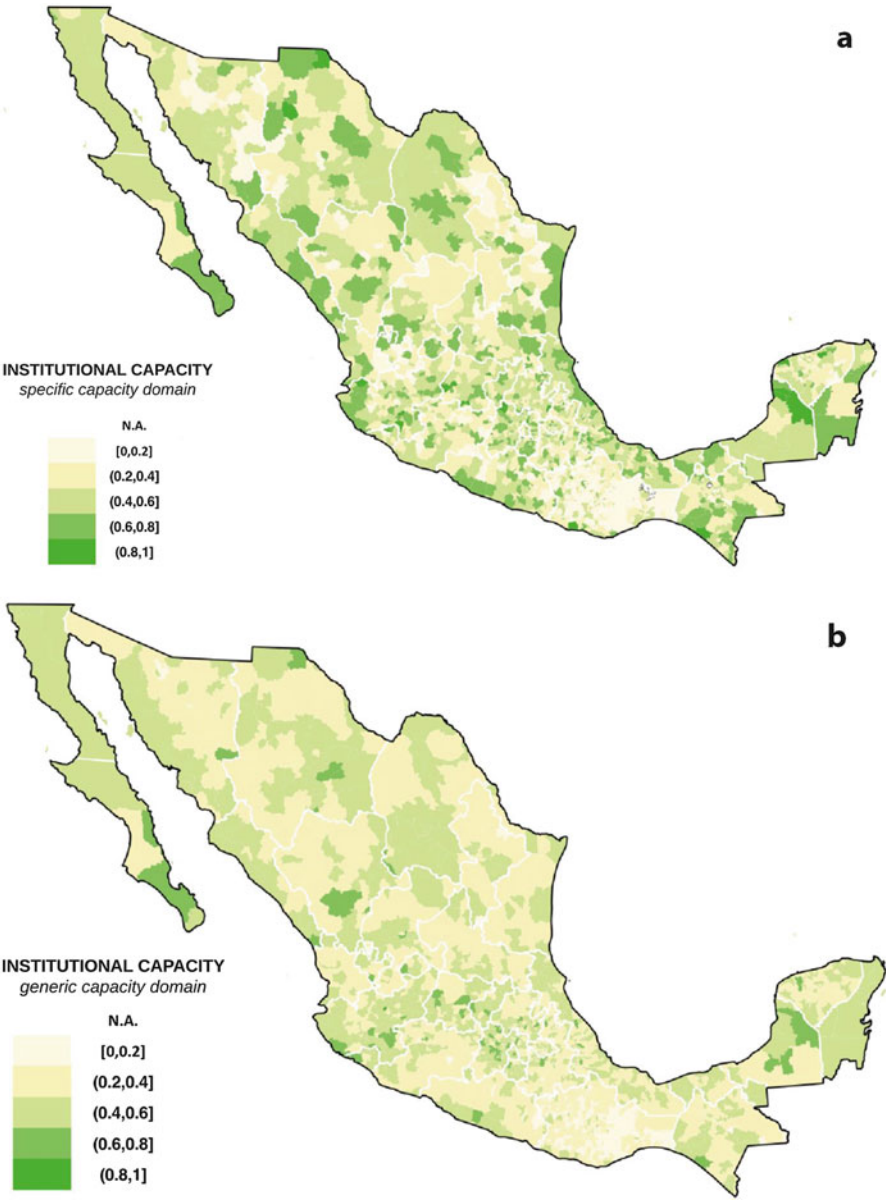

Fig. 2 Spatial distribution of the SC (**a**) and GC (**b**) indices

a governance level. Municipalities from Guerrero (Alpayaca) and Guanajuato (Yuridia) characterized by safety-first conditions. A safe-development paradox coincides with a fail-safe approach, where the citizens bare the risk effects when the so-called bullet-proof system fails (Eakin et al. 2014). Municipalities from Jalisco and

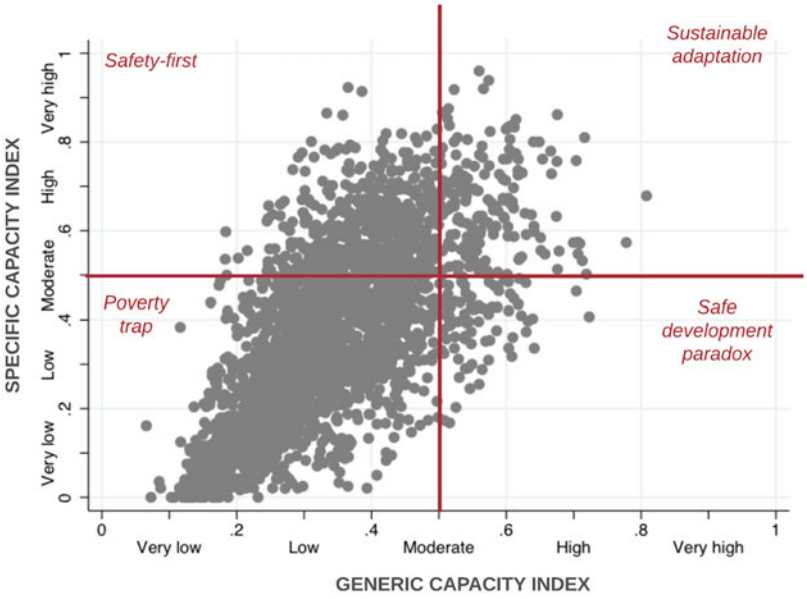

Fig. 3 Distribution of municipalities in the MMIC. (Adapted from Eakin et al. 2014)

Aguascalientes were in the safe development paradox. A sustainable adaptation condition entails a reinforcing feedback between adaptation and development steered to reduce the overall vulnerability. In the Mexican context, that would mean the alignment of the building capacities in both risk management and sustainable development articulated in a hybrid adaptation approach.

Municipalities in the poverty trap are clustered in the same specific and generic institutional capacities clusters. That means that there can be targeted policies and funding to overcome deficiencies in administrative capacity for risk management, public services provision, urban and sustainable development, and gender equality, among others related to human development. Municipalities that fall in the safety-first conditions require attention in the planning instruments and adaptive capacity on risk management. Regarding generic capacities, these municipalities required attention on citizen participation and political and coordination mechanisms. Municipalities in the characteristic of the safe development paradox would need attention on citizen participation and political and institutional coordination mechanisms focused on risk management. Citizen participation mechanisms public services provision, urban and sustainable development, and gender equality, among others would also be needed in these municipalities for building generic capacities.

Generation of Institutional Capacity Clusters of Specific and Adaptive Capacities

The institutional capacity dimensions were ordered in clusters to define groups of municipalities with similar scores of institutional capacities to respond and adapt to climate change. The municipalities were (a) ordered based on the institutional capacity dimensions with a principal component analysis and (b) clustered following a k-means method (OECD 2008). The evaluation of the institutional capacity regarding the specific capacity of the municipalities was conducted on two separate subsamples: the municipalities that were exposed to the effects of hydrometeorological events in 2015 (n = 987) and the ones without exposure in 2015 (n = 1466). The reason for this separation relates to the coordination dimension (Fig. 1), that evaluates the existence of coordination mechanisms that emerge in response to the occurrence of a hydrometeorological event. Thus, the dimensions considered in the cluster analysis of the municipalities exposed are in Fig. 4a. Meanwhile, the municipalities not exposed to a hydrometeorological event considered the above with the exception of the political and institutional coordination (Fig. 4a). The dimensions considered in the cluster analysis regarding generic capacities are in Fig. 4b. Nine institutional capacity groups were defined for the specific capacity domain (Fig. 5a), and three groups for the generic capacity domain (Fig. 5b). The average and relative institutional capacity of the groups was analyzed following a double-centered technique named Gower's residuals (Bojorquez-Tapia et al. 2001). The institutional capacity of groups 1, 2, and 6 is determined by citizen participation mechanisms. Transparency and accountability mechanisms explained the institutional capacity of groups 5 and 7. Administrative capacity, planning instruments, and political and institutional coordination determined the institutional capacity of groups 8, 4, and 3, respectively. The institutional capacity of group 9 cannot be discerned by a specific dimension, because all dimensions are close to the average (Fig. 4a). Regarding the generic capacity domain, the institutional capacity of groups 1 and 3 was determined by the political and institutional coordination; meanwhile, the administrative capacity and citizen participation were the main determinants of the institutional capacity of group 2 (Fig. 4b). Investments in specific capacities entails attention to the dimensions that score lower, such as citizen participations mechanisms in groups 3, 4, 5, 7, and 8 (Fig. 4a), and political and institutional coordination in group 2 to invest in generic capacities (Fig. 4b).

Discussion

Institutions face several challenges in the transition from adaptation planning to implementation. The differences of history, race, ethnicity, gender, social constructions of stratification make adaptation implementation even more complex to face global changes and to build institutional capacity. Mexico has experienced several sociopolitical processes that shape a heterogeneous mosaic of available and latent capacities that evolved from a series of processes that date back from prehispanic

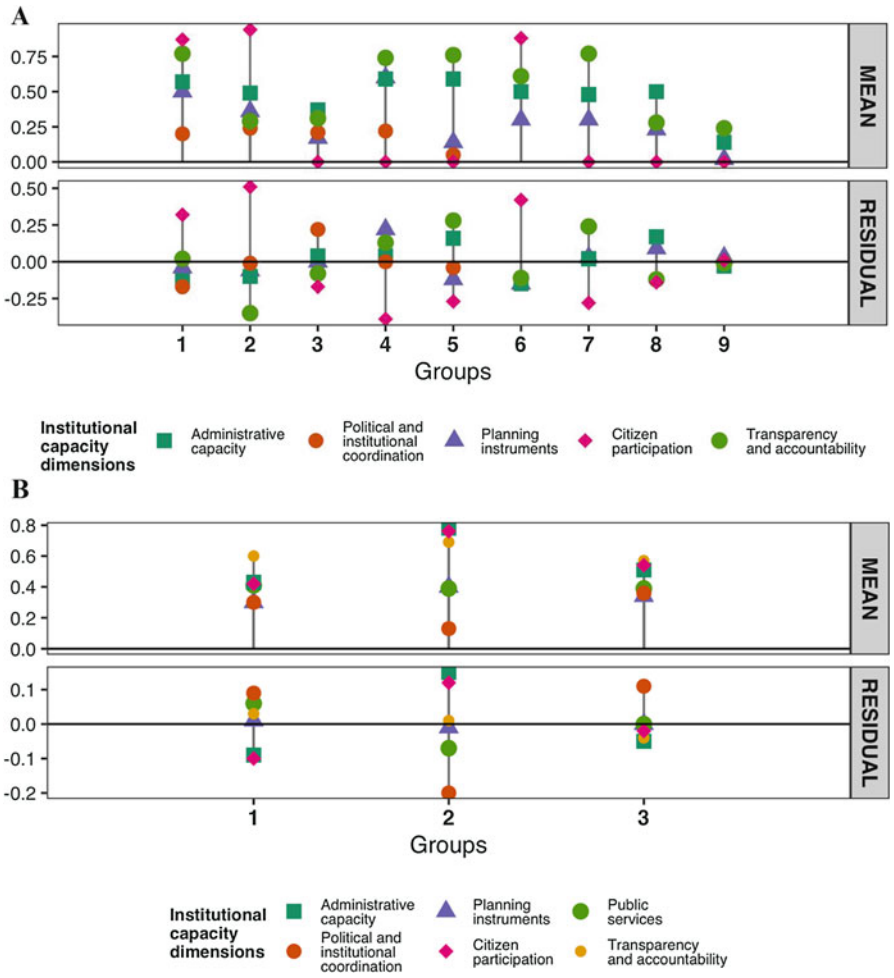

Fig. 4 Gower's residuals of the institutional capacity groups regarding the specific (**a**) and the generic (**b**) capacity domains

times. This mosaic is both a challenge and an opportunity for Mexico to address the impacts of climate change and, in particular, for the identification of the capacity needed to be curtailed from a context and site-specificity In general, Mexico presented scattered capacities (generic and specific) in the territory (Fig. 5a, b) and showed many local governments in a poverty trap with very low specific and generic capacities (Figs. 3 and 2a, b). However, the institutional capacity indices regarding specific and generic capacities exhibited a positive relation, which means that higher values of specific capacity were observed along with higher values of generic capacity. Municipalities in the poverty trap (lower extremes in Fig. 3) gathered in the same specific and generic institutional capacities clusters. That means that there

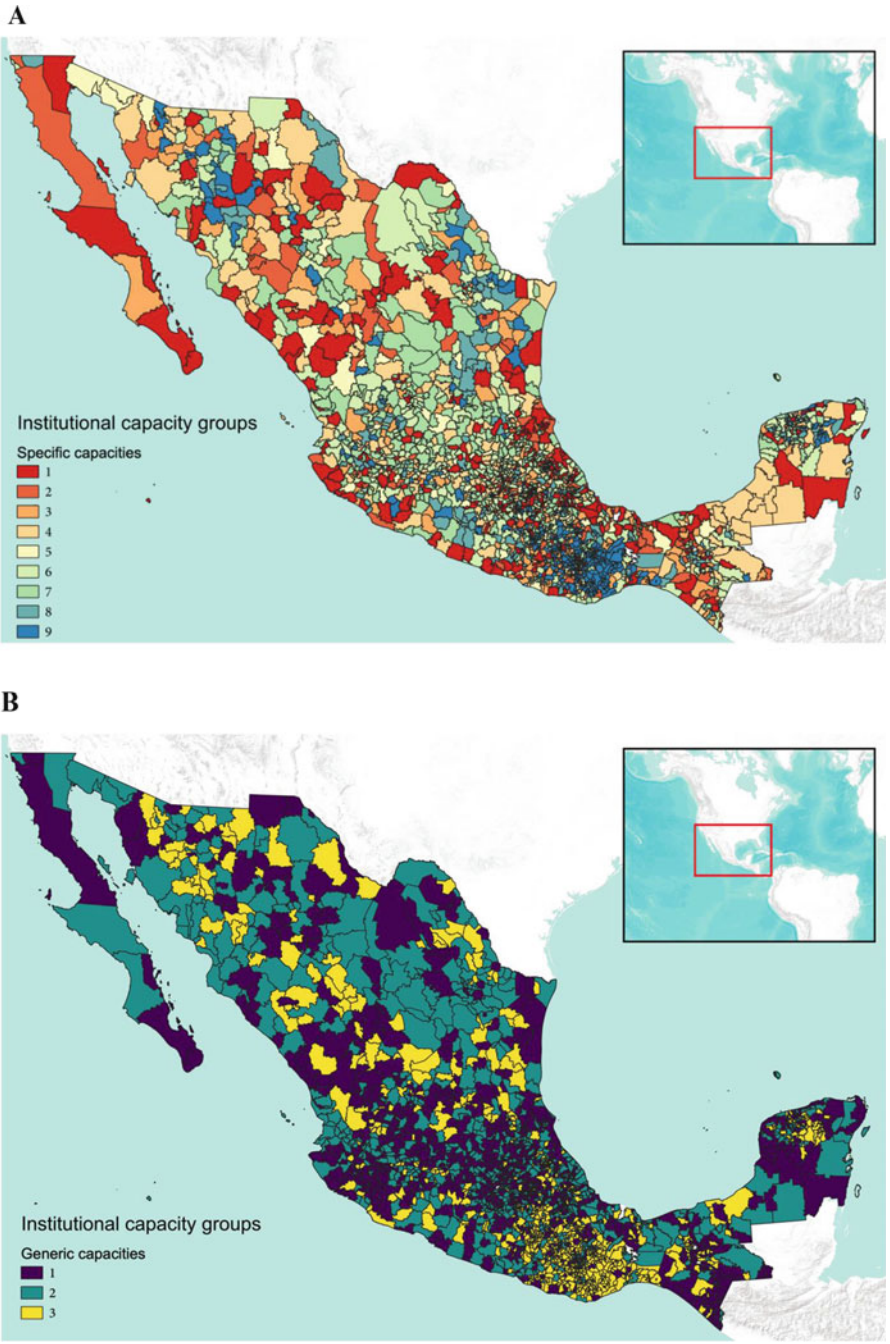

Fig. 5 Institutional capacity groups regarding the specific (**a**) and the generic (**b**) capacity domains

can be targeted policies and funding to overcome deficiencies in an administrative capacity for risk management, public services provision, urban and sustainable development and gender equality, among others related to human development. Visual clustering allowed us to identify the needs and capacities that can potentially be improved.

The assessment of the institutional capacity following the hybrid approach supports horizontal and vertical integration by considering multilevel government systems in the formulation and implementation of climate change adaptation (Preston et al. 2013; Nalau et al. 2015). Moreover, the hybrid approach provides insights to address precise needs on capacity building. The administrative capacity dimension addresses the role of economic resources and the organizational structure for generic capacities (Fig. 1b). The transparency and accountability dimensions aim to draw attention to the mechanisms that allow citizens to monitor and evaluate the government endeavor on climate change adaptation. The integration of elements from a bottom-up approach, i.e., citizen participation, aims to include mechanisms that enable citizens to influence decision-making processes.

The use of a generic and specific capacities approach contributes to account for the relation between adaptation and sustainable development in the planning for vulnerability reduction. In Mexico, there are political and planning instruments focused on integrated risk management, such as Civil Protection Plans and Municipal Risk Atlas. These instruments focus on the spatial distribution of potential risks and the socioeconomic characteristics of the exposed population. However, these instruments do not deal with the underlying processes that determine the distribution and access to opportunities and assets that the vulnerable populations have. Moreover, integrated risk management instruments do not address the potential agency of the vulnerable populations in decision processes, i.e., through civil participation. In this context, the evaluation of generic capacities through the consideration of land-use planning instruments, urban development, accountability, and gender equality aims to provide elements associated with sustainable development in the assessment of adaptive capacities at a local scale. Hence, the evaluation of the institutional capacity of the local governments in Mexico from a generic and specific capacities approach attempts to provide empirical insights into what institutional arrangements would be needed to provide the means for vulnerable populations to steer at a sustainable adaptation.

Evaluation of institutional capacity following a generic and specific capacities approach also provides inputs to inform public policy aimed to fulfill international commitments. In one side, consideration of deficiencies in basic human development needs through the focus on generic capacities (Eakin et al. 2014) can contribute to address commitments established in the Sustainable Development Goals, that draw attention to a long-term vision approach, were citizen participation, gender equality, transparency and accountability are key elements. On the other side, addressing specific capacities as the manifestation of the ability to manage and respond to an identified climate hazard (Lemos et al. 2016) could contribute to commitments dedicated to risk reduction like the targets established in the Sendai Framework. In this study, Mexico did not show evidence of a municipality in a sustainable

adaptation condition. Instead, several municipalities were identified in the safety-first and safe-development paradox (Fig. 3).

National Determined Commitments, Sustainable Development Goals, and others could act as leverage initiatives to increase urgent changes. Current NDC in Mexico has positively addressed structural goals in terms of climate change adaptation. In order to protect communities from adverse impacts of climate change, improve the resilience of infrastructure, and ensure national biodiversity, the country has embraced the responsibility of strengthening the adaptive capacity of at least 50% of the municipalities considered to be the "most vulnerable" (SEMARNAT and INECC 2014; SRE 2016). The compliance of this objective cannot be seen as a one-way track. This commitment represents a challenge and opportunity for coordination among institutions, academia, national and local authorities, and civil society, among others. The Mexican NDC represents a reference to guide the national targets regarding climate change adaptation, and there are different efforts that should be focused on the development of mechanisms and tools that reinforce institutional capacity.

Finally, it is important to mention that all the information used in this work is spatially explicit. This gives the opportunity to design a platform to having a tool with updated information on the indicators of institutional capacity that promote adaptation to climate change at a local level could show the status of the indicators concerning specific spatial units as Mexican local governments. This tool could allow faster mapping and identification of the areas or regions where greater emphasis is required on the establishment of institutional instruments and attributes, or of the areas or regions where the progress of these indicators is noticeable. Moreover, the use of official sources of data for the generation of the institutional capacity indicators provides the means to replicate this analysis on a periodic basis and allows the generation of comparative analysis and the evaluation of adaptation measures. For example, the National Census of Local Governments is generated through the application of a national survey every 2 years by the National Institute of Statistics and Geographic Information (INEGI 2015). These tools have the potential to translate the analytical approach presented here into relevant and credible inputs for the adaptation planning and implementation of local governments in Mexico. The implementation of a hybrid approach would require a transdisciplinary work that articulates the efforts in capacity building in the institutions, as well as the needs for a society able to influence decision processes regarding climate change adaptation. Efforts and further analysis preferably must be done in coordination with local actors from different epistemic communities considering the local context. Institutions also should evaluate the trade-offs of investing in generic and specific capacities at all scales.

Concluding Remarks

This example provides evidence of the challenges in the application of elements of the literature on adaptation to climate change, particularly on adaptive capacity, in the elaboration of analysis tools for decision processes regarding climate change. Although adaptation is considered in the literature as a mainly local process (IPCC 2014b), some authors question this heuristic and suggest that, although adaptation is local, adaptive capacity is an attribute of multi-scalar government processes (Preston et al. 2013; Nalau et al. 2015). Based on this approach, the consideration of multilevel government systems can contribute to tackle the formulation and implementation of climate change adaptation (Preston et al. 2013; Nalau et al. 2015). Evaluating institutional capacity as a component of adaptive capacity, not only of local governments but of multilevel government systems, addresses the lack of capacity of local governments and coordination challenges across multiple levels of government (vertical) and of sectors (horizontal). To that effect, the conceptualization of institutional capacity following a multidimensional approach integrates elements of multilevel government systems by incorporating elements of coordination between different levels of government – political and institutional coordination dimension.

