A Novel Transdisciplinary Methodology and Experience to Guide Climate Change Health Adaptation Plans and Measures

Chapter · February 2020

DOI: 10.1007/978-3-030-37425-9_48

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Climate Change Management

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Climate Change, Hazards and Adaptation Options

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ISSN 1610-2002 ISSN 1610-2010 (electronic)
Climate Change Management
ISBN 978-3-030-37424-2 ISBN 978-3-030-37425-9 (eBook)
https://doi.org/10.1007/978-3-030-37425-9

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

A Novel Transdisciplinary Methodology and Experience to Guide Climate Change Health Adaptation Plans and Measures

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Abstract Climate change and socio-economic and environmental determinants of health (SDH) are the first acknowledged root-causes of infectious diseases. Controlling for SDH would reduce disease burden and promote adaptation. How can we determine which non-health sectors contribute the most and how to health vulnerability? No interdisciplinary and participative methodologies have yet been devised to address, from a complex systems perspective, the degree of responsibility non-health sectors and climate change have in disease occurrence, as a basis for adaptation. This study aims to identify climate change adaptation options for Dengue fever based on Eco-health and watershed approaches to influence public policies in the Bolivian Chaco Ecosystem. We carried out a transdisciplinary "Methodology for climate change Health Vulnerability Assessment considering Eco-health and Watershed Approaches" (MHVA), in selected areas of Pilcomayo watershed. Results established the level and type of current and future Dengue vulnerability, and the degree of responsibility of health and non-health sectors. Then, adaptation

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W. Leal Filho et al. (eds.), *Climate Change, Hazards and Adaptation Options*,
Climate Change Management, https://doi.org/10.1007/978-3-030-37425-9_48

options were participatory prioritised, designing a *Climate Change Health Strategic Adaptation Plan,* which implementation has already begun. The use of MHVA and current adaptation experience would help in identifying the most vulnerable locations and target adaptation actions.

Introduction

Climate change influences the environmental, economic and social determinants of health such as air quality, access to safe water, food availability, family income, education, housing, and essential services. Social determinants of health (SDH) refer to the conditions in which people are born, live and work (Irwin and Scali 2010). Climate change affects health in three ways (IPCC 2012, 2014):

1. Directly, such as the mortality and morbidity due to extreme weather events in which climate change may play a role.
2. Indirect impacts from environmental and ecosystem changes, such as shifts in patterns of disease-carrying mosquitoes and ticks, or increases in waterborne diseases due to warmer conditions and increased precipitation and runoff.
3. Indirect impacts mediated through societal systems (e.g. undernutrition from altered agricultural production, stress caused by population displacement, or other environmental stressors, and damage to health care systems by extreme weather events).

Diseases have a multifactorial origin, considering the many determinants that influence them to which has been added climate change and variability, and extreme events. Thus, "*Climatic factors, coupled with multiple human, biological and ecological determinants, influence the emergence and re-emergence of infectious diseases such as arbovirosis, malaria, leishmaniasis, Chagas disease*" (Amarakoon et al. 2008). With the global expansion of vectors that are able to transmit Dengue, Zika, and Chikungunya virus (Kraemer et al. 2015), neglected tropical diseases that are associated with climate dynamics reiterate the need for intensified political attention and global health action (Watts et al. 2017), particularly in Latin America (Leal Filho et al. 2018).

Operationally, the management of health determinants is a responsibility of health sector as well as of other sectors, for example an optimal quality and availability of water will favour or avoid, the occurrence of cases of diarrhoeas, or the number of hours of water supply contributes to occurrence or not, of cases of dengue fever. Such conditions exist outside the domain where the health sector has direct influence since in most countries water management agencies are not part of health sector. So the policies, strategies, and performance of other sectors will have visible results on occurrence of different diseases and health outcomes.

As far as the stakeholders are concerned, there are some requirements which also need to be met, if their vulnerability is to be reduced, such as to foster more awareness on the means via which vector-borne diseases are transmitted, which may substantiate and add a greater degree of reliability to prevention efforts (Leal Filho et al. 2018).