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References

Aall C, Norland I (2005) Report no. 6/05: indicators for local-scale climate vulnerability assessments. Oslo

Adger WN, Lorenzoni I, O'Brien KL (2009) Adapting to climate change. Thresholds, values, governance

Amend T (2019) Governance for ecosystem-based adaptation. Bonn

Bojórquez-Carrillo AL, Manzano-Loría ME, Uc Heredia LJ (2015) Análisis de la relación entre la capacidad administrativa y la transparencia en gobiernos locales en México. Investig Reg J Reg Res 31:101–118

Bojorquez-Tapia LA, Díaz Mondragón S, Ezcurra E (2001) GIS-based approach for participatory decision making and land suitability assessment. Int J Geogr Inf Sci 15:129–151. https://doi.org/10.1080/13658810010005534

Bojórquez-Tapia L, Luna-González L, Cruz-Bello G et al (2011) Regional environmental assessment for multiagency policy making: implementing an environmental ontology through GIS-MCDA. Environ Plan B Plan Des 38:539–563. https://doi.org/10.1068/b36129

Carrera-Hernández A, Coronilla-Cruz R, Navarro-Arredondo A (2010) Índice de desarrollo institucional y sustentabilidad municipal

CONABIO (2015) Áreas naturales protegidas estatales, municipales, Ejidales y Privadas de México 2015. Retrieved from http://www.conabio.gob.mx/informacion/gis/

Eakin H, Lemos M, Nelson D (2014) Differentiating capacities as a means to sustainable climate change adaptation. Glob Environ Chang 27:1–8. https://doi.org/10.1016/j.gloenvcha.2014.04.013

Eriksen S, Brown K (2011) Sustainable adaptation to climate change. Clim Dev 3:3–6. https://doi.org/10.3763/cdev.2010.0064

Gallopín GC (2006) Linkages between vulnerability, resilience, and adaptive capacity. Glob Environ Chang 16:293–303. https://doi.org/10.1016/j.gloenvcha.2006.02.004

Hallegatte S, Vogt-Schilb A, Bangalore M, Rozenberg J (2017) Unbreakable. Building the resilience of the poor in the face of natural disasters. Washington D.C.

Hinkel J (2011) "Indicators of vulnerability and adaptive capacity": towards a clarification of the science – policy interface. Glob Environ Chang 21:198–208. https://doi.org/10.1016/j.gloenvcha.2010.08.002

INE (2015) Sistema de Consulta de la Estadística de las Elecciones Federales 2014–2015. Retrieved from http://siceef.ine.mx

INEGI (2015) Censo Nacional de Gobiernos y Estadísticas Municipales y Delegacionales

IPCC (2012) Managing the risks of extreme events and disasters to advance climate change adaptation: special report of working gropus I and II of the intergovernmental panel on climate change

IPCC (2014a) Annex II: Glossary. Mach KJ, Planton S, von Stechow C (eds). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

IPCC (2014b) Climate change, adaptation, and vulnerability. Organ Environ 24:1–44. https://doi.org/http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf

Iza A (2019) Gobernanza Para la adaptación basada en ecosistemas. Gland

Jones RN, Patwardhan A, Cohen SJ et al (2014) Chapter 2: foundations for decision making. Fifth Asesement Rep:195–228

Juhola S, Glaas E, Linnér BO, Neset TS (2016) Redefining maladaptation. Environ Sci Pol 55:135–140. https://doi.org/10.1016/j.envsci.2015.09.014

Kates RW (2000) Cautionary tales: adaptation and the global poor. Clim Chang 45:5–17

Lebel L, Anderies J, Campbell B et al (2006) Governance and the capacity to manage resilience in regional social-ecological systems. Ecol Soc 11. https://doi.org/19

Lemos MC, Lo YJ, Nelson DR et al (2016) Linking development to climate adaptation: leveraging generic and specific capacities to reduce vulnerability to drought in NE Brazil. Glob Environ Chang 39:170–179. https://doi.org/10.1016/j.gloenvcha.2016.05.001

López JD, Gómez-Álvarez D (2010) Midiendo las capacidades institucionales de los gobiernos locales de México: un mapa de su diversidad. In: H. Cámara de diputados LL, (PNUD) P de las NU para el D, (UdG) U de G, Miguel Ángel Porrúa L (eds) Capacidades institucionales para el desarrollo humano: conceptos, índices y políticas públicas. México, pp 209–278

Magnan A, Ribera T (2016) Global adaptation after Paris. Nature 352:1280–1282

Martínez-Pellégrini S, Flamand L, Hernández A (2008) Panorama del desarrollo municipal en México. Antecedentes, diseño y hallazgos del Índice de Desarrollo Municipal Básico. Gestión y Política Pública XVII:145–192

Matyas D, Pelling M (2012) Disaster vulnerability and resilience: theory. Modell Prospect Foresight 70. https://doi.org/10.13140/RG.2.1.4684.2409

Mimura N, Pulwarty RS, Duc DM, et al (2014) Adaptation planning and implementation. 15

Moss RH, Brenkert AL, Malone EL (2001) Vulnerability to climate change: a quantitative approach

Nalau J, Preston BL, Maloney MC (2015) Is adaptation a local responsibility? Environ Sci Pol 48:89–98. https://doi.org/10.1016/j.envsci.2014.12.011

Noble IR, Huq S, Anokhin Y et al (2014) Adaptation needs and options. 14

OECD (2008) Handbook on constructing composite indicators: methodology and user guide. OECD publishing, Paris

Pelling M (2011) Adaptation to climate change: from resilience to transformation
Pelling M, O'Brien K, Matyas D (2015) Adaptation and transformation. Clim Chang. https://doi.org/10.1007/s10584-014-1303-0
Phuong LTH, Biesbroek GR, Wals AEJ (2018) Barriers and enablers to climate change adaptation in hierarchical governance systems: the case of Vietnam. J Environ Policy Plan 20:518–532. https://doi.org/10.1080/1523908X.2018.1447366
Preston BL, Mustelin J, Maloney MC (2013) Climate adaptation heuristics and the science/policy divide. Mitig Adapt Strateg Glob Chang 20:467–497. https://doi.org/10.1007/s11027-013-9503-x
Ribot J (2014) Cause and response : vulnerability and climate in the Anthropocene. J Peasant Stud 41:667–705
Rosas Huerta A (2008) Una ruta metodológica para evaluar la capacidad institucional. Política y Cult:119–134
Rosas-Huerta A, Gil-Montes V (2013) La capacidad institucional de gobiernos locales en la atención al cambio climático. Un modelo de análisis. Rev Mex Análisis Político y Adm Pública II:113–138
SEMARNAT, INECC (2014) Elementos mínimos para la elaboración de los programas de cambio climático de las entidades federativas. 1–5. https://doi.org/10.1007/s13398-014-0173-7.2
SEMARNAT (2015) Ordenamientos Ecológicos Expedidos. Retrieved from http://www.semarnat.gob.mx/temas/ordenamientoecologico/ordenamientos-ecologicos-expedidos
SIMBAD-INEGI (2014) Sistema Estatal y Municipal de Bases de Datos. Retrieved from http://sc.inegi.org.mx/cobdem/
Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. Glob Environ Chang 16:282–292. https://doi.org/10.1016/j.gloenvcha.2006.03.008
SRE (2016) Posición de México en la 22a Conferencia de las Partes de la Convención Marco de las Naciones Unidas sobre el Cambio Climático. In: Boletín prensa la Secr. Relac. Exteriores, Gob. Fed. México. https://www.gob.mx/inecc/articulos/posicion-de-mexico-en-la-22-conferencia-de-las-partes-de-la-convencion-marco-de-las-naciones-unidas-sobre-el-cambio-climatico-79523?idiom=es. Accessed 6 Apr 2017

IV. Local governments as key agents in climate change adaptation: challenges and opportunities for institutional capacity-building in Mexico

(Manuscrito 2)

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En este capítulo de libro se examinan las implicaciones de los resultados del capítulo 3 y se determinan grupos de capacidad institucional a nivel nacional y se determinan las principales barreras y retos, junto con las oportunidades para fortalecer la capacidad institucional de los grupos de municipios identificados.

Abstract: Institutional capacity is one of the multiple dimensions of adaptive capacity that determines the level and the pace of climate change adaptation at the local level. Local governments are key actors in climate change adaptation because they have the responsibility to translate top-down risk information to vulnerable populations and can scale bottom-up initiatives of communities in adaptation planning. There is a need for integrated approaches for adaptive capacity building that incorporate specific capacities to tackle multiple climate risks and generic capacities to address basic needs for human development. In this analysis, we assess the institutional capacity profiles of local governments in Mexico through a cluster analysis to understand how different aspects of generic and specific capacities, which operate through bottom-up or top-down approaches, coincide in local governments. Our results show that local governments in Mexico can be grouped by type and level of institutional capacity, as follows: those that (1) engage in intergovernmental coordination; (2) focus on safety-first; (3) exhibit high capacities in transparency and citizen participation; and (4) are in a poverty trap. These groups reflect challenges for local governments in Mexico, including the need to resolve short-term crises, the lack of climate change awareness, and a low capacity to access and mobilize economic resources for adaptation. Conversely, horizontal and vertical coordination, transparency, and citizen participation are found to be key elements able to strengthen institutional capacities for adaptation. In the context of multiple climate risks and underdeveloped enabling conditions for adaptation, there is a need for strategic investment in capacities that are contextually relevant and that can reduce the adaptation gap for climate action in Mexico. Further analysis will be needed to evaluate how the mobilization of the institutional capacities by local governments in each group influences climate change adaptation outcomes, particularly differentiated for urban and rural contexts, as well as for metropolitan scales.

Resumen: La capacidad institucional es una de las múltiples dimensiones de la capacidad de adaptación que determina el nivel y el ritmo de la adaptación al cambio climático a nivel local. Los gobiernos locales son actores clave en la adaptación al cambio climático porque tienen la responsabilidad de trasladar la información descendente sobre riesgos a las poblaciones

vulnerables y pueden ampliar las iniciativas ascendentes de las comunidades en la planificación de la adaptación. Se necesitan enfoques integrados para el desarrollo de la capacidad de adaptación que incorporen capacidades específicas para hacer frente a múltiples riesgos climáticos y capacidades genéricas para abordar las necesidades básicas para el desarrollo humano. En este análisis, evaluamos los perfiles de capacidad institucional de los gobiernos locales de México mediante un análisis de conglomerados para comprender cómo coinciden en los gobiernos locales diferentes aspectos de capacidades genéricas y específicas, que operan mediante enfoques ascendentes o descendentes. Nuestros resultados muestran que los gobiernos locales en México pueden agruparse por tipo y nivel de capacidad institucional, de la siguiente manera: los que (1) se dedican a la coordinación intergubernamental; (2) se centran en la seguridad, ante todo; (3) exhiben altas capacidades en transparencia y participación ciudadana; y (4) se encuentran en una trampa de pobreza. Estos grupos reflejan retos para los gobiernos locales en México, incluyendo la necesidad de resolver crisis a corto plazo, la falta de conciencia sobre el cambio climático y una baja capacidad para acceder y movilizar recursos económicos para la adaptación. Por el contrario, la coordinación horizontal y vertical, la transparencia y la participación ciudadana aparecen como elementos clave capaces de fortalecer las capacidades institucionales para la adaptación. En el contexto de los múltiples riesgos climáticos y el subdesarrollo de las condiciones propicias para la adaptación, existe la necesidad de invertir estratégicamente en capacidades que sean contextualmente relevantes y que puedan reducir la brecha de adaptación para la acción climática en México. Se necesitarán más análisis para evaluar cómo la movilización de las capacidades institucionales por parte de los gobiernos locales en cada grupo influye en los resultados de la adaptación al cambio climático, particularmente diferenciados para contextos urbanos y rurales, así como para escalas metropolitanas.

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Local governments as key agents in climate change adaptation: challenges and opportunities for institutional capacity-building in Mexico

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ABSTRACT

Institutional capacity is one of the dimensions of adaptive capacity that determines the level and pace of climate change adaptation at the local level. Local governments are key actors in climate change adaptation because they have the responsibility to translate top-down risk information to vulnerable populations and can scale bottom-up initiatives of communities in adaptation planning. There is a need for integrated approaches for adaptive capacity building that incorporate specific capacities to tackle multiple climate risks and generic capacities to address basic needs for human development. In this analysis, we assess the institutional capacity profiles of local governments in Mexico through a cluster analysis to understand how different aspects of generic and specific capacities, which operate through bottom-up or top-down approaches, coincide in local governments. Our results show that local governments in Mexico can be grouped by type and level of institutional capacity, as follows: those that (1) engage in intergovernmental coordination; (2) focus on safety-first; (3) exhibit high capacities in transparency and citizen participation; and (4) are in a poverty trap. These groups reflect challenges for local governments in Mexico, including the need to resolve short-term crises, the lack of climate change awareness, and a low capacity to access and mobilize economic resources for adaptation. Conversely, horizontal and vertical coordination, transparency, and citizen participation are found to be key elements able to strengthen institutional capacities for adaptation. In the context of multiple climate risks and underdeveloped enabling conditions for adaptation, there is a need for strategic investment in capacities that are contextually relevant and that can reduce the adaptation gap for climate action in Mexico. Further analysis will be needed to evaluate how the mobilization of the institutional capacities by local governments in each group influences climate change adaptation outcomes, particularly differentiated for urban and rural contexts, as well as for metropolitan scales.

Key policy insights

- Local governments in Mexico are faced with the challenge of resolving urgent and short-term issues, making it difficult to face climate change adaptation.
- Intergovernmental coordination is a key attribute that local governments can develop to address and overcome deficiencies in institutional capacities for climate change adaptation
- Administrative capacity, transparency, accountability, and public participation are critical elements for local governments and will assist them to access and mobilize economic resources for climate change adaptation.

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Introduction

Local governments have been identified as key agents for climate action due to their proximity to citizens and their needs, particularly vulnerable populations (Tschakert et al., 2018). However, the potential role of these agents in the implementation of climate change adaptation can be hindered by contextual and structural deficiencies, with associated scarce resources and capacities. This is particularly relevant for the global South, due to the disproportionate impacts of climate change and the 'adaptation gap', which is often part of a larger development deficit (Noble et al., 2014). In this context, strengthening local governments and scaling up institutional capacities is needed to reduce the vulnerability of the global South to climate change impacts. Institutional capacity is highly context-dependent and is regarded by the IPCC as an enabling condition for adaptation options to reduce climate vulnerability and build resilience to climate change. In particular, institutional capacity is a key determinant to support post-disaster recovery and reconstruction, buffer climate risks, build adaptive capacity and reduce social vulnerability (Coninck et al., 2018). In the global South, local governments are imperative to support adaptation needs through public sector resources with support from development assistance funds (IPCC, 2019).

The effects of climate change are already being experienced in much of the global South, including Mexico, where surface temperature increased nearly 0.85°C above average over the past 50 years and variations in precipitation patterns persist (rainy season periods and extreme events). These effects, alongside income inequality and deficiencies in basic human needs, determine the differential vulnerability to climate change observed in Mexico. In its recently updated Nationally Determined Contributions (NDC), Mexico notes its need to implement climate actions in 50% of the most vulnerable municipalities, particularly those with large development deficiencies (SEMARNAT, 2020). This policy priority illustrates the challenge for local governments to build capacities to mobilize resources for climate change action under conditions of underdevelopment and differential exposure to climate hazards.

In the context of multiple climate risks and underdeveloped enabling conditions, such as the ones characterizing the global South and Mexico in particular, there is a need for integrated approaches for adaptive capacity. Such an approach integrates specific capacities that tackle multiple climate risks with generic capacities focused on addressing structural deficits that underly vulnerability (e.g. lack of income, health, education) (Eakin et al., 2014; M. C. Lemos et al., 2016). These two dimensions of adaptive capacity, specific and generic, are needed for adaptation to contribute to, or at least does not erode, development, social justice and environmental integrity in climate change responses (Eriksen & Brown, 2011). The presence of specific adaptive capacity does not necessarily entail the existence of generic capacity (and vice versa), and there can be trade-offs between both (Lemos et al., 2013).

Institutional capacity is one of the multiple dimensions of adaptive capacity and should contribute to the vertical and horizontal integration of institutions to move toward the implementation of climate change adaptation. This means that institutional capacity can encompass the organizational arrangements and mechanisms to coordinate and align multi-level government actions (vertical integration) and enable society to participate in decision processes (horizontal integration), through the integration of collective action between formal and informal institutions (Mimura et al., 2014). In this approach, institutional capacity addresses the enabling conditions for government coordination at multiple levels and provides space for the emergence of local initiatives and the prevention of negative dependencies of local governments' planning on subnational and national governments (Mimura et al., 2014; Noble et al., 2014).

In this study, we analyze the institutional capacity profiles of local governments in Mexico to understand the relationship between generic and specific institutional capacities and the climate risk response at the local level. We do this by constructing composite indicators and clustering the local governments based on these indicators, to compare determinants of institutional capacity across 2,545 local governments. We identify key challenges and opportunities for local governments to build and strengthen their specific and generic capacities to adapt to climate change. We focused on comparing determinants of institutional capacity in 2,545 local governments in Mexico to provide insights into the trade-offs among generic and specific capacities to adapt to climate change. Based on their performance across 12 institutional capacity indicators, we clustered the local governments into four major groups associated with intergovernmental coordination (Group 1), risk

management-safety first (Group 2), transparency and citizen participation (Group 3), and a poverty trap (Group 4). Based on this clustering of local governments, we identify key challenges and opportunities to build and strengthen their specific and generic capacities to adapt to climate change.

Methods

The methods used for assessing the institutional capacity of the local governments involved the integration of an analytical framework, the construction of composite indicators, and their analysis through a cluster analysis. Several assessments of adaptive capacity use an index-based approach to collapse multiple dimensions of the adaptive capacity into a single metric. In this analysis, we opted for a cluster-based approach that enabled us to identify the diverse forms of institutional capacity at the local level. In doing so, we recognize that the local context influences the conditions of the outcomes we observe and allows us to observe patterns in the generic and specific institutional capacity across the country.

Framework for analysis

The construction of the analytical framework to assess the capacities of local governments in Mexico was based on three main approaches. First, following a sustainable adaptation approach, we focused on the institutional capacity of local governments to manage risks (specific capacities) and address deficiencies in human development (generic capacities), such as education and health (Eakin et al., 2014; M. C. Lemos et al., 2016). Second, the dimensions of the institutional capacity of local governments in Mexico were defined by a hybrid approach, that integrates the *robustness* provided by institutional structures, coordination and accountability mechanisms (top-down), and the *flexibility* of incorporating multiple stakeholders' perspectives in decision processes through citizen participation (bottom-up) (Mimura et al., 2014; Noble et al., 2014). Finally, the implementation of climate adaptation by local governments was considered by integrating or mainstreaming climate adaptation in existing policies and practices, or by developing stand-alone adaptation policies and programmes. The main strategies considered here were *regulatory* (e.g. modification of formal planning procedures), *intra and inter-organizational* (e.g. promotion of collaboration with other departments) and *managerial* mainstreaming (e.g. modification of personnel and organizational working structures) (Runhaar et al., 2018; Wamsler, 2015).

The institutional capacity of local governments was assessed based on six dimensions: planning instruments; administrative capacity; institutional coordination; public services; transparency and accountability; and citizen participation. Planning instruments involve regulations with the potential to reduce risk and increase the adaptive capacity of vulnerable populations. Administrative capacity comprises human, economic, and material resources and management abilities to implement climate change adaptation (Bojórquez-Carrillo et al., 2015; Rosas Huerta, 2008). Institutional coordination focuses on the institutional arrangements and mechanisms that enable effective cooperation and coordination between governmental and non-governmental actors at multiple jurisdictional and spatial scales to adapt to climate change and to effectively manage emerging risks. Public services comprise the actions that are undertaken by local governments to secure the basic human needs of the population (Carrera-Hernández et al., 2010) and can influence the social distribution of vulnerability. Along with the administrative capacity, this dimension relates to the state's institutional capacity to implement development policies seeking to address basic infrastructure deficiencies within communities and across society. Transparency and accountability enable both the monitoring and evaluation of adaptation and provide inputs for the institutional reorganization of processes as required (Mimura et al., 2014; Noble et al., 2014). Citizen participation includes the mechanisms and instruments available for the citizens to engage in planning, implementing, and evaluating climate change adaptation actions.

These definitions of the dimensions also considered previous studies in Mexico focused on the general performance of local governments, particularly for the socioeconomic and environmental dimensions (Bojórquez-Carrillo et al., 2015; Carrera-Hernández et al., 2010; López & Gómez-Álvarez, 2010; Martínez-Pellégrini et al., 2008; Martínez, 2015; Rosas Huerta, 2008). Other studies have focused on institutional capacities regarding climate and environment in Mexico City (Delgado Ramos & Mac Gregor Gaona, 2020; Ibarrarán et al., 2014).

Data and variables

The data used to assess the local governments was on a municipal scale. In this paper, we refer to the term municipality as the territorial and jurisdictional unit administered by the local government. The project was based on PNUD-México-INECC (2017) and aimed to cover all local governments in Mexico (2,457 in 2017) and to be able to rely on official information sources. Therefore, the data comes mainly from the National Census of Local Governments (INEGI, 2017), conducted every two years by the National Institute of Statistics and Geography (INEGI from its Spanish acronym). This census was selected because it provides key information on the performance of local governments regarding government functions, public security, municipal justice, access to potable water and sewage, urban solid waste, and the environment. Also, the economic attributes of local governments were also assessed based on the State and Local System Database. This census provides key information on the local governments' public finances and contributes to the transparency of the use of public resources by these governments (INEGI, 2014, 2019). One of the main premises of this analysis was that it focused on informing climate policy for all municipalities in Mexico and that it had to provide timely and the best available information in order to become relevant for the practitioners developing, implementing, and evaluating climate policy at a national scale (PNUD-México-INECC, 2017). The selection of the national census as a main source of information provides periodic and homogeneous information for all municipalities of the country, making it possible to update it on a regular basis (every three years).

The variables selected provided information on the available resources or capacities of the local governments for each institutional capacity dimension. In total, 19 variables were selected out of an original dataset of 60 variables proposed in PNUD-México-INECC (2017). These variables were both discrete (categories or presence/absence) and continuous (values exist continuously within a range), and comprised information about planning instruments (civil protection plans, municipal development programmes, climate change, and self-protection actions); human resources (government agencies, staff, and capacity-building programmes); material resources (internet access, websites and telephone lines); economic resources (income per capita); citizen participation (multi-actor planning committees, public spaces, and social oversight mechanisms); transparency and accountability (public and available information regarding civil protection and municipal planning); and intergovernmental partnerships.

Construction of composite indicators and institutional capacity groups

The 19 discrete and continuous variables were transformed into 6 scalar and 6 composed indicators (Hinkel, 2011), by means of discrete value functions and then normalized following a min-max method (OECD, 2008). The construction process of the indicators is described in detail in the Supplementary material and the indicators' descriptive statistics are presented in Table 1.

The determination of the institutional capacity groups was defined by means of a principal component and cluster analysis based on a k-means method (OECD, 2008). The large number of variables (12) and the records (2,454 local governments) account for the selection of the k-means method. The results were assessed by

Table 1. Descriptive statistics of the institutional capacity indicators.

Id	Institutional capacity indicators	Mean	Variance
ca_macc	climate change adaptation actions	0.20	0.06
ca_cim	inter-municipal coordination	0.21	0.16
ca_pcgr	capacity-building in adaptation	0.23	0.08
ca_re	economic resources for municipal planning	0.28	0.05
cr_pcgr	risk management planning	0.29	0.08
cr_mp	citizen participation mechanisms for risk management	0.30	0.21
ca_psm	public services provision	0.37	0.03
ins_pdm	planning Committee for Municipal Development	0.40	0.08
cr_rmi	material and IT resources for risk management	0.45	0.04
cr_rhp	human resources for risk management	0.45	0.17
cr_mcs	social oversight mechanisms for risk management	0.50	0.25
cr_ipda	access to public information regarding municipal planning	0.58	0.15

means of a hierarchical dendrogram and a parallel coordinate visualization. The clusters were separated into four major groups and the variables were assessed to further understand the factors forcing the separation of clusters, which gives an identity to the groups of local governments. Additionally, the proportion of local governments in each cluster was assessed for each Mexican state, to uncover potential geographic patterns in institutional capacity.

The limitations of this approach relate to the scale of the data used at a municipal scale. For instance, the division between urban and rural is defined at a locality or settlement scale, which is a lower scale than the municipality. Hence, a single municipality can have both urban and rural conditions and the data used in this analysis does not provide elements to differentiate how capacities and actions implemented by the local governments differ between urban and rural settings. Also, we did not include a variable for the proximity to central urban or metropolitan areas (either within, adjacent, or nonadjacent). This factor could be important for understanding why different municipalities fall into particular groups according to institutional capacity. Further analysis can include assessments of the institutional capacity at a metropolitan scale. In Mexico, there are 74 metropolitan areas that are large urban conglomerates, which comprise 1,116 municipalities (45% of all municipalities in Mexico) (CONAPO-SEDATU-SEGOB, 2018). A more in-depth analysis would require the integration of different data sources, either data at a locality or settlement scale for all municipalities, or for specific case studies. The latter would require alternative or additional ways of eliciting information, i.e. semi-structured interviews, surveys, document analysis, or focus groups, such as the ones used by Delgado Ramos & Mac Gregor Gaona (2020) or Gupta et al. (2010).

Results

Results from the cluster analysis show that the highest value across all groups relates to the access to public information regarding municipal planning (cr_ipda) (Table 1). In contrast, the lowest value of the four groups regarding their institutional capacity relates to the lack of implementation of climate change actions (ca_macc) and the economic resources for municipal planning (ca_re). The low values in the indicator of climate change adaptation actions mean that the municipalities are not focused on preserving or restoring carbon sinks (e.g. through reforestation), on promoting actions for its population or ecosystems to adapt (e.g. through sustainable development projects). The low values in the indicator of economic resources mean that the local governments have low tax revenue and depend almost entirely on the a priori labelled subnational or national funding.

In addition to the institutional capacity indicators with the lower scores across the four groups, there are some indicators that provided little information to differentiate the four groups, particularly public services provision (ca_psm) and the existence of a planning committee for Municipal Development (ins_pdm). Public services provision was generally low for all groups (below 0.5), which coincides with the heterogeneity of access to public services such as potable water and sewage within the states (SE, 2021). The overall low values in the existence of a planning Committee for Municipal Development (ins_pdm) indicates a general lack of a governance mechanism to enable multi-actor participation in municipal planning.

The cluster analysis generated four main groups that are differentiated in their generic and specific capacities and top-down or bottom-up adaptation approach. The first represents a group of municipalities that engage in intergovernmental coordination (504 municipalities), the second is a safety-first group (544 municipalities), the third is a transparency and citizen participation group (632 municipalities), and the last is a poverty trap group (763 municipalities).

Group 1: Intergovernmental coordination – Low values were observed for the inter-municipal coordination indicator (ca_cim) in all groups, except in one (Figure 1). Group 1 is characterized by the highest values in intergovernmental coordination (ca_cim) and access to public information regarding municipal planning (cr_ipda). These two indicators provide insights into the generic capacity of the local governments, either from a top-down approach, through collaborating with subnational and the national governments, or from a bottom-up approach, by providing public and available information to enable citizen participation regarding municipal planning. This group has the smallest number of local governments, and the states of Jalisco and Baja California

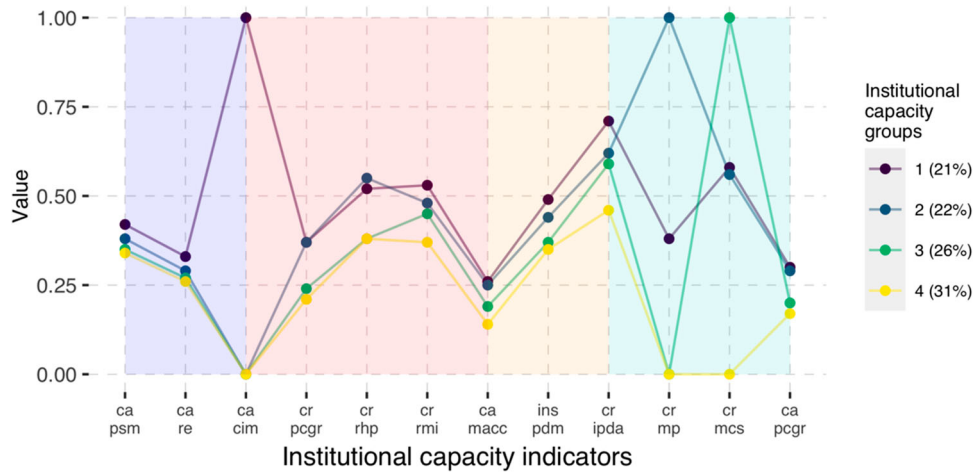

Figure 1. Institutional capacity indicators score for each group and organize following the adaptation and capacity dimensions approach. Indicators: ca_psm, public services provision; ca_re, economic resources for municipal planning; ca_cim, inter-municipal coordination; cr_pcgr, risk management planning; cr_rhp, human resources for risk management; cr_rmi, material and IT resources for risk management; ca_macc, climate change adaptation actions; ins_pdm, planning Committee for Municipal Development (COPLADEMUN for its acronym in Spanish); cr_ipda, access to public information regarding municipal planning; cr_mp, citizen participation mechanisms for risk management; cr_mcs, social oversight mechanisms for risk management; ca_pcgr, capacity-building in adaptation.

Sur are the states with the largest number of their local governments in this group (Figure 2). The state of Jalisco has been recognized as a subnational entity advancing in the implementation of inter-municipal associations that contribute to the capacity-building of local governments regarding sustainable development and climate change actions. These inter-municipal associations act as collaborative forums where local and state governments, non-governmental organizations, and representatives from the private sector and society participate in decision processes (González-Franco et al., 2018; González, 2012).

Group 2: Safety-first – the name of the group refers to conditions of low generic and high specific capacities, where populations prioritize present-day safety and security (specific capacities) over generic capacities, and there are weak safety nets at a governance or system level (Eakin et al., 2014). Local governments in Group 2 exhibit high institutional capacity for risk management both from a bottom-up (i.e. citizen participation mechanisms for risk management, cr_mp) and a top-down approach (i.e. human resources for risk management, cr_rhp). High capacity in citizen participation relates to public spaces for citizen access to risk maps and consultation regarding risk management by the local government. Meanwhile, a local government with human resources for risk management has a specific department within its organizational structure with qualified staff and capacity-building programmes for risk management. Baja California, Quintana Roo, and Veracruz are some of the states with a large percentage of their local governments in this group (Figure 2). These states have large extensions of coastline, which in turn make them some of the most vulnerable to the effects of sea-level rise and the increased frequency and intensity of tropical storms due to rising temperatures of surface seawater (Nava-Fuentes et al., 2017). It is worth remembering that the effects of Hurricane Wilma in Quintana Roo in 2005 generated 1.8 billion USD in damages and was one of the highest insurance losses in Latin America (Romero-Lankao et al., 2014). Also, Baja California and Quintana Roo have more than 50% of their local governments with risk maps, contrasting Veracruz where only 18% of its local governments have a risk map.[1] Instead, Veracruz has human and material resources for risk management.

Group 3: Transparency and citizen participation – Group 3 has high scores in the mechanisms enabling the citizen oversight of the local government actions regarding risk management (cr_mcs) and in the existence of public information about municipal planning (cr_ipda). Regardless of the focus on social oversight and access to information, local governments in Group 3 exhibit low capacity-building in adaptation (ca_pcgr), such as

STATE	INSTITUTIONAL CAPACITY GROUPS			
	Intergovernmental coordination	Safety first	Transparency and citizen participation	Poverty trap
Aguascalientes	36%	45%	18%	0%
Baja California	20%	60%	0%	20%
Baja California Sur	60%	20%	0%	20%
Campeche	36%	9%	55%	0%
Chiapas	16%	34%	5%	45%
Chihuahua	16%	33%	10%	40%
Coahuila	16%	42%	18%	24%
Colima	50%	10%	20%	20%
Ciudad de México	25%	31%	31%	13%
Durango	21%	28%	31%	21%
Guanajuato	43%	15%	41%	0%
Guerrero	15%	17%	10%	58%
Hidalgo	37%	13%	43%	6%
Jalisco	53%	10%	5%	32%
Estado de México	42%	20%	33%	5%
Michoacán	27%	10%	27%	36%
Morelos	30%	36%	18%	15%
Nayarit	15%	20%	20%	45%
Nuevo León	12%	20%	22%	47%
Oaxaca	7%	15%	34%	44%
Puebla	18%	24%	30%	28%
Querétaro	28%	28%	17%	28%
Quintana Roo	10%	60%	30%	0%
San Luis Potosí	26%	21%	31%	22%
Sinaloa	11%	39%	39%	11%
Sonora	8%	28%	32%	32%
Tabasco	18%	29%	29%	24%
Tamaulipas	12%	16%	28%	44%
Tlaxcala	48%	23%	10%	18%
Veracruz	14%	45%	31%	9%
Yucatán	17%	22%	8%	53%
Zacatecas	31%	7%	29%	33%

Figure 2. Percentage of local governments in each institutional capacity group per state in Mexico.

particular actions to prepare citizens to adapt and manage risks. However, some of the states with more than 50% of their local governments, i.e. Campeche and Guanajuato (Figure 2), have developed public websites targeting the general public with a focus on reducing vulnerability and promoting local adaptation actions, through accessible audio-visual material (SEMARNAT-INECC, 2018).

Group 4: Poverty trap – A poverty trap refers to conditions of chronic intense stress that undermine human welfare and limit necessary attributes to manage risk (e.g. social fabric), and these conditions are characterized by positive feedback between generic and specific capacities (Eakin et al., 2014). Group 4 was labeled as a poverty trap because it has the largest number of local governments that exhibit the lower scores in all of the institutional capacity indicators. The higher scores are in the indicators of risk management from a top-

down approach, which means that the better performance of these local governments resides in responding to risk based on human resources (cr_rhp) and material and IT resources (cr_rmi). Some of the states with a large number of local governments in this category are Chiapas, Guerrero, and Oaxaca, the poorest states in Mexico (Figure 2). These states have low scores in human development, such as education, the highest percentage of their population living under the poverty line compared to other states (below 1.9 USD per day) and high illiteracy rates (SE, 2021; SEMARNAT-INECC, 2018). Also, these local governments have limited resources for risk management, where less than 18% of their local governments have risk maps.[2]

Regarding the generic capacity of local governments, the lowest values are observed in indicators such as the mainstreaming adaptation in the local governments' agendas and the access to economic resources for municipal planning. The provision of public services requires more detail to provide enough information to differentiate the capacities of local governments, which was low in this analysis. Group 1 exhibits larger generic capacities than the rest by having vertical coordination mechanisms with subnational and national governments and horizontal collaboration capacities through transparency to engage citizen participation in municipal planning. Group 2 had the highest scores in the specific capacity indicators (i.e. risk management); and local governments in this group had the administrative capacity for risk management (e.g. human resources and organizational structures). Along with Group 2, local governments in Group 3 have capacities to promote citizen participation through transparency about risk management in the municipality. The specific capacities of Group 4 are mainly explained as a dependency on the resources (e.g. human, financial and other material) provided by subnational and national governments.

Discussion

Local governments are key actors for successful adaptation because they have the responsibility to translate top-down risk information to vulnerable populations and can scale bottom-up initiatives of communities in planning adaptation actions (Noble et al., 2014). Based on the results observed here, we identified a tragedy of urgency (see below), lack of climate change awareness, and low capacity to access and mobilize economic resources as major challenges to building the necessary institutional capacity of local governments to implement climate change adaptation in Mexico. The 'tragedy of urgency' refers to the local governments being caught in a vicious cycle of resolving short-term 'urgent' needs and relegating adaptation as not urgent enough to act on it today or to mainstream it in their current policy agendas(Moser et al., 2019). In Mexico, the tragedy of urgency that local governments face is a common condition associated with scarce resources and continual turnover that hinders medium to long-term adaptation planning (PNUD-México-INECC, 2017). The observed low values in the generic capacity indicators correspond to the conditions of a tragedy of urgency where specific capacities become more relevant in the short-term, at the expense of generic capacities for human development in the long-term.

The lack of climate change awareness translates into a lack of human and material resources allocated to adaptation (Romero-Lankao et al., 2013), and has been accounted for in climate change policy at sub-national levels in Mexico (D.O.F., 2019), and as a low priority for local governments (Solorio, 2021). The lack of climate change awareness also relates to the need for available and actionable information, as part of the climate services needed in adaptation decision-making. However, the provision of climate services is challenged by inadequate institutions, limitations to up-scale climate services to larger scales due to low capacity, and difficulties in maintaining systems beyond the pilot project stage (Coninck et al., 2018). Beyond data generation and availability, there is also a lack of mechanisms to effectively ascertain information needs in decision processes and the collaboration between data producers and data users (IPCC, 2012). Education and training courses for staff and elected officials that focus on framing, communication, and engagement for diverse audiences are proposed interventions to address these challenges (Moser et al., 2019).

Low capacity to access and mobilize economic resources for local governments is a key barrier to the implementation of relevant adaptation actions at a local scale. In Mexico, local governments can access economic resources from fees for the provision of public services or the use of public property, and from national and sub-national contributions (article 115 in the Constitución Política de Los Estados Unidos de México, 1917). Local governments with a low capacity to collect revenues by themselves are conditioned to depend on the

contributions established by the subnational and national governments, which can hinder the local government's capacity to independently plan for adaptation (i.e. group 4 – poverty trap). However, governments already challenged by a limited budget will be further constrained to effectively implementing adaptation (Moser et al., 2019). In Mexico, access to additional funding (i.e. international cooperation) is particularly challenging for local governments due to a lack of administrative capacity, accountability mechanisms, and institutional arrangements (Castillo et al., 2019; GFLAC, 2018). Local governments can also incur high transaction costs when seeking access to climate funds. Strategies to reduce such costs involve direct transfers from donors to recipients, which can prove a more efficient way to access funding, if adequate mechanisms for transparency, accountability, and citizen participation are in place to ensure public scrutiny on the budget allocation and performance of local governments (Brunner & Enting, 2014).

Opportunities for institutional capacity building for climate change adaptation

Horizontal and vertical coordination, transparency, and citizen participation were key elements present in existing processes that are helping to strengthen the institutional capacity of local governments. Without the capacity for collaboration, local governments rely solely on their own capacities and resources (i.e. Groups 2 and 3), or depend directly on the resources provided by the subnational and national governments (i.e. Group 4). The lack of effective coordination can promote policy gaps and prevent a coordinated response to effectively manage risks (Romero-Lankao et al., 2013). Furthermore, the lack of vertical or horizontal coordination also hinders the possibilities for mainstreaming adaptation through shared experiences and learning. In this context, intergovernmental coordination is key for the vertical integration of local governments with the subnational and national governments. Despite its relevance, only Group 1 exhibited a high capacity for intergovernmental collaboration, and governments in this group have developed inter-municipal associations that are decentralized government agencies mainly implemented and supported at a subnational scale in Mexico (Onainor, 2021). In the state of Jalisco, these associations have provided examples of local governance models for integrated land management. These associations promote cross-cutting coordination through (i) decision-making processes and programmes that operate beyond administrative periods; (ii) promoting vertical coordination with the subnational and national governments, and horizontal coordination with non-governmental actors; (iii) providing the institutional architecture for the implementation of long-term processes; and (iv) providing technical capacities and long-term oversight for municipal planning and operation (González-Franco et al., 2018; González, 2012).

Regarding access to climate finance, inter-governmental coordination can contribute to dismantling the typical siloed government syndrome. This syndrome creates a problem of disconnection between and among jurisdictions, resulting in unclear responsibilities, leadership, accountability, and authority. Some of the proposed interventions to address this syndrome are the creation of informal learning and collaborative networks, leadership that demands cross-sector/agency accounting of costs and benefits of projects within the local budget framework, and the establishment of funding for coordinating entities (Moser et al., 2019). Also, the use or development of partner systems is one of the strategies recommended to reduce the transaction costs that local governments bear when accessing climate funds (Brunner & Enting, 2014).

Policy implications for the institutional capacity groups

The Mexican regulatory framework on climate change establishes responsibilities at the local, subnational and national government levels and has five main dimensions: (i) normative regulation, (ii) planning and coordination, (iii) public policy instruments, (iv) financing, (v) evaluation, monitoring, reporting, and verification system (Ley General de Cambio Climático, 2012). Local governments are key elements of the administrative and political structure of Mexico, and share the authority, with the state and federation, to adapt to climate change (Monterroso & Conde, 2017). These governments have to develop, implement and evaluate climate change policy at the local level and participate in the design and implementation of local adaptation initiatives (SEMARNAT-INECC, 2015). Also, local governments have the possibility to mainstream adaptation in existing

policies and practices, particularly those impacting land uses and the public administration of their territories, including public services provision to the population (article 115 in the Constitución Política de Los Estados Unidos Mexicanos, 2021).

In this context, Group 1 can foster or consolidate collaboration and networking with other government agencies, non-governmental organizations, communities, and stakeholders to generate shared understanding and knowledge and channel collective efforts for climate adaptation. Local governments in Group 1 can be analyzed and used as an example of how intergovernmental collaboration supports adaptation by both mainstreaming and developing stand-alone policies and practices. For example, there are currently eight inter-municipal associations accounting for 70% of the local governments in Jalisco (Group 1), and these local governments have developed their local and regional climate change programmes (SEMARNAT-INECC, 2018).

Local governments in Groups 2 and 3 can be reviewed and updated to integrate the climate adaptation lens and risk management in their planning instruments. Local governments in these groups could benefit from managerial and intra-inter organizational mainstreaming strategies. This means modifying managerial and working structures to better address and institutionalize adaptation in their practice and promote or consolidate collaboration networks for a better vertical and horizontal cooperation (Runhaar et al., 2018).

Local governments in Group 4 pose a more serious challenge for both dedicated adaptation programmes and for mainstreaming adaptation. Local governments in this group appear to be in a poverty trap and other studies have found similar outcomes. Monterroso and Conde (2017) found that many of the local governments in the same states we used to illustrate Group 4 (Chiapas, Guerrero, and Oaxaca in Figure 2) have low adaptive capacity regarding available human (i.e. population structure and literacy), social (i.e. land tenure and areas with technical training), financial (i.e. GDP and access to credit), and natural capital (i.e. reforested areas). Local governments in Group 4 also seem to face legacy barriers to adaptation (Moser & Ekstrom, 2010). Governments like the ones in this group appear to be focused mainly on the most urgent issues, on long-standing vulnerabilities and have constant low capacity, which puts them at prior disadvantages to access economic resources for adaptation (Moser et al., 2019). These are the governments that would not benefit solely from more budget allocated from the subnational and national governments; instead, capacity-building for the administration, planning instruments, transparency, and citizen participation would also be needed. Also, due to the diversity of conditions of these governments, horizontal collaboration through networks can mainstream adaptation as an informal activity promoted by local needs and bottom-up processes (Runhaar et al., 2018).

There is also a need for structures or organizations that can support the development and mobilization of the institutional capacities of local governments, such as the National System on Climate Change (SINACC) at a national scale, international cooperation, and the structural leadership of the subnational governments. Jalisco (group 1) has developed subnational climate laws and programmes, cross-sectoral climate budgets, and the implementation of inter-secretarial commissions (Solorio, 2021).

The analytical framework used here evaluated the capacities of local governments as attributes that enable climate adaptation. However, there is a need to understand how these capacities are mobilized into action (Mortreux & Barnett, 2017). Further analysis will be needed to evaluate how the mobilization of institutional capacities influences climate change adaptation outcomes, particularly differentiated for urban and rural contexts, as well as for metropolitan scales.

Conclusion

Institutional capacity is a fundamental component of local responses to climate change because it is an enabling condition for climate adaptation planning and implementation. Among the key challenges that local governments face in Mexico to develop and mobilize their capacities to plan and implement climate change adaptation, we found that there were several. First, is the 'tragedy of urgency' (Moser et al., 2019) which is a pervasive condition hindering the development and mobilization of institutional capacity for climate change adaptation, due to the use of scarce resources for resolving short-term 'urgent' needs, instead of using them for adaptation. Second is low awareness of climate change and its impacts, which

translates into the lack of human, technical, material, and economic resources allocated to climate change adaptation. Third is the limited capacity of local governments to access and mobilize economic resources for adaptation.