However, no interdisciplinary and participatory methodologies have yet been devised to address, from a complex systems perspective, the degree of responsibility non-health sectors, and climate change and variability have in disease occurrence, as a basis for adaptation. The project "Climate Change, vulnerability and health-Colombia and Bolivia", funded by IDRC, carried out a transdisciplinary vulnerability assessment "Methodology for climate change Health Vulnerability Assessment considering Eco-health and Watershed Approaches" (MHVA) (Aparicio-Effen et al. 2016a), aimed at developing adaptation decisions, to reduce the deleterious impacts of climate change on health, which include vulnerability dimensions, climate and non-climate factors. We applied MHVA to assessing the climate vulnerability related to Dengue fever in Bolivian Pilcomayo watershed. After that, adaptation options were participatory prioritised, designing a Climate Change Health Strategic Adaptation Plan, which implementation has already begun.

The overall goal of this project research is: To identify climate change adaptation options for Dengue fever from Eco-health and integrated watershed approaches to influence public policies and reduce vulnerability to Dengue and associated diseases like the Chikungunya and Zika in Bolivian Chaco Ecosystem.

To achieve the goal as mentioned above we have worked with (i) decision-makers at the local, regional and national level; (ii) the health networks of project area; (iii) urban planners of the municipal governments and (iv) representatives of social movements and ethnicities (e.g. indigenous groups and urban, peri-urban and rural populations), of the Pilcomayo basin. We focused on strengthening climate adaptation capacities, which included the evaluation of the current and future vulnerability initially, the rise of adaptation options and their implementation.

The use of MHVA and current adaptation experience would help in identifying the most vulnerable locations and target adaptation actions.

Conceptual and Methodological Framework About Health Vulnerability Assessment

Methodology

The methodology followed in this project to assess climate-related health vulnerability to Dengue (V_{CCD}) considered Watersheed approach (IWRM) and Ecosystem approach to health (Eco-health) (Charron 2012). Eco-health is an emerging field of transdisciplinary research that brings together public health, environmental health people, veterinarians, ecologists, social scientists, policy makers, local authorities and experts from other fields and community members to explore how ecosystem changes can have adverse impacts on human health and implement practical solutions to address these health challenges (Hung and Tran 2016). Six principles of this approach include transdisciplinarity, participation, gender, and social equity, system-thinking, sustainability and research-to-action (Charron 2012). Eco-health research integrates different disciplines and world-views to tackle difficult health issues (Waage et al. 2010).

The Integrated Water Resources Management (IWRM) (Rahaman and Varis 2005) of river basins is a systematic process for the sustainable development, allocation, and monitoring of water resources used in the context of socio-economic and environmental objectives. When several agencies share responsibilities for drinking, irrigation, and environmental water, the lack of cross-sectoral linkages leads to uncoordinated water resource development and management, resulting in conflict, waste and unsustainable systems.

Climate vulnerability is "*a condition of a natural or human system with a propensity to be adversely affected by vulnerability factors such as exposure, the nature, and magnitude of the change in weather patterns, sensitivity, and adaptability*" (IPCC 2007). It should also be considered that all dimensions of human activity: physical, socio-economic and environmental act together (inter and transdisciplinary) to build vulnerability, serving as a basis to study the direct and indirect effects of climate on specific diseases (e.g. V_{CCC} for Chagas (Nagy et al. 2017).

We followed the "Methodology for climate change Health Vulnerability Assessment (MHVA) considering Eco-health and IWRM Approaches" to address, from a complex systems perspective, the degree of health and non-health sectors responsibilities and climate change effects on disease occurrence, as a basis for adaptation options (Aparicio-Effen et al. 2016a).

Vulnerability Factors

The adaptive capacity of health sector depends on vulnerability factors and dimensions, the types of human and socio-economic development, social organisation, and relationship with access, coverage to health services and social participation of community. The adaptive capacity of health sector and other health-related sectors is a fundamental part of the vulnerability. The climate vulnerability (V_{CC}) includes the following factors (IPCC 2007; Aparicio-Effen et al. 2016a):

$$V_{CC} = f\left(Exp, CMC,\ Sens,\ CR_{-Adap}\right)$$

where

Exp: Exposition, variation to which a system is exposed
Sen: The sensitivity
CMC: The character, magnitude, and rapidity of change in weather patterns

C_(R-Adap): The ability to respond and or adapt.

(a) Exposure: The exposure is determined by geographical location of an area of analysis, the physiographic and climatic characteristics, which can determine the condition of fragility or sensitivity that determines the greater or lesser impact of climate change.
(b) Sensitivity: characteristic of system that is being evaluated, which can be altered positively or negatively (resilient or fragile). The epidemiological and environmental dimensions are sensitive to climate variability, gradual global climate change, and changes in land use.
(c) Nature and magnitude of change: Changes generated in climate behaviour, due to natural variability, or anthropogenic climate change, which affects or alters the condition of the system under study. Climate Change Vulnerability (VCC) is Character and Magnitude of change = Differences (Δ) between current climate and historical climate and future climate and current climate = CMC: f (Δ1) (Nagy et al. 2017).

where: Δ1: ((current climate (CA) − Historical Climate (CH))
CMC: f − Δ 2
Δ 2: ((future climate (CF) − Current Climate (CA))
Future climate scenarios (Aparicio-Effen et al. 2016a; Nagy et al. 2016)

CMC represents the influence of climate in series that are available in the reference area which includes the thermal amplitude between the minimum and maximum average temperatures recorded and the precipitation patterns. These values are associated with altitude ranges in which people live and influence both temperature and precipitation. Thus the climatic index is obtained (IC) being its expression the following equation:

$$IC_i = IPP\ (Tmax - Tmin)/\Delta h$$

where:

ICi: Climate Index
IPP: Precipitation index that is the ratio between the observed precipitation during the studied period and the average precipitation over the analysed periods.
Tmax: Maximum average temperature of the studied period.
Tmin: Minimum average temperature of the studied period.
Δh: Temperature variation range due to the change in altitude determined by Ti: *i*th (observation of the average temperature), Hi: (*i*th observation of the altitude where the temperature was measured) and N (Number of observations of the ten years series of observation).

The valuation of the index mentioned above applies to each of the diseases to be analysed (e.g. Chagas, Dengue, Zika) and allows us to read how the climatic conditions are modified according to the precipitation rate and the average thermal amplitude.

Vulnerability Dimensions

The representation of vulnerability factors and interdisciplinary dimensions of the MHVA is shown in Fig. 1.

The vulnerability corresponds to a historical and temporal context, so the evaluation of climate system should be done considering baseline, the current and future climate, and spatial area of analysis (river basin, location, altitude, and topography) where evaluated human system is located (Aparicio-Effen et al. 2016a).

The IWRM approach seeks to balance the use of natural resources with its conservation, taking into account climate change within the river basin system, with subsystems (dimensions of vulnerability). The "integrated" concept includes goals of production and social development, with the consequent impact on human health. For this process, key actors for development and adaptation measures must be same inhabitants and users of watershed. In this context, the eco-health approach in watersheds (spatial scope), also incorporates the temporal scope of change (climate) and allows the improvement of productive and social interactions with current and future human and ecosystem needs, which potentially improves the health and equity of gender and race.

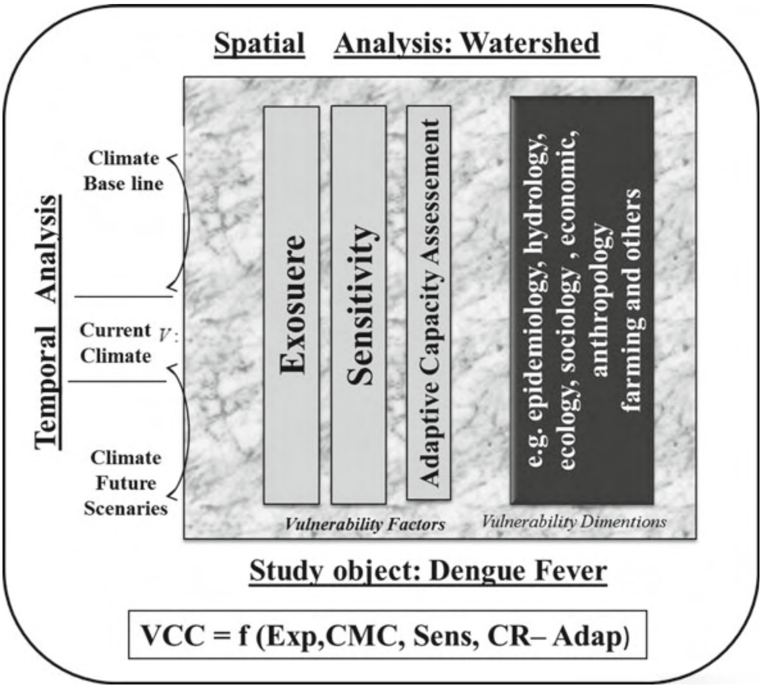

Fig. 1 The methodological framework for climate-related health vulnerability assessment considering eco-health and watershed approaches. Modified from Aparicio-Effen et al. (2016a) and Nagy et al. (2017)