Regarding building institutional capacities of local governments, we identified key opportunities, such as increasing administrative capacity, accountability, and public participation for local governments to access and mobilize economic resources for climate change adaptation. Additionally, intergovernmental coordination is a key attribute that local governments can develop to address deficiencies in institutional capacities for climate change adaptation. Finally, transparency and public participation can prove a relevant means to (i) engage the citizens to effectively respond to the risks posed by climate change, and (ii) address knowledge management gaps that can influence access to climate services needed at the local scale.

In this analysis, we recognize that the local context influences the conditions of the outcomes we observe. The four institutional capacity groups illustrate the heterogeneous conditions that local governments exhibit in a global South context, from governments getting closer to sustainable adaptation by means of intergovernmental collaboration to governments being caught in a poverty trap. Even though the analysis was specific to Mexico, some of the general features identified could be of relevance to other countries in the global South whose local governments also face the tragedy of urgency and limited economic resources for mainstreaming or developing stand-alone policies and practices for climate change adaptation.

Notes

1. http://rmgir.proyectomesoamerica.org/portal/apps/opsdashboard/index.html#/3e7adf434b834775b11ca7504d62bfe6. Consulted on September 11th, 2021
2. http://rmgir.proyectomesoamerica.org/portal/apps/opsdashboard/index.html#/3e7adf434b834775b11ca7504d62bfe6. Consulted on September 11th, 2021

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References

Bojórquez-Carrillo, A. L., Manzano-Loría, M. E., & Uc Heredia, L. J. (2015). Análisis de la relación entre la capacidad administrativa y la transparencia en gobiernos locales en México. *Investigaciones Regionales - Journal of Regional Research*, *31*, 101–118. http://search.proquest.com/openview/dc6b8f22166fa0b4afc212c36e474cfa/1?pq-origsite=gscholar.

Brunner, S., & Enting, K. (2014). Climate finance: A transaction cost perspective on the structure of state-to-state transfers. *Global Environmental Change*, *27*(1), 138–143. https://doi.org/10.1016/j.gloenvcha.2014.05.005

Carrera-Hernández, A., Coronilla-Cruz, R., & Navarro-Arredondo, A. (2010). *Índice de desarrollo institucional y sustentabilidad municipal*.

Castillo, A., Rodríguez, G., & Estrada, L. (2019). *Estado del Arte del Financiamiento Climático para México de Fuentes Públicas Internacionales y Nacionales*.

CONAPO-SEDATU-SEGOB. (2018). *Sistema Urbano Nacional 2018*. https://www.google.com.mx/maps/place/México/.

Coninck, H., Revi, A., Babiker, M., Bertoldi, P., Buckeridge, M., Cartwright, A., Dong, W., Ford, J., Fuss, S., Hourcade, J.-C., Ley, D., Mechler, R., Newman, P., Revokatova, A., Schultz, S., Steg, L., & Sugiyama, T. (2018). Strengthening and implementing the global response. In *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change* (pp. 313–443). https://www.ipcc.ch/site/assets/uploads/sites/2/2018/11/SR15_Chapter4_Low_Res.pdf.

Constitución Política de los Estados Unidos de México, 295. (1917). http://www.diputados.gob.mx/LeyesBiblio/pdf/1_240217.pdf.

Constitución política de los estados unidos mexicanos. (2021). (testimony of D.O.F.).

Delgado Ramos, G. C., & Mac Gregor Gaona, M. F. (2020). Índice de capacidades institucionales climáticas–ambientales locales, ICI–CLIMA 2019: el caso de la Zona Metropolitana del Valle de México. In *Plataforma de Conocimiento para la Transformación Urbana*.

D.O.F. (2019). *Resultados y recomendaciones de la evaluación estratégica del avance subnacional de la Política Nacional de Cambio Climático*. http://www.dof.gob.mx/nota_detalle.php?codigo=5549585&fecha=05/02/2019.

Eakin, H., Lemos, M., & Nelson, D. (2014). Differentiating capacities as a means to sustainable climate change adaptation. *Global Environmental Change*, *27*(1), 1–8. https://doi.org/10.1016/j.gloenvcha.2014.04.013

Eriksen, S., & Brown, K. (2011). Sustainable adaptation to climate change. *Climate and Development*, *3*(March), 3–6. https://doi.org/10.3763/cdev.2010.0064

GFLAC. (2018). *Hacia una ruta de movilización de financiamiento para alcanzar las metas nacionales de cambio climático en México*. https://doi.org/10.1017/CBO9781107415324.004.

González, R. F. (2012). *La gobernanza intermunicipal y la implementación de mecanismos REDD+ a nivel local*.

González-Franco, R., Muradás, P., Gutiérrez, C., & Carrillo, J. C. (2018). *Manual para la conformación y operación de una junta intermunicipal de medio ambiente*. http://sis.cnf.gob.mx/wp-content/plugins/conafor-files/2018/nacional/catalogo/biblioteca/163.pdf.

Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., Nooteboom, S., & Bergsma, E. (2010). The adaptive capacity wheel: A method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science and Policy*, *13*(6), 459–471. https://doi.org/10.1016/j.envsci.2010.05.006

Hinkel, J. (2011). '" Indicators of vulnerability and adaptive capacity "': Towards a clarification of the science – policy interface. *Global Environmental Change*, *21*, 198–208. https://doi.org/10.1016/j.gloenvcha.2010.08.002

Ibarrarán, M. E., Reyes, M., & Altamirano, A. (2014). Adaptación al cambio climático como elemento de combate a la pobreza. *Región y Sociedad*, *26*(61), 5–50.

INEGI. (2014). *Sistema Estatal y Municipal de Bases de Datos*. SIMBAD. http://sc.inegi.org.mx/cobdem/.

INEGI. (2017). Censo Nacional de Gobiernos Municipales y Delegacionales. In *CNGDM*.

INEGI. (2019). *Estadística de Finanzas Públicas Estatales y Municipales 2017*. SIMBAD. https://www.inegi.org.mx/rnm/index.php/catalog/360/related_materials?idPro=V.

IPCC. (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation: special report of working gropus I and II of the Intergovernmental Panel on Climate Change* (M. D. M. Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi & and P. M. M. K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor (eds.)). https://doi.org/10.1017/CBO9781139177245.

IPCC. (2019). Summary for Policymakers. In J. M. P. R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, & K. Kissick (Eds.), *Climate Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* (pp. 41). https://doi.org/10.1002/9781118786352.wbieg0538

Lemos, M., Agrawal, A., Eakin, H., Nelson, D., Engle, N., & Johns, O. (2013). Building adaptive capacity to climate change in less developed countries. *Climate science for serving society*, *1*, 1–20. https://doi.org/10.1017/CBO9781107415324.004

Lemos, M. C., Lo, Y. J., Nelson, D. R., Eakin, H., & Bedran-Martins, A. M. (2016). Linking development to climate adaptation: Leveraging generic and specific capacities to reduce vulnerability to drought in NE Brazil. *Global Environmental Change*, *39*, 170–179. https://doi.org/10.1016/j.gloenvcha.2016.05.001

Ley General de Cambio Climático, 1. (2012). http://www.diputados.gob.mx/LeyesBiblio/pdf/LGCC_061120.pdf.

López, J. D., & Gómez-Álvarez, D. (2010). Midiendo las capacidades institucionales de los gobiernos locales de México: un mapa de su diversidad. In L. L. H. Cámara de diputados, P. de las N. U. para el D. (PNUD), U. de G. (UdG), & L. Miguel Ángel Porrúa (Eds.), *Capacidades institucionales para el desarrollo humano: conceptos, índices y políticas públicas* (pp. 209–278.

Martínez, J. (2015, July). Medición de las capacidades administrativas municipales. *Analéctica*. http://www.analectica.org/articulos/martinez-capacidades/.

Martínez-Pellégrini, S., Flamand, L., & Hernández, A. (2008). Panorama del desarrollo municipal en México. Antecedentes, diseño y hallazgos del Índice de Desarrollo Municipal Básico. *Gestión y Política Pública*, *XVII*(1), 145–192.

Mimura, N., Pulwarty, R. S., Duc, D. M., Elshinnawy, I., Redsteer, M. H., Huang, H. Q., Nkem, J. N., & Rodriguez, R. A. S. (2014). 15. Adaptation Planning and Implementation. In *Assessment Report 5- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*.

Monterroso, A., & Conde, C. (2017). Adaptive capacity: Identifying the challenges faced by municipalities addressing climate change in Mexico. *Climate and Development*, *0*(0), 1–13. https://doi.org/10.1080/17565529.2017.1372264

Mortreux, C., & Barnett, J. (2017). Adaptive capacity: Exploring the research frontier. *Wiley Interdisciplinary Reviews: Climate Change*, *8*(4), https://doi.org/10.1002/wcc.467

Moser, S. C., & Ekstrom, J. A. (2010). A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences*, *107*(51), 22026–22031. https://doi.org/10.1073/pnas.1007887107

Moser, S. C., Ekstrom, J. A., Kim, J., & Heitsch, S. (2019). Adaptation finance archetypes: Local governments' persistent challenges of funding adaptation to climate change and ways to overcome them. *Ecology and Society*, *24*(2), https://doi.org/10.5751/ES-10980-240228

Nava-Fuentes, J. C., Arenas-Granados, P., & Cardoso-Martins, F. (2017). Coastal management in Mexico: Improvements after the marine and coastal policy publication. *Ocean and Coastal Management*, *137*, 131–143. https://doi.org/10.1016/j.ocecoaman.2016.12.017

Noble, I. R., Huq, S., Anokhin, Y., Carmin, J., Goudou, D., Lansigan, F. P., Osman-Elasha, B., & Villamizar, A. (2014). 14. Adaptation Needs and Options. In *Assessment Report 5- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. https://doi.org/31 March 2014.

OECD. (2008). Handbook on constructing composite indicators: Methodology and user guide. In *Methodology (Vol. 3)*. OECD publishing. https://doi.org/10.1787/9789264043466-en

Onainor, E. R. (2021). *México ante la encrucijada de la gobernanza climática. Retos institucionales* (Vol. 1).

PNUD-México-INECC. (2017). Medición multidimensional de capacidad institucional a nivel municipal que fomente la adaptación al cambio climático. In *Proyecto #86487 "Plataforma de Colaboración sobre Cambio Climático y Crecimiento Verde entre Canadá y México" Convenio de colaboración: Transparencia Mexicana, A.C*.

Romero-Lankao, P., Hughes, S., Rosas-Huerta, A., Borquez, R., & Gnatz, D. M. (2013). Institutional capacity for climate change responses: An examination of construction and pathways in Mexico City and Santiago. *Environment and Planning C: Government and Policy*, *31*(5), 785–805. https://doi.org/10.1068/c12173

Romero-Lankao, P., Smith, J. B., Davidson, D. J., Diffenbaugh, N. S., Kinney, P. L., Kirshen, P., Kovacs, P., & Ruiz, L. V. (2014). North America. In *IPCC Fifth Assessment Report*.

Rosas Huerta, A. (2008). Una ruta metodológica para evaluar la capacidad institucional. *Política y Cultura*, *30*, 119–134.

Runhaar, H., Wilk, B., Persson, Å, Uittenbroek, C., & Wamsler, C. (2018). Mainstreaming climate adaptation: Taking stock about "what works" from empirical research worldwide. *Regional Environmental Change*, *18*(4), 1201–1210. https://doi.org/10.1007/s10113-017-1259-5

SE. (2021). *Informe Nacional Voluntario 2021. Agenda 2030 en México*. ttps://sustainabledevelopment.un.org/content/documents/288982021_VNR_Report_Mexico.pdf.

SEMARNAT. (2020). *Contribución Determinada a nivel Nacional: México. Actualización 2020. https://mma.gob.cl/wp-content/uploads/2020/04/NDC_Chile_2020_español-1.pdf*.

SEMARNAT-INECC. (2015). *Elementos mínimos para la elaboración de los programas de cambio climático de las entidades federativas*. https://www.google.com.mx/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwj9nObX-vPPAhWc8oMKHe1cB_wQFggdMAA&url=http%3A%2F%2Fwww.inecc.gob.mx%2Fdescargas%2Fcclimatico%2F2015_elem_minims_prog_cc_efederativas.pdf&usg=AFQjCNH_ZmeDvttzFzdhtXoaRCK6b_6z2g.

SEMARNAT-INECC. (2018). *Sexta Comunicación Nacional y Segundo Informe Bienal de Actualización ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático*.

Solorio, I. (2021). Leader on paper, laggard in practice: Policy fragmentation and the multi-level paralysis in implementation of the Mexican Climate Act. *Climate Policy*, *21*(9), 1175–1189. https://doi.org/10.1080/14693062.2021.1894084

Tschakert, P., Waisman, H., Abdul Halim, S., Antwi-Agyei, P., Dasgupta, P., Hayward, B., Kanninen, M., Liverman, D., Okereke, C., Pinho, P., Riahi, K., & Suarez, A. (2018). Sustainable Development, Poverty Eradication and Reducing Inequalities. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global gre. In *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change* (pp. 445–538). https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter5_Low_Res.pdf.

Wamsler, C. (2015). Mainstreaming ecosystem-based adaptation: Transformation toward sustainability in urban governance and planning. *Ecology and Society*, *20*(2), https://doi.org/10.5751/ES-07489-200230

V. Mobilizing institutional capacities to adapt to climate change: local government collaboration networks for risk management in Mexico City

(manuscrito 3)

Cid, A., Siqueiros-García, J.M., Mazari-Hiriart, M., Guerra, A. & A. Lerner. (*In prep*). Mobilizing institutional capacities to adapt to climate change: emergent strategies of local governments in Mexico City. Climate Action (*abstract accepted for the Topical Collection on "Local Climate Action in Latin America" in Climate Action*)

Abstract

State-centered and hierarchical government strategies based on technocratic top-down approaches have proved inadequate to address multiple interacting and cross-scale risks. In contrast, multilevel governance (MLG) provides a form of governance by networks that operate both in a horizontal arena with neighboring local governments, civil society organizations, and local communities, and in vertical settings, with higher-level governmental authorities and international organizations. In this paper, we examined the experience of local governments in their role in a multilevel governance system for risk management in Mexico City. We sought to understand what collaborative resources local governments have to address multiple risks in Mexico City? How do they mobilize these resources in specific actions to address a risk, what were the main similarities and differences among them, and how do they interact with different levels on a jurisdictional scale (inter-governmental, local, regional and national governments) and at a network scale (society). Our results show that resources for vertical (with other government levels) and horizontal (with non-governmental actors, and other local governments) collaboration were key for local governments to act, as local governments coordinated to address multiple risks. We found that collaboration was more common between local governments and with the subnational government (Mexico City Government). We determined that the collaboration networks to address earthquakes and flooding were similar regarding their network size and composition, mainly with government agencies with key responsibilities for disaster response. In contrast, we characterized a more diverse network to address wildfires in Mexico, that indicated the need for the local governments to access a wide set of resources under conditions of financial scarcity. We found evidence of successful elements of multilevel governance and identified the need for further research on the engagement and representation for non-governmental organizations and private actors in networks of risk management. The results from this study provide a better understanding of the arrangement of collaborative resources underlying local government actions under a state of urgency and scarcity, where action cannot wait for institutional change.

Resumen: Las estrategias de gobierno jerárquicas y centradas en el Estado, basadas en enfoques tecnocráticos tradicionales de descendentes (*top-down*), han demostrado ser inadecuadas para

hacer frente a los múltiples riesgos que interactúan entre sí y ocurren en distintas escalas. En cambio, la gobernanza multinivel ofrece una forma de gobernanza basada en redes que operan tanto en un ámbito horizontal con gobiernos locales vecinos, organizaciones de la sociedad civil y comunidades locales, como en entornos verticales, con autoridades gubernamentales de nivel superior y organizaciones internacionales. En este trabajo examinamos el papel de los gobiernos locales en un sistema de gobernanza multinivel para la gestión de riesgos en Ciudad de México. Nuestros resultados muestran que los recursos para la colaboración vertical (con otros niveles de gobierno) y horizontal (con actores no gubernamentales y otros gobiernos locales) fueron clave para que los gobiernos locales actuaran, ya que los gobiernos locales se coordinaron para abordar riesgos comunes. Encontramos que la colaboración era más común entre los gobiernos locales y con el gobierno subnacional (Gobierno de la Ciudad de México). Determinamos que las redes de colaboración para hacer frente a sismos e inundaciones eran similares en cuanto a su tamaño y composición, principalmente con organismos gubernamentales con responsabilidades clave en la respuesta a desastres. En contraste, caracterizamos una red más diversa para hacer frente a los incendios forestales, que indicaba la necesidad de los gobiernos locales de acceder a un amplio conjunto de recursos en condiciones de escasez de recursos financieros. Encontramos evidencias de elementos exitosos de gobernanza multinivel e identificamos la necesidad de mayor investigación sobre el compromiso y la representación de organizaciones no gubernamentales y actores privados en las redes de riesgos prioritarios (sismos, inundaciones e incendios forestales). Los resultados de este estudio pretenden proporcionar una mejor comprensión de la disposición de recursos colaborativos que subyace a las acciones de los gobiernos locales en un estado de urgencia y escasez, en el que la atención no puede esperar al cambio institucional.

Introduction

Climate change hazards pose challenges for sustainable adaptation in cities that experience rapid urbanization, high levels of inequality, and exposure to multiple and interconnected risks (IPCC, 2022). Climate adaptation in cities is mainly led by local governments, which have the responsibility of implementing climate action in coordination with the national and subnational governments and are the immediate government level in contact with vulnerable populations (Mimura et al., 2014; Tschakert et al., 2018). Effective local institutions require adequate institutional capacity to build consensus for climate action, enable coordination and inform strategy setting (IPCC, 2023). Local governments need to be flexible in order to enable top-down and bottom-up action that can bring capacities together from across government levels (IPCC, 2022). The institutional capacity of local governments for climate action can be hindered by the "tragedy of urgency"–constant pressure from immediate needs, daily demands or other pressing issues– (Moser et al., 2019), the lack of climate change awareness, and the low capacity to access and mobilize economic resources (Cid & Lerner, 2023). Asymmetries in institutional capacities of local governments also relate to political inequality (Ruiz-Rivera & Melgarejo-Rodríguez, 2017) and the centralization of the political systems, preventing the state and local governments to share experiences and cooperate (Solorio, 2021). Nevertheless, the institutional capacity of local

governments to response to multiple risks can be strengthen by collaboration networks (Romero-Lankao et al., 2013) and supported by multilevel governance (MLG) (Frey & Ramírez, 2019). Both are an enabling condition for effective climate action, through: (a) enabling or strengthening cooperation and coordination between government levels and society; (b) improving the efficient use of scarce resources through shared responsibilities and learning; and (c) preventing policy gaps and contradictive policies (Frey & Ramírez, 2019; IPCC, 2023; Romero-Lankao et al., 2013). MLG can also contribute to decentralization of climate action through the devolution of power from central to local governments and increase power sharing between the state and civil society (Di Gregorio et al., 2019). Successful elements in the attention of disaster risks by MLG involve the protagonist role of local governments and their capacity to engage local communities and citizens and to interact constantly with higher-level authorities in implementation processes (Frey & Ramírez, 2019).

In this paper, we examined the experience of local governments in their role in a multilevel governance system for risk management. We aimed to understand how the local governments mobilize their collaborative resources to address multiple risks in Mexico City. We chose Mexico City as a case study, where the main risks that the city will experience due to climate change are associated with heat waves, droughts, floodings due to intense rainfall events, and landslides (SEDEMA, 2021; SGIRPC, 2021; Sosa-Rodriguez, 2014; Vargas & Magaña, 2020). To understand the available collaborative resources that local governments have and how these resources are mobilized to address multiple risks, we used a mixed-methods approach based on workshops with the 16 local governments (*alcaldías*) of Mexico City. We mapped the collaborative resources perceived by the government officials to address priority risks *(what collaborative resources do local governments have to address multiple risks in Mexico City?)*. Then we determined *how do governments mobilized the collaborative resources in specific actions to address a risk, and what were the main similarities and differences among them*. We used an Integrated Risk Management approach because it aims at minimizing human, economic and physical losses, as well as reducing conditions of vulnerability to increase resilience and maintain the livelihoods of Mexico City dwellers (SGIRPC, 2021). Finally, we aimed to understand further how do the local governments mobilized their collaborative resources by analyzing *how do they interact with different levels on a jurisdictional scale (inter-governmental, local, regional and national governments) and another type of organizational scale (society)* (Cash et al., 2006), based on a network approach. Our results show that resources for vertical (with other government levels) and horizontal (with non-governmental actors, and other local governments) collaboration were key for local governments to act, as local governments coordinated to address common risks. The lack of access to resources and a knowledge base has been addressed through collaboration with non-governmental actors. In this study, we characterized the mobilization of collaborative resources as a key determinant of institutional capacity response under a multi-level governance approach. In doing so, we aimed to better understand the collaborative resources arrangement underlying local government actions under a state of urgency and scarcity, in which attention cannot wait for institutional change.

Legal and normative framework

The Mexican federal system was originally structured in accordance with the classic model of U.S. federalism, including: (i) power at the federal level and bodies of power at the local level; (ii) a constitutional formula for the distribution of powers under the logic of dual federalism (with express powers of the federation and residual powers in favor of the federative or state entities); and (iii) a bicameral federal legislative branch. In this federal system, the state and local governments are elected independently from the federal government. However, the federal structure of the country exhibits a high degree of centralization that has part of its roots in the historical struggles between federalists and centralists during the XIX century, and that was later consolidated during the XX century, and resulted in the subordination of the states and local governments to the federal or national government (Serna, 2016).

Local governments in Mexico are key elements of the administrative and political structure of Mexico to mitigate and adapt to climate change (Monterroso & Conde, 2017). These governments have sovereignty and the capacity of self-determination in their territories as defined in the Mexican legal framework stated in the constitution. Some of the major responsibilities of the local governments in Mexico are the public administration of their territories, including public services provision to the population (i.e. potable water and sewage supply), and the determination of land uses (article 115 in the Constitución Política de Los Estados Unidos Mexicanos, 2021).

Local governments in Mexico have to develop, implement and evaluate climate change policy at the local level (SEMARNAT-INECC, 2015). Even though local governments can mainstream adaptation into their work, they still depend on the national and subnational governments for resources, capacities and to scale-up local adaptation initiatives. Negative dependencies due to the lack of investment in capacity building by national and subnational governments can hinder climate action by local governments. Solorio (2021) identified the low attention that the Mexico Government, through the National System on Climate Change (SINACC), pays to subnational and local concerns regarding climate action. Local governments in Mexico City face additional challenges than local governments in other states in Mexico because they exhibit some differences in their administrative capacity, particularly regarding budget allocation from the Mexico City Government (article 122 in the Constitución Política de los Estados Unidos Mexicanos, 2021). These constraining conditions that local governments face in Mexico City have also been acknowledged regarding climate change adaptation, which has been traditionally considered the responsibility of the Ministry of Environment of the Mexico City Government. In this context, inter-institutional coordination and communication has been acknowledged as a key element to be improved to ensure a proper fit and alignment of climate change policies and strategies at various government levels and reduce the current level of institutional fragmentation (Sosa-Rodriguez, 2014).

The attention to the vulnerability of the CDMX to multiple interconnected risks, together with the strengthening of adaptive capacity and resilience building, implies the consideration of policy and planning instruments that involve effective and innovative coordination between different jurisdictional levels (vertical) and network levels, government interacting with diverse sectors of society (horizontal). We mapped at least 16 policy, planning, management, financing and participation instruments with direct attribution to Mexico City that can be leveraged to address the multiple and interconnected risks (Table 1). These instruments can be understood under a hybrid approach of planning adaptation, were the benefit from the stability provided by regulations and institutional architecture, characteristic of a top-down approach, and from the flexibility that fosters the participation of diverse societal actors, provided by a bottom-up approach. The following is a non-exhaustive list of policy, planning, management, financing and participation instruments of Mexico City that supports the attention to multiple interconnected risks from diverse dimensions.

Table 1. List of relevant policy, planning, management, financial and public participation instruments for Mexico City that manage and respond to multiple risks

Instrument type	**Instrument**	**Reference**
Policy	State Action Program for Climate Change (PECC) Programa de Acción Estatal de Cambio Climático (PECC)	*(Ley General de Cambio Climático, 2012)*
Policy	Municipal Climate Change Program Programa Municipal de Cambio Climático	
Policy	Specific Program for Integral Risk Management and Civil Protection Programa Específico de Gestión Integral de Riegos y Protección Civil	*(Ley de Gestión Integral de Riesgos y Protección Civil de La Ciudad de México, 2019)*
Policy	CDMX Resilience Strategy Estrategia de Resiliencia de la CDMX	
Policy	Mexico City Civil Protection Program Programa de Protección Civil	
Policy	Mexico City Local Climate Action Strategy (2021-2050) Estrategia Local de Acción Climática (2021-2050)	(*Ley de Mitigación y Adaptación al Cambio Climático y Desarrollo Sustentable de la Ciudad de México*, 2021)
Policy	Mexico City Climate Action Program (2021-2030)	

Instrument type	Instrument	Reference
	Programa de Acción Climática de la Ciudad de México (2021-2030)	
Planning	Natural Protected Areas Management Program Programa de Manejo de Areas Naturales Protegidas (ANP)	*(Ley General del Equilibrio Ecológico y la Protección al Ambiente, 2018)*
Planning	Areas of Environmental Value Management Program Programa de Manejo de Areas de Valor Ambiental (AVA)	*(Ley Ambiental de Protección a la Tierra en la Ciudad de México, 2023)*
Planning	Community Conservation Area Plans Planes de Áreas Comunitarias para la Conservación (ACC)	
Planning	Mexico City Risk Atlas and risk atlas at a municipal scale Atlas de Riesgos de la CDMX y Atlas de Riesgos por Alcaldía	(Ley de Gestión Integral de Riesgos y Protección Civil de La Ciudad de México, 2019; *Ley de Mitigación y Adaptación al Cambio Climático y Desarrollo Sustentable de la Ciudad de México*, 2021)
Planning	Information systems: - Early Warning System /Sistema de Alerta Temprana - Digital Platform / Plataforma Digital - Climate Change Virtual Center /Centro Virtual de Cambio Climático	
Management	Construction Regulations for Mexico City Reglamento de Construcción de la CDMX	
Management	Regulation for agroecological production on conservation land in Mexico City Norma sobre producción agroecológica en suelo de conservación en CDMX	PROY-NACDMX-002-RNAT-2019
Auditing/ financial	Disaster and Emergency Assistance Fund Fondo de Atención a Desastres y Emergencias (FADE)	*(Ley de Gestión Integral de Riesgos y Protección Civil de La Ciudad de México, 2019)*
Participation	Council for Integrated Risk Management and Civil Protection for each municipality Consejo de Gestión Integral de Riesgos y Protección Civil de cada Alcaldía	

Case study

We chose Mexico City as a case study (Figure 1), where the main risks that the city will experience due to climate change are associated with heat waves, droughts, flooding due to intense rainfall events, landslides, in addition to non-climate risks, such as earthquakes (SEDEMA, 2021; SGIRPC, 2021; Sosa-Rodriguez, 2014; Vargas & Magaña, 2020). As of 2020, Mexico City had a population of 9,209,944, distributed in 1,494.3 km^2, with a population density of 6,163.3 inhabitants per km^2. Iztapalapa territorial district, with 1,835,486 inhabitants, is the most populated, followed by Gustavo A. Madero with 1,173,351 inhabitants. On the other hand, the territorial districts with the lowest population are Cuajimalpa and Milpa Alta with 217,686 and 152,685 people respectively. The territorial districts of Iztacalco (17,523), Cuauhtémoc (16,784), Benito Juárez (16,260) and Iztapalapa (16,220) have a density of more than 16,000 inhabitants per square kilometer (INEGI, 2021).

Figure 1. The 16 local governments of Mexico City

It is expected that warming related to the Urban Heat Island effect (UHI) will be of a magnitude (2.5-4.5 ºC) associated with climate scenarios of high emissions for the end of the century (Estrada & Perron, 2021). The temperature of Mexico City has already had a significant increase of 3º to 4ºC in the past 100 years. This increase relates to the UHI of the Mexico City Metropolitan Area (MCMA), associated with urbanization patterns and the loss of vegetation and surface water bodies. Newly urbanized regions increase the maximum temperature by the order of 1ºC per decade (Vargas & Magaña, 2020, p.1). In addition to the gradual increase in temperature, heatwaves or warm spells (days with more than 30ºC) have doubled in the central, eastern, and northwestern parts of the city (Vargas & Magaña, 2020, p.9).

Regarding precipitation, Mexico City will face a progressive reduction in the mean annual precipitation and an increase in intense rainfall events. Mean precipitation is expected to decline on average by 7% in the 2050s, and by 10.4% by 2070. Reduced annual precipitation will trigger

drought events and increase water scarcity, leading to heat strokes and a lack of water for human use (Sosa-Rodriguez, 2014, p. 972). Warmer conditions in the atmosphere can lead to intense precipitation or rainfall events. Mexico City has experienced an increase in the number of extreme rainfall events, crossing the precipitation threshold of 20 mm per day (Vargas & Magaña, 2020, p.6). The distribution of extreme rainfall events has spread in the city, and nine out of 16 boroughs are considered to be at very high risk of flooding, representing 68% of Mexico City's population (SEDEMA, 2021, p. 58). Extreme rainfall can also cause runoff and landslides due to the landscape (differential soil subsidence), the unplanned urbanization, the absence of green open spaces, and the complete dependence on the extensive underground drainage system, particularly in the center, western and southwestern areas of the city (Gobierno de la Ciudad de México, 2016; Sosa-Rodriguez, 2014). The climate risks will interact or will be exacerbated by other social-ecological risks affecting Mexico City, like those related to geophysical hazards, such as earthquakes and subsidence due to the overexploitation of the aquifer (SGIRPC, 2021), and socio-political factors, such as protests due to social unrest.

Methods

We used a mixed-methods approach based on participatory workshops with the 16 local governments (*alcaldías*), involving 221 government officials, from 119 government agencies alcaldías), in a 13-month period (between 2019 and 2020). The first six workshops were in-person at the local government facilities (October 2019 to March 2020). Due to the COVID-19 lock-out restrictions, the subsequent ten workshops were virtual (Figure 2).

Figure 2. Timeline of workshop execution

The workshops were organized by the Ministry of Integrated Risk Management and Civil Protection of Mexico City (SGIRPC by its Spanish acronym) with the collaboration of the National Laboratory of Sustainable Science (LANCIS by its Spanish acronym) at the National Autonomous University of Mexico. The SGIRPC coordinated the dates and sites for the workshops with the Civil Protection Agencies of each local government; however, they were only observers and did not contribute to the workshops' inputs. The results of the workshops were systematized and analyzed by LANCIS and published by the SGIRPC.[1]

The in-person workshops comprised the integration of groups from diverse areas (i.e., Civil Protection, Urban Development, Citizen Participation, etc.) with a facilitator for each group. The dynamic of the groups was divided into three sections: the construction of a resource matrix, were

[1] https://serviciosatlas.sgirpc.cdmx.gob.mx/portal/apps/sites/#/alcaldias. Consulted on September 17th, 2023

the participants described in cards the human, financial, material, and collaborative resources of their respective area. The resources matrix also included the three main risks perceived as priority to address in their boroughs. Subsequently, a timeline was built to understand how they mobilized the resources previously described into actions given a particular extreme event (i.e., flood, earthquake, etc.). Finally, a map of the borough was used to understand the perceptions of the participants of the spatial distribution of extreme events and the distribution of the actions previously described to address them. The general design of the workshops had to be adjusted to fit a virtual environment, where the construction of the resource matrix was built mainly through on-line surveys, and the timeline and mapping were conducted in live virtual workshops using QGIS software and Zoom.

The data from the workshops was elicited and assessed in three main phases: (1) construction of the collaborative resource matrix for risk management of the local government; (2) mapping of risk management actions implemented by the local governments; and (3) assessment of the collaboration resources that local governments mobilize to address priority risks (Figure 3).

The construction of the collaborative resource matrix consisted of identifying the resources that local governments perceived they already have and mobilize to address risks. The original data entailed human, material, financial, and collaborative resources, following PNUD-México-INECC (2017). However, in this paper we only assess the collaborative resources, which entailed those coordination or cooperation relationships between the local government, with different levels in jurisdictional (inter-governmental, local, regional and national governments) and network (society) scales (Cash et al., 2006). The collaborative resources were determined for each department in each local government and organized in five main categories, depending on if they collaborate: (a) between departments within the local government (RC1); (b) with other local governments (RC2); (c) with the state government (e.g., Mexico City Government) (RC3); (d) with the national government (RC4); and (e) with non-governmental organizations (RC5). For every local government, the collaborative resources for each department comprised the presence or absence of each resource category (RC1-RC5), and its corresponding description. For example, in one workshop the RC3 resources of the Civil Protection Department included the ministries of Risk Management and Civil Protection, Water and Sanitation, Infrastructure and Services, the Fire Department, and the Rescue and Medical Emergencies Squad of the Mexico City Government. The value of each local government per each collaborative resource category was estimated as the average for all departments within that local government.

The mapping of risk management actions involved the characterization of the actions in a structured board inspired by the work of Withycombe-Keeler et al. (2017). The board consisted of a timeline in which participants collectively determined the sequence of actions that were implemented to address a risk, previously prioritized in the resource matrix. The actions were coded following a thematic analysis with MAXQDA 2022 (VERBI, 2021), based on an Integrated Risk Management cycle approach in five main categories: 1) risk identification; 2) forecasting and

prevention; 3) mitigation; 4) preparedness and relief; and, 5) recovery and reconstruction, based on an Integrated Risk Management (IRM) approach (Mohibbullah et al., 2021). Then the frequencies of the actions were estimated for each category and the results were transformed to an interval scale in order to allow for comparison, by means of a min-max normalization (OECD, 2008). The IRM categories of actions are described below:

- **Risk identification** focuses on the factors that contributed to the generation of risks; actions of this phase include the identification of areas of social marginalization, urban growth, urban and environmental impact, and irregular human settlements.
- **Forecasting and prevention** comprises the actions and mechanisms carried out prior to the occurrence of an extreme event, to reduce or prevent it and its impact. The elaboration of risk maps to inform the planning of the city and early warning systems are examples of forecasting and prevention actions.
- **The mitigation phase** includes actions carried out to reduce the vulnerability of the population and key infrastructure. Preventive and corrective maintenance of infrastructure, technical training, and relocation of infrastructure are examples of actions aimed at mitigating risks.
- **Preparedness and relief** contain two phases in one. Preparedness actions maintain an adequate response capacity when a risk materializes into a disaster and reduce the damage and losses caused to the population. Among them are drills and permanent training of brigade and community members, emergency squads, public agents, and the population in general. Relief refers to the immediate response to a disaster and includes the period from the moment the risk causes damage and losses, until the rehabilitation of systems and services. Actions in this phase include the establishment of a coordination station, the delimitation of affected areas, the provision of relief to the population, and the establishment of shelters.
- **The recovery and reconstruction** phase focuses on gradually reestablishing and improving the conditions of the sites affected by a disaster. Actions in this stage include the recovery of communication routes, the reconstruction or rehabilitation of infrastructure and equipment, the creation of temporary jobs, and the coordination of inter-institutional actions.

The IRM phases and actions are conceived as part of a cycle. Hence, it was expected that the recovery and reconstruction phase would inform the actions to be carried out in the risk identification, prevention, mitigation, and preparedness phases. As a result, this would promote continuous learning and more robust Integrated Risk Management systems (SGIRPC, 2021). The assessment of the collaboration resources followed a Social Network Analysis (SNA) approach (Fliervoet et al., 2016) to examine the experience of local governments in their role in a multi-level governance system for risk management in Mexico City. The nodes of the system came from the collaborative resource matrix and the ties came both from the collaborative resource matrix and the IRM actions mapping. The ties of the network included elements of horizontal (e.g., between local governments) or vertical coordination (e.g., between federal, state or local government structures). We built the *ego-centered network or egonet* of each local government, which was then integrated with all the remaining egonets into a single network per priority risk,

which resulted in three networks. An egonet is a network, or part of it, that involves a particular node we are focusing on, which we call egos or index nodes (in our case the local governments are the egos). This network consists of ego, the nodes ego refers to be connected to (also referred as ego's alters), and usually the ties between ego's alters (Borgatti et al., 2013).

Each priority risk network was assessed in terms of its density, degree centralization, and cross-boundary exchange with *Cytoscape* (Shannon, 2013). The density was used to analyzed the connectedness of the network, and also as a proxy for the potential for collaborative processes within the network. The lower the network density -closer to 0- the more potential for the existence of subgroups and potentially less collaboration between such subgroups; in contrast, the higher the density -closer to 1- the more homogeneous the network will be (Fliervoet et al., 2016). Degree centralization indicates the existence of dominant organizations (nodes) that may hold the most information or quickly connect with the broader network, and act as a crucial channel for information or resources flow (Mohibbullah et al., 2021). Regarding the degree centralization, because of the relative concentration of observed edges, value 1 represents a network with all node connected only to a single node (with a star like structure), and 0 when they are all equally connected. Cross-boundary exchange is a measure of network heterogeneity, where a low cross-boundary exchange -closer to 0- indicates a relatively high tie density within groups and potentially less collaboration between groups. It is estimated by the number of ties connecting actors with different affiliations divided by the total number of connections in the network and expressed as a percentage (Fliervoet et al., 2016). We assessed the cross-boundary exchange between node types, which were defined as different levels in a jurisdictional scale (local, subnational and national government agencies) and a other type of organizational scale (governments and non-governmental organizations).

Figure 3. Description of analysis of the collaborative resources of local governments in Mexico City.

Results

Collaborative resources (what collaborative resources do local governments have to address multiple risks in Mexico City?). It is worth noting the central role that the Civil Protection Department had in all the local governments (RC1) and the Integrated Risk Management and Civil Protection Mexico City Ministry. However, this may be explained by the fact that both types of government agencies were the ones that organized the workshops and summoned the workshops' participants (Figure 4). The risks prioritized in the workshops were earthquakes, flooding, wildfires, landslides, and those associated with social causes, such as protests and pilgrimages. To

assess the local governments' capacities, we decided to focus on the three priority risks that were more frequently reported by the workshop's participants: earthquakes, flooding, and wildfires.

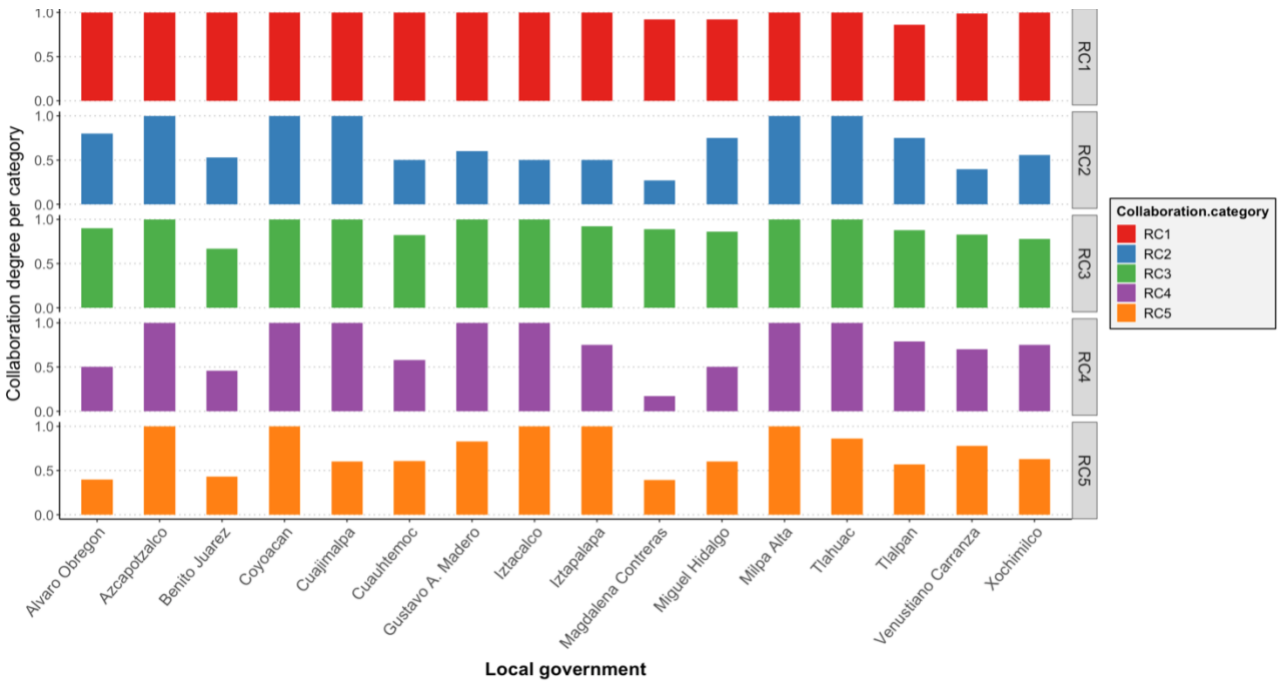

Figure 4. Collaborative resources perceived by the 16 local governments to address risks in Mexico City. Collaboration: collaboration between departments within the local government RC1; with other local governments (RC2); with the state government (e.g., Mexico City Government) (RC3); with the national government (RC4); and (e) with non-governmental organizations (RC5).

Actions (How do governments mobilized the collaborative resources in specific actions to address a risk?). More than half of the Integrated Risk Management (IRM) actions corresponded to the preparedness-relief and prevention-prediction stages, and less than half to mitigation, risk identification, and recovery (Figure 5). The actions of the preparedness-relief stage were aimed at carrying out drills and preparing brigades to respond to risks, mainly earthquakes. The prevention-prevision actions focused on preventing the adverse effects of floodings, wildfires, and earthquakes, such as investment in infrastructure or urban equipment to prevent flooding through the Municipal Infrastructure Contribution Fund (FAISM). Regarding the identification of risks, the workshop participants mentioned the existence of initiatives focused on the spatial identification of areas vulnerable to flooding. However, most of the local governments (69%, 11 local governments) indicated that they rely mainly on the Mexico City Risk Atlas or simply do not have enough information and responded directly to areas where the risk already materialized into a disaster. Recovery or reconstruction actions were mainly aimed to recover the function of the affected areas. It is worth noting that few local governments pointed out the scope of reconstruction after the 2017 earthquake.

What are the differences between the local governments? Even though 61% of the actions concentrated in the preparedness-relief and prevention-prevision stages, there were differences in

the distribution of actions by risk between local governments (Figure 5). For example, Azcapotzalco, Coyoacán, Cuauhtémoc, Cuajimalpa, Tláhuac and Venustiano Carranza showed a common pattern in relation to the distribution of IRM actions with a higher percentage of actions related to the preparedness-prevention stage. However, differences in the distribution of actions for the same risk stand out. Such was the case of actions to address flooding through forecasting and prevention (Cuajimalpa, Iztacalco and Venustiano Carranza), risk identification (Milpa Alta), risk mitigation (Gustavo A. Madero and Tlalpan), preparedness and relief (Álvaro Obregón and Coyoacán), and recovery and reconstruction (Xochimilco); or all of them equally distributed (Iztapalapa). It is important to mention that in the local governments where the workshops were conducted in person, more than one risk was explored in the timeline boards. This did not occur in the virtual workshops where only one risk was explored due to time constraints (Figure 5).

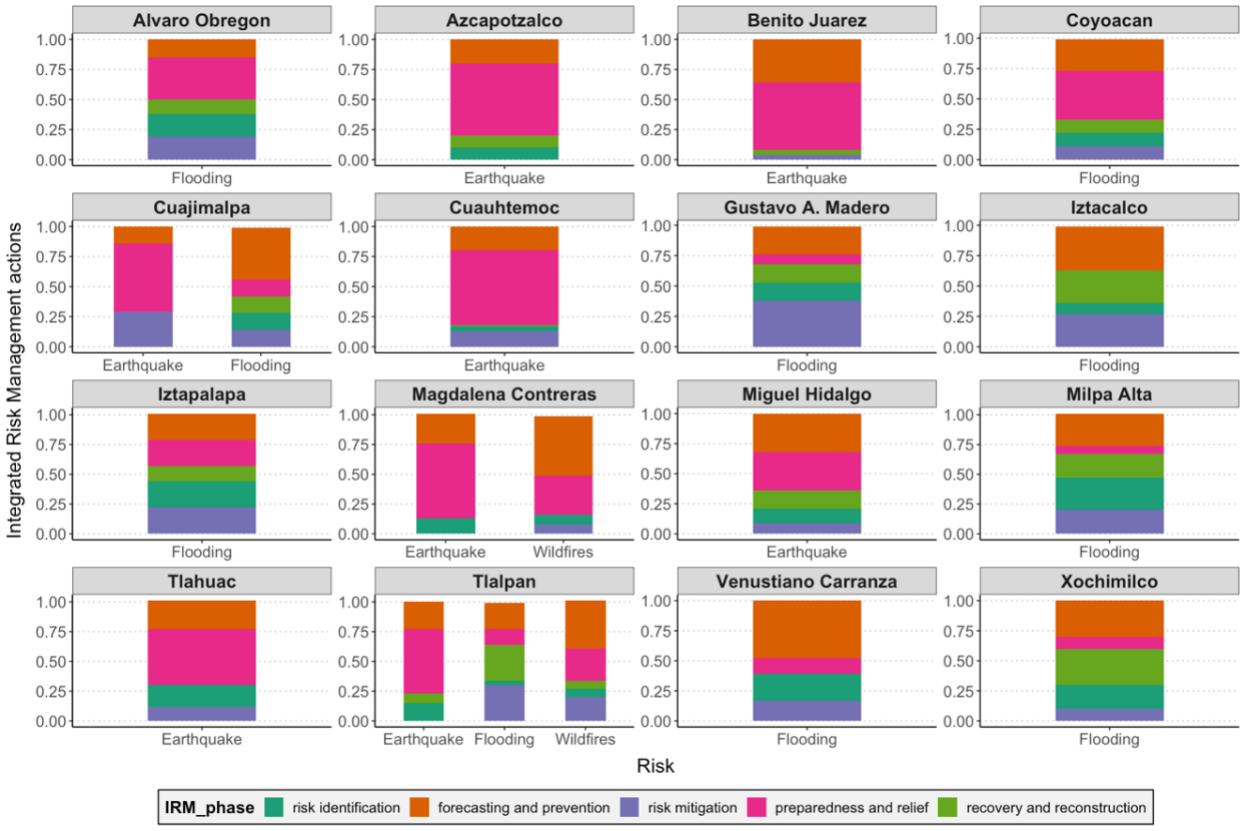

Figure 5. Distribution of IRM actions by local government and by risk

Collaboration networks (How do local governments interact with different levels on a jurisdictional scale -inter-governmental, local, regional and national governments- and another type of organizational scale -society-). Results showed similar sizes (number of nodes and edges) regarding the collaboration networks of the local governments to address earthquakes and flooding; meanwhile, the wildfires collaboration network was smaller, both in the number of edges and nodes (Figure 6).

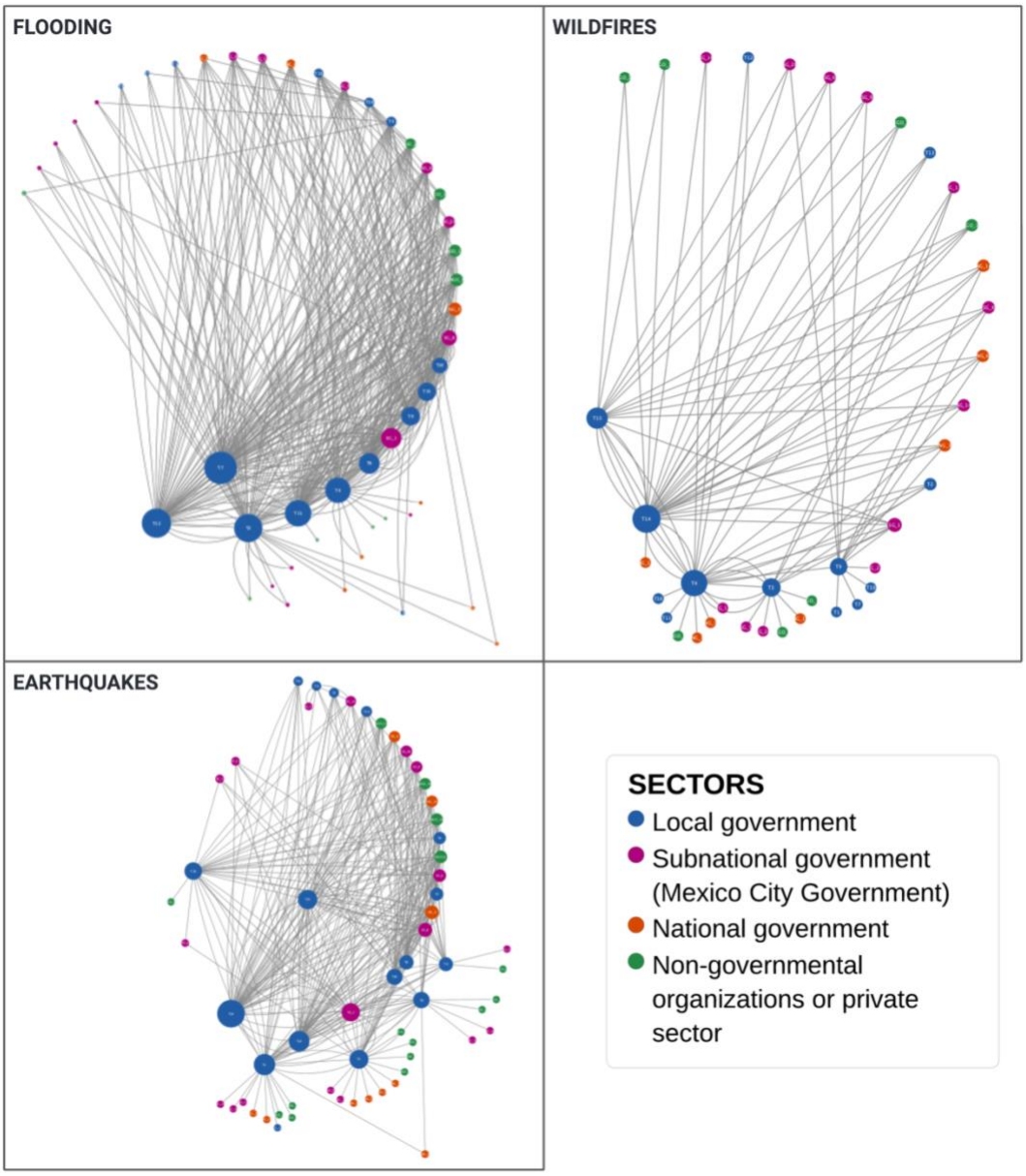

Figure 6. Collaboration networks per priority extreme event

Regardless of their differences in size, the three collaboration networks exhibited similar characteristics regarding degree centralization but differences for density and cross-boundary exchange. Density in the three networks is relatively low, for example, the maximum number of potential edges of the earthquake network could be 1770 given 60 nodes; in contrast, there are 320 edges. This meant that there was a low connectedness in the networks and the most connected nodes were the egos of the network, which are the local governments. The higher centrality of the local governments (blue node size in Figure 6) can be partially explained because the integrated networks were built with the egonets of each local government. That is, the workshops' participants were local government officials and there were no participants from the subnational and national government, or from non-governmental organizations. The cross-boundary exchange

appeared to be mainly in local and sub-national governments, and to a lesser extent with non-governmental organizations and the national government (Table 2).

The organizations (nodes) with the higher centrality in each priority risk network are referred in

Table 3. The earthquake and flooding networks shared similar results regarding the more connected organizations. In both networks, the local governments were from both the central area (e.g., Cuauhtémoc, Coyoacán, Iztapalapa) and the outer or more peripheral area of Mexico City (e.g., Álvaro Obregón and Tlalpan). Also, the earthquake and flooding networks shared similarities regarding higher jurisdictional levels, which mainly have key responsibilities for disaster response both at subnational (e.g., Risk Management and Civil Protection) and national (e.g., National Center for Disaster Prevention), with some differences (e.g., Ministry of Energy). In contrast, the five more central local governments in the wildfire network were in more peripheral areas of Mexico City and have the larger areas of vegetated areas under a conservation status. Meanwhile, this network had subnational and national government agencies for disaster response, but also regarding environment, mobility, and human rights. The composition of the more central non-governmental organizations was similar in the three priority risk networks, with a predominance of academic institutions and neighborhood committees.

Table 2. Density, degree centralization and cross-boundary exchange for the priority risks.

SNA metric	Earthquake	Flooding	Wildfires
Local governments in the network	16	16	13
Number of nodes	60	48	39
Number of edges	320	369	93
Density	0.11	0.16	0.09
Degree centralization	0.38	0.52	0.40
Cross-boundary exchange			
National government	8%	7%	9%
Subnational government (Mexico City Government)	20%	20%	18%
Local governments	62%	62%	66%
Non-governmental organizations	10%	11%	8%

Table 3. Top key organizations in the priority risks networks by type of organization

SNA metric	Earthquake	Flooding	Wildfires
Local government	1) Tláhuac 2) Miguel Hidalgo 3) Coyoacán 4) Xochimilco 5) Cuauhtémoc	1) Venustiano Carranza 2) Coyoacán 3) Álvaro Obregón 4) Iztapalapa 5) Tlalpan	1) Milpa Alta 2) Tlalpan 3) Xochimilco 4) Magdalena Contreras 5) Gustavo A. Madero
Subnational government (Mexico City Government Ministry of…)	1) Risk Management and Civil Protection 2) Citizen Security 3) Infrastructure and Services 4) Health 5) Interior	1) Risk Management and Civil Protection 2) Citizen Security 3) Health 4) Infrastructure and Services 5) Interior	1) Risk Management and Civil Protection 2) Citizen Security 3) Mobility 4) Environment 5) Infrastructure and Services
National government (Ministry of…)	1) Defense 2) Internal Affairs 3) Navy 4) National Center for Disaster Prevention 5) Energy	1) Defense 2) Navy 3) Internal Affairs 4) National Center for Disaster Prevention 5) National Guard	1) Defense 2) National Commission on Human Rights 3) National Forestry Commission 4) Environment and Natural Resources 5) National Agrarian Registry
Non-governmental organization	1) National Autonomous University of Mexico 2) Neighborhood committees 3) Metropolitan Autonomous University 4) National Polytechnic Institute 5) Civil Engineers Association	1) National Autonomous University of Mexico 2) Neighborhood committees 3) National Polytechnic Institute 4) Metropolitan Autonomous University 5) Civil Associations	1) Neighborhood committees 2) National Autonomous University of Mexico 3) National Polytechnic Institute 4) Metropolitan Autonomous University 5) Supercívicos

Discussion

Regarding the experience of local governments in their role in a multilevel governance system for risk management in Mexico City, the highest cross-boundary exchange with local governments indicated strong horizontal collaboration between local governments, particularly for dealing with wildfires between governments from the peripheral area of Mexico City (Tables 2 and 3). Also, neighborhood committees and research centers were the most common non-governmental organization that local governments collaborated with to address the three priority risks. Regarding vertical collaboration, the Risk Management and Civil Protection Ministry of Mexico City and the Ministry of Defense were the most connected subnational and national governmental agencies in the three priority risks networks. The wildfire network provided additional elements to understand the diversity of collaboration by including subnational and national governmental agencies focused

on environment, mobility and human rights. The local governments with higher centrality in this network have in their territories natural protected areas and indigenous communities, and three of them had a lower income (less than 6%) of the total budget transferred from the Mexico City Government.[2] The diversity in the vertical and horizontal collaboration in the wildfire network indicated the need for the local governments to access a wide set of resources under financial scarcity conditions. Also, the highest values of the local governments in the cross-boundary exchange metric and the horizontal and vertical collaboration, particularly for the wildfire network, may indicate the existence of successful elements of multilevel governance, following Frey and Ramírez (2019). That is, the protagonist role of local governments (most of them had the higher centrality in the priority risks networks, see large blue nodes in Figure 6); the abilities of local governments to involve local communities (particularly neighborhood committees and other NGOs, see Table 3); and the capacities of local governments to interact constantly with higher-level authorities (particularly with the subnational CDMX government according the cross-boundary exchange results in Table 2). However, further research is needed to better understand the potential routes for the local governments to collaborate with other types of non-governmental or private organizations for addressing multiple risks. The engagement of non-governmental organizations and actors is key due to the potential role of environmental groups and other socio-political constituencies, that can integrate the needs and demands of the most vulnerable segments population and provide support for stronger climate policies by means of a higher level of environmental community activism (Ryan, 2015). There is also the need to further understand degree of democratic legitimacy of the risk management in the multilevel governance system for risk management. That is, to understand the extent to which citizens have an effective say in risk management by the local governments (Di Gregorio et al., 2019).

There is a need for empirical evidence to understand how the institutional capacity as an enabling condition for adaptation can be mobilized into climate action (Mortreux & Barnett, 2017). In this regard, the results suggested that the IRM actions associated with preparedness-relief (e.g., drills) and prevention-prevision (e.g., investment in public infrastructure through federal funds) were more important for the local governments. This indicated the existence, at the local level, of a well-structured and organized system of capacities related to relief during flood events and earthquake management. For example, in the case of floods, many government agents identified actions aimed at mitigating flood risk (e.g., periodic drainage in collaboration with the Mexico City Water System), preparing the population (e.g., communication campaigns), and prevention (e.g., investment in public infrastructure, with contributions from federal funding). These actions represented the specific capacities of each local government to provide relief during flooding events. There were also few actions associated with the recovery and reconstruction stage after earthquakes, and when these were mentioned, they were mainly related to recover the function of the affected areas. Also, in six workshops, reference was made to the 2017 earthquake, the most

[2] https://datos.cdmx.gob.mx/dataset/recursos-de-la-ciudad-transferidos-a-las-alcaldias. Consulted on March 6th, 2023.

recent large earthquake that occurred in Mexico City; however, participants did not specify the scope of reconstruction in subsequent years. This may be due to the Mexico City Government's approach to coordinating these activities, which may not depend directly on the local governments.

Another IRM action with fewer references was risk identification. The participants pointed out various initiatives in their municipalities for the identification of vulnerable areas to risks such as flooding. However, local governments did not focus on risk identification by themselves. Instead, they relied on the Mexico City Risk Atlas or on the collaboration with research institutions and local universities. Nonetheless, some local governments (e.g., Iztapalapa) referred the use of participatory mapping with local communities and organizations for planning at a neighborhood scale. As for risk mitigation, it was mentioned by only 15% of the local governments. This result may reflect the lack of capacities at the local government level to plan for the reduction of the adverse effects of multiple risks. Although some of the IRM actions coincided with previous findings (e.g. Romero-Lankao et al., 2013), particularly the importance of coordination and cooperation networks, there are still several challenges acknowledged by the participants regarding the participation of non-governmental organizations, besides research centers and neighborhood committees previously mentioned in

Table 3, and the ability to generate their own data for risk identification. Further research may benefit from the implementation of the same workshops, but with representatives from the subnational and national government and from non-governmental sectors.

The earthquake and flooding networks can be used to illustrate the role and relevance of vertical collaboration, mainly led by a top-down approach. That means that those networks exhibited the articulation between local governments with the subnational (Mexico City Government) and national government (Mexican Government). In this case, the Mexico City government plays a key role to support the development of regulatory frameworks and create the conditions for local governments to protect vulnerable groups and areas, such as the provision of financial support (Cid et al., 2020). The low level of cross-boundary exchange between the local governments and the national government (Table 2) may indicate the barriers posed by jurisdictional boundaries (Di Gregorio et al., 2019) and the low relevance of the development of local institutional capacities in the national agenda for climate action (Solorio, 2021). Nevertheless, vertical coordination is key to address some of the main challenges to a top-down approach, including the restrictions to up-scale local initiatives and the generation of negative dependencies in local governments due to the lack of investment in capacity building (Mimura et al., 2014). For example, Cid and Lerner (2023) explored how inter-governmental coordination can reduce the gap of local governments to access climate finance in Mexico.

The wildfire network can be used to illustrate the relevance of horizontal collaboration, from a bottom-up approach, to address multiple risks, including those exacerbated or generated by climate change. The horizontal collaboration is illustrated by the integration of diverse sectors, both governmental and non-governmental, beyond the ones traditionally associated to risk management

(Table 3). However, the low levels of cross-boundary exchange between the local governments (Table 2) denote the need to develop bottom-up processes with more active local level participation (Di Gregorio et al., 2019). Potential responses to address cross-scales problems, such as the ones posed by multiple interconnected risks in Mexico City, can involve the interaction between management systems located at adjacent levels and co-management strategies, involving a series of agreements based on varying degrees of power and responsibility sharing between governments and local communities (Cash et al., 2006).

Conclusion

State-centered and hierarchical government strategies based on technocratic top-down approaches have proved inadequate to address multiple interacting and cross-scale risks. Under these approaches, unilateral local government strategies are ineffective to tackle complex cross-jurisdictional problems such as climate change and disaster risks (Frey & Ramírez, 2019). In contrast, multilevel governance (MLG) provides a form of governance by networks that operate both in a horizontal arena with neighboring local governments, civil society organizations, and local communities, and in vertical settings, with higher-level governmental authorities and international organizations (Fliervoet et al., 2016; Frey & Ramírez, 2019).

In this study, we analyzed the experience of local governments in their role in a multilevel governance system for risk management in Mexico City. We found that collaboration was more common between local governments and with the subnational government (Mexico City Government). We determined that the collaboration networks to address earthquakes and flooding were similar regarding their size and composition, mainly with government agencies with key responsibilities for disaster response. In contrast, we characterized a more diverse network to address wildfires in Mexico, with government agencies and non-governmental organizations focused on disaster management, environment, mobility, and human rights. The diversity in the vertical and horizontal collaboration in the wildfire network indicated the need for the local governments to access a wide set of resources under financial scarcity conditions. We found evidence of successful elements of multilevel governance, following Frey and Ramírez (2019) and identified the need for further research on the engagement and representation for non-governmental organizations and private actors in the priority risk networks. Regarding the mobilization of resources into Integrated Risk Management actions, we found evidence of actions focused on both prevention and response, with potential needs to strengthen the recovery and risk identification actions, due to the reliance on the subnational government (Mexico City Government) and on research centers. The results from this study provide a better understanding of the arrangement of collaborative resources underlying local government actions under a state of urgency and scarcity, where disasters will increase under climate change and action is needed immediately.

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Literature

Borgatti, S., Everett, M., & Johnson, J. (2013). *Analyzing social networks*. https://scholar.google.com.mx/scholar?q=Analyzing+social+networks+stephen+borgatti&btnG=&hl=es&as_sdt=0%2C5#0

Cash, D. W., Adger, W. N., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, L., & Young, O. (2006). Scale and Cross-Scale Dynamics: Governance and Information in a Multilevel World. *Ecology and Society*, *11*(2). https://doi.org/10.5751/es-01759-110208

Cid, A., Cano, D., Montalvo, V., Ruíz-Bedolla, K., Romero-Cazares, M., Monterroso-Rivas, A. I., Caso, M., & García-Meneses, P. M. (2020). Insights for building institutional capacities for climate change adaptation: evidence from Mexico. In W. Leal Filho, J. M. Luetz, & D. Yayeh Ayal (Eds.), *Handbook of Climate Change Management: Research, Leadership, Transformation*. Springer Nature.

Cid, A., & Lerner, A. M. (2023). Local governments as key agents in climate change adaptation: challenges and opportunities for institutional capacity-building in Mexico. *Climate Policy*, 1–13. https://doi.org/10.1080/14693062.2022.2163972

Ley General de Cambio Climático, 1 (2012). http://www.diputados.gob.mx/LeyesBiblio/pdf/LGCC_061120.pdf

Ley General del Equilibrio Ecológico y la Protección al Ambiente, Diario Oficial de la Federación 1 (2018).

Constitución política de los estados unidos mexicanos, (2021) (testimony of D.O.F.).

Di Gregorio, M., Fatorelli, L., Paavola, J., Locatelli, B., Pramova, E., Nurrochmat, D. R., May, P. H., Brockhaus, M., Sari, I. M., & Kusumadewi, S. D. (2019). Multi-level governance and power in climate change policy networks. *Global Environmental Change*, *54*(April 2018), 64–77. https://doi.org/10.1016/j.gloenvcha.2018.10.003

Estrada, F., & Perron, P. (2021). Disentangling the trend in the warming of urban areas into global and local factors. *Annals of the New York Academy of Sciences*, *1504*(1), 230–246. https://doi.org/10.1111/nyas.14691

Fliervoet, J. M., Geerling, G. W., Mostert, E., & Smits, A. J. M. (2016). Analyzing Collaborative Governance Through Social Network Analysis: A Case Study of River Management Along

the Waal River in The Netherlands. *Environmental Management*, *57*(2), 355–367. https://doi.org/10.1007/s00267-015-0606-x

Frey, K., & Ramírez, D. R. C. (2019). Multi-level network governance of disaster risks: the case of the Metropolitan Region of the Aburra Valley (Medellin, Colombia). *Journal of Environmental Planning and Management*, *62*(3), 424–445. https://doi.org/10.1080/09640568.2018.1470968

Ley Ambiental de Protección a la Tierra en la Ciudad de México, (2023) (testimony of Gaceta Oficial de la Ciudad de México).

Ley de Gestión Integral de Riesgos y Protección Civil de la Ciudad de México, 52 (2019).

Gobierno de la Ciudad de México. (2016). Hacia una Ciudad de México sensible al agua. El espacio público como una estrategia de gestión de agua de lluvia. In *Gob Cdmx*.

INEGI. (2021). Censo de Población y Vivienda 2020. In *Censo De Población Y Vivienda 2020*. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2021/EstSociodemo/ResultCenso2020_Nal.pdf

IPCC. (2022). Cities, Settlements and Key Infrastructure. In *IPCC WGII Sixth Assessment Report* (pp. 20–22).

IPCC. (2023). Summary for policymakers. In *Synthesis Report of the IPCCC Sixth Assessment Report (AR6)*. https://doi.org/10.4324/9781315071961-11

Ley de Mitigación y Adaptación al Cambio Climático y Desarrollo Sustentable de la Ciudad de México, (2021) (testimony of Gaceta Oficial de la Ciudad de México). https://www.consejeria.cdmx.gob.mx/

Mimura, N., Pulwarty, R. S., Duc, D. M., Elshinnawy, I., Redsteer, M. H., Huang, H. Q., Nkem, J. N., & Rodriguez, R. a. S. (2014). 15. Adaptation Planning and Implementation. In *Assessment Report 5- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*.

Mohibbullah, M., Gain, A. K., & Ahsan, M. N. (2021). Examining local institutional networks for sustainable disaster management: Empirical evidence from the South-West coastal areas in Bangladesh. *Environmental Science and Policy*, *124*(January), 433–440. https://doi.org/10.1016/j.envsci.2021.07.016

Monterroso, A., & Conde, C. (2017). Adaptive capacity: identifying the challenges faced by municipalities addressing climate change in Mexico. *Climate and Development*, *0*(0), 1–13. https://doi.org/10.1080/17565529.2017.1372264

Mortreux, C., & Barnett, J. (2017). Adaptive capacity: exploring the research frontier. *Wiley Interdisciplinary Reviews: Climate Change*, *8*(4). https://doi.org/10.1002/wcc.467

Moser, S. C., Ekstrom, J. A., Kim, J., & Heitsch, S. (2019). Adaptation finance archetypes: local governments' persistent challenges of funding adaptation to climate change and ways to overcome them. *Ecology and Society*, *24*(2). https://doi.org/10.5751/ES-10980-240228

OECD. (2008). Handbook on Constructing Composite Indicators: Methodology and User Guide. In *Methodology* (Vol. 3). OECD publishing. https://doi.org/10.1787/9789264043466-en

PNUD-México-INECC. (2017). Medición multidimensional de capacidad institucional a nivel municipal que fomente la adaptación al cambio climático. In *Proyecto #86487 "Plataforma de Colaboración sobre Cambio Climático y Crecimiento Verde entre Canadá y México" Convenio de colaboración: Transparencia Mexicana, A.C.*

Romero-Lankao, P., Hughes, S., Rosas-Huerta, A., Borquez, R., & Gnatz, D. M. (2013). Institutional capacity for climate change responses: An examination of construction and pathways in Mexico City and Santiago. *Environment and Planning C: Government and Policy*, *31*(5), 785–805. https://doi.org/10.1068/c12173

Ruiz-Rivera, N., & Melgarejo-Rodríguez, C. R. (2017). Political inequality and local government capacity for Disaster Risk Reduction: Evidence from Mexico. *International Journal of Disaster Risk Reduction*, *24*(January), 38–45. https://doi.org/10.1016/j.ijdrr.2017.05.024

Ryan, D. (2015). From commitment to action: a literature review on climate policy implementation at city level. *Climatic Change*, *131*(4), 519–529. https://doi.org/10.1007/s10584-015-1402-6

SEDEMA. (2021). *Estrategia Local de Acción Climática 2021-2050 / Programa de Acción Climática de la Ciudad de México 2021-2030*. http://www.data.sedema.cdmx.gob.mx/cambioclimaticocdmx/images/biblioteca_cc/Estrategia-Local-de-Accion-Climatica-de-la-Ciudad-de-Mexico-2014-2020.pdf

SEMARNAT-INECC. (2015). *Elementos mínimos para la elaboración de los programas de cambio climático de las entidades federativas*. https://www.google.com.mx/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwj9nObX-vPPAhWc8oMKHe1cB_wQFggdMAA&url=http%3A%2F%2Fwww.inecc.gob.mx%2Fdescargas%2Fcclimatico%2F2015_elem_minims_prog_cc_efederativas.pdf&usg=AFQjCNH_ZmeDvttzFzdhtXoaRCK6b_6z2g

Serna, J. M. (2016). *El sistema federal mexicano: trayectoria y características*. Instituto Nacionnal de Estudios Históricos de las Revoluciones de México-Secretaría de Cultura, Instituto de Investigaciones Jurídicas-UNAM.

SGIRPC. (2021). *Ciudad Resiliente: Retrospectiva y Proyección de una Ciudad (In) Vulnerable*.

Shannon, S. E. (2013). Cytoscape. In *Genome researchh* (2.0). https://www.cytoscape.org

Solorio, I. (2021). Leader on paper, laggard in practice: policy fragmentation and the multi-level paralysis in implementation of the Mexican Climate Act. *Climate Policy*, *21*(9), 1175–1189. https://doi.org/10.1080/14693062.2021.1894084

Sosa-Rodriguez, F. S. (2014). From federal to city mitigation and adaptation: Climate change policy in Mexico City. *Mitigation and Adaptation Strategies for Global Change*, *19*(7), 969–996. https://doi.org/10.1007/s11027-013-9455-1

Tschakert, P., Waisman, H., Abdul Halim, S., Antwi-Agyei, P., Dasgupta, P., Hayward, B., Kanninen, M., Liverman, D., Okereke, C., Pinho, P., Riahi, K., & Suarez, A. (2018). Sustainable Development, Poverty Eradication and Reducing Inequalities. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global gre. In *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change* (pp. 445–538). https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter5_Low_Res.pdf

Vargas, N., & Magaña, V. (2020). Climatic risk in the Mexico City Metropolitan Area due to urbanization. *Urban Climate*, *33*(May), 100644. https://doi.org/10.1016/j.uclim.2020.100644

VERBI. (2021). *MAXQDA 2022* (No. 2022). VERBI Software. maxqda.com.

Withycombe-Keeler, L., Gabriele, A., Kay, B. R., & Wiek, A. (2017). Future Shocks and City Resilience: Building Organizational Capacity for Resilience and Sustainability through Game Play and Ways of Thinking. *Sustainability: The Journal of Record*, *10*(5), 282–292. https://doi.org/10.1089/sus.2017.0011

VI. Discusión y conclusión

La pregunta principal de este proyecto es ¿Cómo las capacidades institucionales de gobiernos locales se pueden movilizar en acciones de adaptación? De esta pregunta central surgen las siguientes preguntas de investigación: ¿Cómo se puede analizar la capacidad institucional de gobiernos locales bajo un enfoque de capacidades que permita articular el bienestar humano como parte de estrategias de adaptación al cambio climático? ¿Cuáles son las principales barreras y oportunidades para el fortalecimiento de capacidades institucionales de gobiernos locales para la adaptación al cambio climático? ¿Cómo movilizan los gobiernos locales sus recursos de colaboración en acciones dirigidas a múltiples riesgos? y ¿cuáles son las implicaciones para sistemas de gobernanza multinivel?

Para responder a las preguntas de investigación, se desarrolló un proyecto de investigación con el objetivo de integrar un enfoque teórico-analítico de las capacidades institucionales que considere tanto las capacidades como los determinantes para movilizarlas, así como las condiciones reales de procesos de decisión en la escala de implementación local de la adaptación al cambio climático. A partir de la aplicación del enfoque teórico-analítico propuesto, se buscó examinar las condiciones que inciden en el desarrollo, fortalecimiento y movilización de capacidades latentes de gobiernos locales en sistemas de gobernanza multinivel. Esta discusión está estructurada de acuerdo con las preguntas de investigación.

VI.2. Enfoque teórico-metodológico para el análisis de la capacidad institucional de gobiernos locales para la adaptación al cambio climático

La evaluación de la capacidad institucional con base en un enfoque híbrido entre uno descendente (*top-down*) y uno ascendente (*bottom-up*) generada en esta investigación contribuye a la integración horizontal y vertical al considerar los sistemas gubernamentales multinivel en la formulación y aplicación de la adaptación al cambio climático (Nalau et al., 2015; Preston et al., 2013). La dimensión de capacidad administrativa aborda el papel de los recursos económicos y la estructura organizativa para las capacidades genéricas (ver Capítulo III). Las dimensiones de transparencia y rendición de cuentas dirigen la atención sobre mecanismos que permiten a los ciudadanos supervisar y evaluar la labor del gobierno en materia de adaptación al cambio climático. La integración de elementos de un enfoque ascendente (*bottom-up*), es decir, la participación ciudadana, contribuye a incluir mecanismos que permitan a los ciudadanos influir en los procesos de toma de decisiones.

En esta investigación, el uso de un enfoque de capacidades genéricas y específicas contribuye a considerar la relación entre adaptación y desarrollo sostenible en la planeación para la reducción de la vulnerabilidad. En México existen instrumentos políticos y de planeación enfocados a la gestión integral del riesgo, como los Planes de Protección Civil y los Atlas Municipales de Riesgo. Estos instrumentos se enfocan en la distribución espacial de los riesgos potenciales y las características socioeconómicas de la población expuesta. Sin embargo, estos instrumentos no se ocupan de los procesos subyacentes que determinan la distribución y el acceso a las oportunidades

y activos que tienen las poblaciones vulnerables. Además, los instrumentos de gestión integrada de riesgos no abordan la posible intervención de las poblaciones vulnerables en los procesos de decisión, es decir, a través de la participación civil. En este contexto, la evaluación de las capacidades genéricas a través de la consideración de los instrumentos de ordenación del territorio, el desarrollo urbano, la rendición de cuentas y la igualdad de género busca aportar elementos asociados al desarrollo sostenible en la evaluación de las capacidades adaptativas a escala local. Por consiguiente, la evaluación de la capacidad institucional de los gobiernos locales en México desde un enfoque de capacidades genéricas y específicas se dirige a aportar conocimientos empíricos sobre qué arreglos institucionales serían necesarios para proporcionar los medios para que las poblaciones vulnerables se dirijan hacia una adaptación sostenible.

El enfoque híbrido de capacidades genéricas y específicas de adaptación también proporciona insumos para informar las políticas públicas destinadas a cumplir compromisos internacionales. Por un lado, la consideración de las deficiencias en las necesidades básicas de desarrollo humano a través del enfoque de capacidades genéricas (Eakin et al., 2014) puede contribuir a abordar los compromisos establecidos en los Objetivos de Desarrollo Sostenible, que consideran una visión de largo plazo, donde la participación ciudadana, la igualdad de género, la transparencia y la rendición de cuentas son elementos clave. Por otro lado, abordar las capacidades específicas como la habilidad para gestionar y responder a una amenaza climática identificada (M. C. Lemos et al., 2016) podría contribuir a los compromisos dedicados a la reducción de riesgos como los objetivos establecidos en el Marco de Sendai. Cabe resaltar que los resultados del Capítulo III no aportan evidencias de que en México exista un municipio en una situación de adaptación sostenible.

Siguiendo con el tema de compromisos internacionales, las Contribuciones Nacionalmente Determinadas, Objetivos de Desarrollo Sostenible y otros compromisos podrían actuar como iniciativas para incrementar los cambios urgentes en materia de adaptación. La actual NDC en México ha abordado positivamente los objetivos estructurales en términos de adaptación al cambio climático. Con el fin de proteger a las comunidades de los impactos adversos del cambio climático, mejorar la resiliencia de la infraestructura y asegurar la biodiversidad nacional, el país ha asumido la responsabilidad de fortalecer la capacidad de adaptación de al menos 50% de los municipios considerados como los más vulnerables de acuerdo con el Atlas Nacional de Vulnerabilidad al Cambio Climático y el Programa Especial de Cambio Climático 2020-2024 (SEMARNAT, 2020). Los estados con la mayor cantidad de municipios en condiciones de trampa de pobreza (Chiapas, Guerrero y Oaxaca ver resultados en Capítulo IV) albergan también a municipios señalados en la NDC.[3] El cumplimiento de este objetivo no puede verse como una vía de un solo sentido. Este compromiso representa un reto y una oportunidad de coordinación entre instituciones, academia, autoridades nacionales y locales, y sociedad civil, entre otros. La NDC mexicana representa un referente para orientar las metas nacionales en materia de adaptación al cambio climático, y existen

[3] https://www.gob.mx/inafed/articulos/el-20-de-los-municipios-son-vulnerables-al-cambio-climatico-que-acciones-de-mitigacion-y-adaptacion-implementa-municipiohttps://www.gob.mx/inafed/articulos/el-20-de-los-municipios-son-vulnerables-al-cambio-climatico-que-acciones-de-mitigacion-y-adaptacion-implementa-municipio. Consultado el 6 de abril de 2023.

diversos esfuerzos que deben enfocarse en el desarrollo de mecanismos y herramientas que refuercen la capacidad institucional de los gobiernos locales (municipios) en México.

VI.3. Barreras y oportunidades para el fortalecimiento de capacidades institucionales de gobiernos locales para la adaptación al cambio climático

La capacidad institucional es un componente fundamental de las respuestas locales al cambio climático porque es una condición habilitante para la planificación e implementación de la adaptación al cambio climático. Entre los retos clave que enfrentan los gobiernos locales en México para desarrollar y movilizar sus capacidades para planear e implementar la adaptación al cambio climático, en esta investigación se identificaron tres principales:

a) La "tragedia de la urgencia" (Moser et al., 2019), que es una condición generalizada que obstaculiza el desarrollo y la movilización de la capacidad institucional para la adaptación al cambio climático, debido al uso de recursos escasos para resolver necesidades "urgentes" a corto plazo, en lugar de utilizarlos para la adaptación. En México, la tragedia de la urgencia que enfrentan los gobiernos locales es una condición común asociada a la escasez de recursos y la rotación continua que dificulta la planeación de la adaptación a mediano y largo plazo (PNUD-México-INECC, 2017).
b) La falta de conciencia sobre el cambio climático y sus efectos, que se traduce en la falta de recursos humanos, técnicos, materiales y económicos destinados a la adaptación al cambio climático. La falta de conciencia sobre el cambio climático se traduce en una falta de recursos humanos y materiales destinados a la adaptación (Romero-Lankao et al., 2013), y ha sido contabilizada en la política de cambio climático a nivel subnacional en México (D.O.F., 2019), y como una baja prioridad para los gobiernos locales (Solorio, 2021).
c) La limitada capacidad de los gobiernos locales para acceder y movilizar recursos económicos para la adaptación, que es un obstáculo clave para la aplicación de medidas de adaptación pertinentes a escala local. Los gobiernos locales con escasa capacidad para recaudar ingresos por sí mismos están condicionados a depender de los gobiernos subnacionales y nacionales, lo que puede obstaculizar la capacidad del gobierno local para planificar de forma independiente la adaptación. En México, el acceso a financiamiento adicional (p.ej. cooperación internacional) es particularmente difícil para los gobiernos locales debido a la falta de capacidad administrativa, mecanismos de rendición de cuentas y arreglos institucionales (Castillo et al., 2019; GFLAC, 2018).

En esta investigación se identificaron oportunidades clave para el desarrollo de las capacidades institucionales de los gobiernos locales, como el aumento de la capacidad administrativa, la rendición de cuentas y la participación pública para que los gobiernos locales puedan acceder y movilizar recursos económicos para la adaptación al cambio climático. Además, la coordinación intergubernamental es un atributo clave que los gobiernos locales pueden desarrollar para abordar las deficiencias en las capacidades institucionales para la adaptación al cambio climático. Por último, la transparencia y la participación pública pueden aportar medios relevantes para (i) comprometer a la ciudadanía a responder eficazmente a los riesgos que plantea el cambio climático,

y (ii) abordar los vacíos en la gestión del conocimiento que pueden influir en el acceso a los servicios climáticos necesarios a escala local.

Los gobiernos locales dependen de sus recursos o de los que brindan los gobiernos nacionales y subnacionales cuando carecen de medios de colaboración con otras organizaciones. La falta de coordinación eficaz puede promover lagunas en las políticas e impedir una respuesta coordinada para gestionar eficazmente los riesgos (Romero-Lankao et al., 2013). Además, la falta de coordinación vertical u horizontal también obstaculiza las posibilidades de transversalizar la adaptación mediante el intercambio de experiencias y el aprendizaje. En relación con el acceso a la financiación climática, en esta investigación se determinó que la coordinación intergubernamental puede contribuir a desmantelar típico síndrome del gobierno aislado. Este síndrome crea un problema de desconexión entre jurisdicciones, lo que se traduce en responsabilidades, liderazgo, rendición de cuentas y autoridad poco claros. Algunas de las intervenciones propuestas para abordar este síndrome son la creación de redes informales de aprendizaje y colaboración, un liderazgo que exija una rendición de cuentas intersectorial de los costes y beneficios de los proyectos dentro del marco presupuestario local, y el establecimiento de financiamiento para las entidades coordinadoras (Moser et al., 2019). Asimismo, el uso o desarrollo de asociaciones es una de las estrategias recomendadas para reducir los costos de transacción que soportan los gobiernos locales a la hora de acceder a los fondos climáticos (Brunner & Enting, 2014).

VI.4. Movilización de recursos de colaboración en acciones dirigidas a atender múltiples riesgos e implicaciones para sistemas de gobernanza multinivel

La capacidad adaptativa se ha evaluado tradicionalmente bajo el enfoque de capacidades de la teoría de Amartya Sen y de las evaluaciones de los modos de vida. Pese a que generalmente se evalúan los cinco capitales definidos en el enfoque de modos de vida sostenibles (capitales natural, físico, financiero, social y humano), no existe un método estandarizado para operacionalizar este enfoque. El reto de operacionalizar este enfoque reside en la aplicación en múltiples escales y riesgos, debido a que ha sido exitosamente aplicado a nivel de hogar, pero pierde capacidad de explicación a nivel de escalas mayores. Una de las mayores críticas a este enfoque es que se basa en el supuesto de que la existencia de capacidades se traduce automáticamente en acciones. Por lo tanto, existe la necesidad de entender cómo estas capacidades se movilizan para implementar acciones de adaptación. Por otra parte, existen estudios que han demostrado que la relación entre capacidad adaptativa y adaptación no siempre es directa y que existen casos de baja capacidad adaptativa en donde se observa mayor adaptación, que en casos con alta capacidad adaptativa (Mortreux & Barnett, 2017). En este contexto, se plantea la necesidad de entender los determinantes de las instituciones locales y cómo éstas las movilizan para responder ante la ocurrencia simultánea de múltiples estresores en sistemas de gobernanza multinivel.

Las estrategias gubernamentales jerárquicas y centradas en el Estado, basadas en enfoques tecnocráticos descendentes tradicionales, han demostrado ser inadecuadas para abordar múltiples riesgos interactivos y de escala cruzada. En el marco de estos enfoques, las estrategias unilaterales

de los gobiernos locales han demostrado ser inadecuadas para abordar problemas complejos interjurisdiccionales como el cambio climático y los riesgos de catástrofe (Frey & Ramírez, 2019). Por el contrario, la gobernanza multinivel (MLG) proporciona una forma de gobernanza por redes que operan tanto en un ámbito horizontal con gobiernos locales vecinos, organizaciones de la sociedad civil y comunidades locales; como en entornos verticales, con autoridades gubernamentales de nivel superior y organizaciones internacionales (Fliervoet et al., 2016; Frey & Ramírez, 2019). En esta investigación, analizamos el papel de los gobiernos locales en un sistema de gobernanza multinivel para la gestión de riesgos en la Ciudad de México. Encontramos que la colaboración era más común entre los gobiernos locales y con el gobierno subnacional (Gobierno de la Ciudad de México). Determinamos que las redes de colaboración para hacer frente a terremotos e inundaciones eran similares en cuanto a su tamaño y composición, principalmente con organismos gubernamentales con responsabilidades clave en la respuesta a desastres. En contraste, caracterizamos una red más diversa para hacer frente a los incendios forestales en México, con agencias gubernamentales y organizaciones no gubernamentales centradas en la gestión de desastres, el medio ambiente, la movilidad y los derechos humanos. La diversidad en la colaboración vertical y horizontal en la red de incendios forestales indicaba la necesidad de los gobiernos locales de acceder a un amplio conjunto de recursos en condiciones de escasez financiera. Encontramos evidencia de elementos exitosos de gobernanza multinivel, con base en Frey y Ramírez (2019) e identificamos la necesidad de desarrollar más esfuerzos de investigación sobre el compromiso y la representación de organizaciones no gubernamentales y actores privados en las redes de riesgo prioritario. En cuanto a la movilización de recursos en acciones de gestión integral de riesgos, se encontró evidencia de acciones enfocadas tanto a la prevención como a la respuesta, con necesidades potenciales de fortalecer las acciones de recuperación e identificación de riesgos, debido a la dependencia del gobierno subnacional (Gobierno de la Ciudad de México) y de centros de investigación. Los resultados de esta investigación tuvieron como objetivo proporcionar una mejor comprensión de la disposición de recursos colaborativos que subyacen a las acciones de los gobiernos locales bajo un estado de urgencia y escasez, en el que la atención no puede esperar al cambio institucional.

VI.5. Conclusiones

Los hallazgos de esta investigación evidencian los desafíos en la aplicación de elementos de la literatura sobre adaptación al cambio climático, particularmente sobre capacidad adaptativa, en la elaboración de herramientas analíticas para procesos de decisión en materia de acción climática. Aunque la adaptación es considerada en la literatura como un proceso principalmente local (IPCC, 2014), algunos autores cuestionan esta heurística y sugieren que, si bien la adaptación es local, la capacidad adaptativa es un atributo de procesos de gobierno multiescalares (Nalau et al., 2015; Preston et al., 2013). A partir de este enfoque, la consideración de los sistemas de gobierno multinivel puede contribuir a abordar la formulación y puesta en práctica de la adaptación al cambio climático. La evaluación de la capacidad institucional como componente de la capacidad de adaptación aborda la falta de capacidad de los gobiernos locales y los retos de coordinación entre múltiples niveles de gobierno (vertical) y de sectores (horizontal). Para ello, la

conceptualización de la capacidad institucional siguiendo un enfoque multidimensional integra elementos de los sistemas de gobierno multinivel al incorporar elementos de coordinación entre los distintos niveles de gobierno: dimensión de coordinación política e institucional.

En esta investigación, reconocemos que el contexto local influye en las condiciones de los resultados que observamos. Los grupos de capacidad institucional que determinamos en el Capítulo IV ilustran las condiciones heterogéneas que exhiben los gobiernos locales en un contexto del Sur Global, desde gobiernos que se acercan a la adaptación sostenible mediante la colaboración intergubernamental hasta gobiernos atrapados en una trampa de pobreza, sin recursos propios para planear su adaptación independientemente de las prioridades de los gobiernos nacional y subnacionales. Aunque el análisis fue específico para México, algunas de las características generales identificadas podrían ser relevantes para otros países del Sur global cuyos gobiernos locales también enfrentan la tragedia de la urgencia y los recursos económicos limitados para integrar o desarrollar políticas y prácticas autónomas para la adaptación al cambio climático.

Referencias

Aall, C., & Norland, I. (2005). *Report no. 6/05: Indicators for Local-Scale Climate Vulnerability Assessments* (Issue 6).

Amend, T. (2019). *Governance for Ecosystem-based Adaptation: Understanding the diversity of actors & quality of arrangements*. https://www.international-climate-initiative.com/en/infotheque/publications/publication/article/governance_for_ecosystem_based_adaptation_understanding_the_diversity_of_actors_quality_of_arrangements

Brunner, S., & Enting, K. (2014). Climate finance: A transaction cost perspective on the structure of state-to-state transfers. *Global Environmental Change*, *27*(1), 138–143. https://doi.org/10.1016/j.gloenvcha.2014.05.005

Calderón-Contreras, R. (2017). *Los Sistemas Socioecológicos y su Resiliencia. Casos de Estudio* (R. Calderón-Contreras (ed.)). UAM Unidad Cuajimalpa-Gedisa Editorial. https://www.cua.uam.mx/pdfs/revistas_electronicas/libros-electronicos/2017/sistemas-SR/LosSSEysuResiliencia_CasosdeEstudio.pdf

Carpenter, S., Walker, B., Anderies, J., & Abel, N. (2001). From Metaphor to Measurement: Resilience of What to What? *Ecosystems*, *4*(8), 765–781. https://doi.org/10.1007/s10021-001-0045-9

Carrera-Hernández, A., Coronilla-Cruz, R., & Navarro-Arredondo, A. (2010). *Índice de desarrollo institucional y sustentabilidad municipal*.

Cash, D. W., Adger, W. N., Berkes, F., Garden, P., Lebel, L., Olsson, P., Pritchard, L., & Young, O. (2006). Scale and Cross-Scale Dynamics: Governance and Information in a Multilevel World. *Ecology and Society*, *11*(2). https://doi.org/10.5751/es-01759-110208

Castillo, A., Rodríguez, G., & Estrada, L. (2019). *Estado del Arte del Financiamiento Climático para México de Fuentes Públicas Internacionales y Nacionales*.

Cid, A., & Lerner, A. M. (2023). Local governments as key agents in climate change adaptation: challenges and opportunities for institutional capacity-building in Mexico. *Climate Policy*, 1–13. https://doi.org/10.1080/14693062.2022.2163972

D.O.F. (2019). *Resultados y recomendaciones de la evaluación estratégica del avance subnacional de la Política Nacional de Cambio Climático*. http://www.dof.gob.mx/nota_detalle.php?codigo=5549585&fecha=05/02/2019

Constitución política de los estados unidos mexicanos, (2021) (testimony of D.O.F.).

Di Gregorio, M., Fatorelli, L., Paavola, J., Locatelli, B., Pramova, E., Nurrochmat, D. R., May, P. H., Brockhaus, M., Sari, I. M., & Kusumadewi, S. D. (2019). Multi-level governance and power in climate change policy networks. *Global Environmental Change*, *54*(April 2018), 64–77. https://doi.org/10.1016/j.gloenvcha.2018.10.003

Eakin, H. (2015). The "turn to capacity" in vulnerability research. In *Applied Studies in Climate Adaptation* (pp. 227–230). John Wiley & Sons, Ltd.

Eakin, H., Lemos, M., & Nelson, D. (2014). Differentiating capacities as a means to sustainable climate change adaptation. *Global Environmental Change*, *27*(1), 1–8. https://doi.org/10.1016/j.gloenvcha.2014.04.013

Fliervoet, J. M., Geerling, G. W., Mostert, E., & Smits, A. J. M. (2016). Analyzing Collaborative Governance Through Social Network Analysis: A Case Study of River Management Along the Waal River in The Netherlands. *Environmental Management*, *57*(2), 355–367. https://doi.org/10.1007/s00267-015-0606-x

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C. S., & Walker, B. (2002). Resilience and sustainable development: building adaptive capacity in a world of transformations. *Ambio*, *31*(5), 437–440. https://doi.org/10.1639/0044-7447(2002)031[0437:RASDBA]2.0.CO;2

Frey, K., & Ramírez, D. R. C. (2019). Multi-level network governance of disaster risks: the case of the Metropolitan Region of the Aburra Valley (Medellin, Colombia). *Journal of Environmental Planning and Management*, *62*(3), 424–445. https://doi.org/10.1080/09640568.2018.1470968

Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, *16*(3), 293–303. https://doi.org/10.1016/j.gloenvcha.2006.02.004

GFLAC. (2018). *Hacia una ruta de movilización de financiamiento para alcanzar las metas nacionales de cambio climático en México*. https://doi.org/10.1017/CBO9781107415324.004

Gobierno de la Ciudad de México. (2016). Hacia una Ciudad de México sensible al agua. El espacio público como una estrategia de gestión de agua de lluvia. In *Gob Cdmx*.

Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., Nooteboom, S., & Bergsma, E. (2010). The Adaptive Capacity Wheel: A method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science and Policy*, *13*(6), 459–471. https://doi.org/10.1016/j.envsci.2010.05.006

IPCC. (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation: special report of working gropus I and II of the Intergovernmental Panel on Climate Change* (M. D. M. Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi & and P. M. M. K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor (eds.)). https://doi.org/10.1017/CBO9781139177245

IPCC. (2014). Climate Change, Adaptation, and Vulnerability. In *Organization & Environment* (Vol. 24, Issue March). https://doi.org/http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf

IPCC. (2022). Cities, Settlements and Key Infrastructure. In *IPCC WGII Sixth Assessment Report* (pp. 20–22).

IPCC. (2023). Summary for policymakers. In *Synthesis Report of the IPCCC Sixth Assessment Report (AR6)*. https://doi.org/10.4324/9781315071961-11

Kates, R. W. (2000). Cautionary tales: adaptation and the global poor. *Climatic Change*, *45*(1), 5–17.

Lebel, L., Anderies, J., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T., & Wilson, J. (2006). Governance and the capacity to manage resilience in regional social-ecological systems. *Ecology and Society*, *11*(1). https://doi.org/19

Lemos, M., Agrawal, A., Eakin, H., Nelson, D., Engle, N., & Johns, O. (2013). Building adaptive capacity to climate change in less developed countries. In *Climate science for serving society*

(Vol. 1, pp. 1–20). https://doi.org/10.1017/CBO9781107415324.004

Lemos, M. C., Lo, Y. J., Nelson, D. R., Eakin, H., & Bedran-Martins, A. M. (2016). Linking development to climate adaptation: Leveraging generic and specific capacities to reduce vulnerability to drought in NE Brazil. *Global Environmental Change*, *39*, 170–179. https://doi.org/10.1016/j.gloenvcha.2016.05.001

Mimura, N., Pulwarty, R. S., Duc, D. M., Elshinnawy, I., Redsteer, M. H., Huang, H. Q., Nkem, J. N., & Rodriguez, R. a. S. (2014). 15. Adaptation Planning and Implementation. In *Assessment Report 5- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*.

Mohibbullah, M., Gain, A. K., & Ahsan, M. N. (2021). Examining local institutional networks for sustainable disaster management: Empirical evidence from the South-West coastal areas in Bangladesh. *Environmental Science and Policy*, *124*(January), 433–440. https://doi.org/10.1016/j.envsci.2021.07.016

Mortreux, C., & Barnett, J. (2017). Adaptive capacity: exploring the research frontier. *Wiley Interdisciplinary Reviews: Climate Change*, *8*(4). https://doi.org/10.1002/wcc.467

Moser, S. C., Ekstrom, J. A., Kim, J., & Heitsch, S. (2019). Adaptation finance archetypes: local governments' persistent challenges of funding adaptation to climate change and ways to overcome them. *Ecology and Society*, *24*(2). https://doi.org/10.5751/ES-10980-240228

Moss, R. H., Brenkert, a L., & Malone, E. L. (2001). Vulnerability to climate change: a quantitative approach. In *U.S. Department of Energy, Oak Ridge, TN* (Issue September).

Nalau, J., Preston, B. L., & Maloney, M. C. (2015). Is adaptation a local responsibility? *Environmental Science and Policy*, *48*, 89–98. https://doi.org/10.1016/j.envsci.2014.12.011

Nelson, D. R., Adger, N., Brown, K., Adger, W. N., & Brown, K. (2007). Adaptation to Environmental Change: Contributions of a Resilience Framework. *Annual Review of Environment and Resources*, *32*(1), 395–419. https://doi.org/10.1146/annurev.energy.32.051807.090348

Noble, I. R., Huq, S., Anokhin, Y., Carmin, J., Goudou, D., Lansigan, F. P., Osman-Elasha, B., & Villamizar, A. (2014). 14. Adaptation Needs and Options. In *Assessment Report 5- Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects*. https://doi.org/31 March 2014

OECD. (2008). Handbook on Constructing Composite Indicators: Methodology and User Guide. In *Methodology* (Vol. 3). OECD publishing. https://doi.org/10.1787/9789264043466-en

Phuong, L. T. H., Biesbroek, G. R., & Wals, A. E. J. (2018). Barriers and enablers to climate change adaptation in hierarchical governance systems: the case of Vietnam. *Journal of Environmental Policy & Planning*, *20*(4), 518–532. https://doi.org/10.1080/1523908X.2018.1447366

PNUD-México-INECC. (2017). Medición multidimensional de capacidad institucional a nivel municipal que fomente la adaptación al cambio climático. In *Proyecto #86487 "Plataforma de Colaboración sobre Cambio Climático y Crecimiento Verde entre Canadá y México" Convenio de colaboración: Transparencia Mexicana, A.C.*

Preston, B. L., Mustelin, J., & Maloney, M. C. (2013). Climate adaptation heuristics and the

science/policy divide. *Mitigation and Adaptation Strategies for Global Change*, *20*(3), 467–497. https://doi.org/10.1007/s11027-013-9503-x

Romero-Lankao, P., Hughes, S., Rosas-Huerta, A., Borquez, R., & Gnatz, D. M. (2013). Institutional capacity for climate change responses: An examination of construction and pathways in Mexico City and Santiago. *Environment and Planning C: Government and Policy*, *31*(5), 785–805. https://doi.org/10.1068/c12173

Ruiz-Rivera, N., & Melgarejo-Rodríguez, C. R. (2017). Political inequality and local government capacity for Disaster Risk Reduction: Evidence from Mexico. *International Journal of Disaster Risk Reduction*, *24*(January), 38–45. https://doi.org/10.1016/j.ijdrr.2017.05.024

Ryan, D. (2015). From commitment to action: a literature review on climate policy implementation at city level. *Climatic Change*, *131*(4), 519–529. https://doi.org/10.1007/s10584-015-1402-6

SEDEMA. (2021). *Estrategia Local de Acción Climática 2021-2050 / Programa de Acción Climática de la Ciudad de México 2021-2030*. http://www.data.sedema.cdmx.gob.mx/cambioclimaticocdmx/images/biblioteca_cc/Estrategia-Local-de-Accion-Climatica-de-la-Ciudad-de-Mexico-2014-2020.pdf

SEMARNAT-INECC. (2015). *Elementos mínimos para la elaboración de los programas de cambio climático de las entidades federativas*. https://www.google.com.mx/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwj9nObX-vPPAhWc8oMKHe1cB_wQFggdMAA&url=http%3A%2F%2Fwww.inecc.gob.mx%2Fdescargas%2Fcclimatico%2F2015_elem_minims_prog_cc_efederativas.pdf&usg=AFQjCNH_ZmeDvttzFzdhtXoaRCK6b_6z2g

SEMARNAT. (2020). *Contribución Determinada a nivel Nacional: México. Actualización 2020*. https://mma.gob.cl/wp-content/uploads/2020/04/NDC_Chile_2020_español-1.pdf

SGIRPC. (2021). *Ciudad Resiliente: Retrospectiva y Proyección de una Ciudad (In) Vulnerable*.

Shannon, S. E. (2013). Cytoscape. In *Genome researchh* (2.0). https://www.cytoscape.org

Siders, A. R. (2019). Adaptive capacity to climate change: A synthesis of concepts, methods, and findings in a fragmented field. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(3), 1–18. https://doi.org/10.1002/wcc.573

Solorio, I. (2021). Leader on paper, laggard in practice: policy fragmentation and the multi-level paralysis in implementation of the Mexican Climate Act. *Climate Policy*, *21*(9), 1175–1189. https://doi.org/10.1080/14693062.2021.1894084

Sosa-Rodriguez, F. S. (2014). From federal to city mitigation and adaptation: Climate change policy in Mexico City. *Mitigation and Adaptation Strategies for Global Change*, *19*(7), 969–996. https://doi.org/10.1007/s11027-013-9455-1

Tschakert, P., Waisman, H., Abdul Halim, S., Antwi-Agyei, P., Dasgupta, P., Hayward, B., Kanninen, M., Liverman, D., Okereke, C., Pinho, P., Riahi, K., & Suarez, A. (2018). Sustainable Development, Poverty Eradication and Reducing Inequalities. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global gre. In *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related*

global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change (pp. 445–538). https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter5_Low_Res.pdf

Turner, B. L. (2010). Vulnerability and resilience: Coalescing or paralleling approaches for sustainability science? *Global Environmental Change*, *20*(4), 570–576. https://doi.org/10.1016/j.gloenvcha.2010.07.003

Turner, B. L., Kasperson, R. E., Matson, P., McCarthy, J. J., Corell, R. W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M. L., Polsky, C., Pulsipher, A., & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the National Academy of Sciences of the United States of America*, *100*(14), 8074–8079. https://doi.org/10.1073/pnas.1231335100

Vargas, N., & Magaña, V. (2020). Climatic risk in the Mexico City Metropolitan Area due to urbanization. *Urban Climate*, *33*(May), 100644. https://doi.org/10.1016/j.uclim.2020.100644

VERBI. (2021). *MAXQDA 2022* (No. 2022). VERBI Software. maxqda.com.

Withycombe-Keeler, L., Gabriele, A., Kay, B. R., & Wiek, A. (2017). Future Shocks and City Resilience: Building Organizational Capacity for Resilience and Sustainability through Game Play and Ways of Thinking. *Sustainability: The Journal of Record*, *10*(5), 282–292. https://doi.org/10.1089/sus.2017.0011

Anexo I. Literatura sugerida para profundizar más en materia de capacidad institucional

Capacidad adaptativa:

- Siders, A. R. (2019). Adaptive capacity to climate change: A synthesis of concepts, methods, and findings in a fragmented field. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(3), 1–18. https://doi.org/10.1002/wcc.573
- Mortreux, C., & Barnett, J. (2017). Adaptive capacity: exploring the research frontier. *Wiley Interdisciplinary Reviews: Climate Change*, *8*(4). https://doi.org/10.1002/wcc.467
- Ford, J. D., Berrang-Ford, L., Sayles, J. S., Belfer, E., Pearce, T., & McDowell, G. (2018). Vulnerability and its discontents: the past, present, and future of climate change vulnerability research. *Climatic Change*, *151*(2), 189–203. https://doi.org/10.1007/s10584-018-2304-1
- Mikulewicz, M. (2018). Politicizing vulnerability and adaptation: on the need to democratize local responses to climate impacts in developing countries. *Climate and Development*, *10*(1), 18–34. https://doi.org/10.1080/17565529.2017.1304887
- Smith, M. S., Horrocks, L., Harvey, A., & Hamilton, C. (2011). Rethinking adaptation for a 4 C world. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *369*(1934), 196–216. https://doi.org/10.1098/rsta.2010.0277

Capacidad institucional – antecedentes de análisis de la capacidad institucional en adaptación al cambio climático:

- Fidelman, P., Van Tuyen, T., Nong, K., & Nursey-Bray, M. (2017). The institutions-adaptive capacity nexus: Insights from coastal resources co-management in Cambodia and Vietnam. *Environmental Science and Policy*, *76*(June), 103–112. https://doi.org/10.1016/j.envsci.2017.06.018
- Cuevas, S. C. (2017). Institutional dimensions of climate change adaptation: insights from the Philippines. *Climate Policy*, *00*(0), 1–13. https://doi.org/10.1080/14693062.2017.1314245
- Cuevas, S. C., Peterson, A., Robinson, C., & Morrison, T. H. (2016). Institutional capacity for long-term climate change adaptation: evidence from land use planning in Albay, Philippines. *Regional Environmental Change*, *16*(7), 2045–2058. https://doi.org/10.1007/s10113-015-0909-8
- Berman, R., Quinn, C., & Paavola, J. (2012). The role of institutions in the transformation of coping capacity to sustainable adaptive capacity. *Environmental Development*, *2*(1), 86–100. https://doi.org/10.1016/j.envdev.2012.03.017
- Grothmann, T., Grecksch, K., Winges, M., & Siebenhüner, B. (2013). Assessing institutional capacities to adapt to climate change: Integrating psychological dimensions in the adaptive

capacity wheel. *Natural Hazards and Earth System Sciences*, *13*(12), 3369–3384. https://doi.org/10.5194/nhess-13-3369-2013

- Eakin, H., & Lemos, M. C. (2010). Institutions and change: The challenge of building adaptive capacity in Latin America. *Global Environmental Change*, *20*(1), 1–3. https://doi.org/10.1016/j.gloenvcha.2009.08.002
- Engle, N. L., & Lemos, M. C. (2010). Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. *Global Environmental Change-Human and Policy Dimensions*, *20*(1), 4–13. https://doi.org/10.1016/j.gloenvcha.2009.07.001
- Gupta, J., Termeer, C., Klostermann, J., Meijerink, S., van den Brink, M., Jong, P., Nooteboom, S., & Bergsma, E. (2010). The Adaptive Capacity Wheel: A method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science and Policy*, *13*(6), 459–471. https://doi.org/10.1016/j.envsci.2010.05.006
- Preston, B. L., Brooke, C., Measham, T. G., Smith, T. F., & Gorddard, R. (2009). Igniting change in local government: Lessons learned from a bushfire vulnerability assessment. *Mitigation and Adaptation Strategies for Global Change*, *14*(3), 251–283. https://doi.org/10.1007/s11027-008-9163-4

Capacidad institucional – antecedentes en México:

- Monterroso, A., & Conde, C. (2017). Adaptive capacity: identifying the challenges faced by municipalities addressing climate change in Mexico. *Climate and Development*, *0*(0), 1–13. https://doi.org/10.1080/17565529.2017.1372264
- Álvarez, D. G. (2010). *Capacidades institucionales para el desarrollo humano: conceptos, índices y políticas públicas*. (L. L. H. Cámara de diputados, P. de las N. U. para el D. (PNUD), U. de G. (UdG), & L. Miguel Ángel Porrúa (eds.); Vol. 53, Issue 9). https://doi.org/10.1017/CBO9781107415324.004
- Rosas-Huerta, A., & Gil-Montes, V. (2013). La capacidad institucional de gobiernos locales en la atención al cambio climático. Un modelo de análisis. *Revista Mexicana de Análisis Político y Administración Pública*, *II*(2), 113–138.
- UNDP. (2009). *Informe sobre desarrollo humano Jalisco 2009. Capacidades institucionales para el desarrollo humano*.
- Rosas Huerta, A. (2008). Una ruta metodológica para evaluar la capacidad institucional. *Política y Cultura*, *30*, 119–134.
- Martínez-Pellégrini, S., Flamand, L., & Hernández, A. (2008). Panorama del desarrollo municipal en México. Antecedentes, diseño y hallazgos del Índice de Desarrollo Municipal Básico. *Gestión y Política Pública*, *XVII*(1), 145–192.

Enfoques de análisis de la capacidad adaptativa:

- Engle, N. L. (2011). Adaptive capacity and its assessment. Global Environmental Change, 21(2), 647–656. https://doi.org/10.1016/j.gloenvcha.2011.01.019
- Vincent, K. (2007). Uncertainty in adaptive capacity and the importance of scale. Global Environmental Change, 17(1), 12–24. https://doi.org/10.1016/j.gloenvcha.2006.11.009
- Keskitalo, E. C. H., Juhola, S., Baron, N., Fyhn, H., & Klein, J. (2016). Implementing local climate change adaptation and mitigation actions: The role of various policy instruments in a multi-level governance context. Climate, 4(1). https://doi.org/10.3390/cli4010007

Antecedentes de evaluación de la dimensión institucional de la capacidad adaptativa:

- El índice de evaluación de capacidad adaptativa más usado para evaluar la capacidad adaptativa de las instituciones es la Rueda de Capacidad Adaptativa (Gupta et al., 2010). No obstante, la práctica más común es la de desarrollar un índice específico al contexto y a la entidad vulnerable (Siders, 2019).
- Además, existen marcos de análisis teóricos que incorporan la dimensión institucional al evaluar la capacidad adaptativa. Entre ellos se encuentra:
    - El marco de análisis de análisis de las evaluaciones regionales de capacidad adaptativa. Juhola, S., & Kruse, S. (2014). A framework for analysing regional adaptive capacity assessments: Challenges for methodology and policy making. Mitigation and Adaptation.
    - Rueda de Capacidad Adaptativa (Gupta et al., 2010).
- Monterroso, A., Conde, C., 2017. Adaptive capacity: identifying the challenges faced by municipalities addressing climate change in Mexico. Clim. Dev. 0, 1–13.