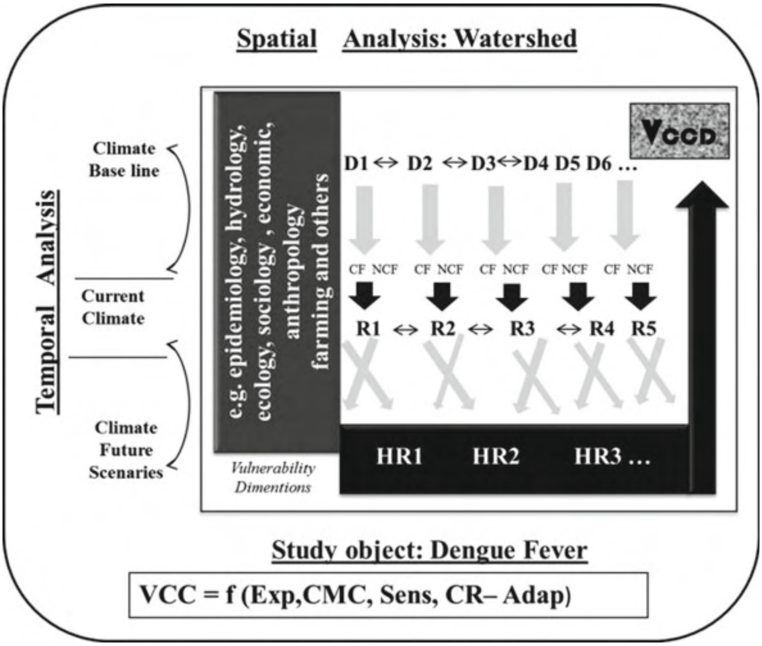

Fig. 2 Climate-related health vulnerability (V_{CCD}) constructivism process

The MHVA refers to a study object (or problem) related to discipline (e.g. epidemiology, hydrology, ecology, sociology, and climatology), science or sector, which analyses the exposure, sensitivity and adaptive capacity to the climatic and non-climatic pressures that exert influence on the object as mentioned earlier. The MHVA initially follows a deconstructivist process of the discipline favouring a health central element and leaving aside other no-health elements considered peripheral. This opposition, centre/periphery, can be inverted and deconstruct the discipline, by virtue of the "difference" and later these health central elements obtained from differents disciplines will follow a constructivist process for obtein climate change health vulnerability for specific disease, in this case Dengue Fever (VCCD) (Aparicio-Effen et al. 2016a; Nagy et al. 2017) (Fig. 2).

The MHVA allows the assessment of the V_{CC}. VCC results from the action of climate and non-climate factors on vulnerability dimensions of studied object with following time-space variations and magnitude.

Vulnerability Results

The project determined the level and type of current and future V_{CCD} in the five prioritised municipalities of the Pilcomayo watersheed (Box 1).

Box 1 Health vulnerability to climate change and variability for dengue (V_{CCD})

We identified and compiled the factors and dimensions of vulnerability for dengue, from all disciplines and dimensions under study. We applied the MHVA and then proceeded to integrate collected information (aedic indices, number of cases of dengue, maximum temperature, minimum temperature, $\Delta 1$ of temperatures, precipitation, use of mosquito nets, storage of water, habits, waste solids, and biodiversity indices such as Shanon index and Simpson's inverse for birds, insects and plants).

Then a multiple linear regression model was developed, processed with the SAS program (Statistical Analysis System), obtaining the correlation matrix for dengue, that was interpreted and analysed to parameterise the correlation coefficients whose results were emptied in a vulnerability matrix, which also incorporated the rate of adaptation capacity of evaluated municipality.

The results were presented with colours representing low, medium, high and very high levels of vulnerability. For statistical analysis, the database was structured considering the grouping of variables by dimensions of vulnerability. For the hydrologic dimension, annual precipitation variables and observed decrease were included. We assessed the climate baseline and current climate for urban, peri-urban and rural areas.

For the epidemiological dimension, epidemiological indices for dengue were considered: housing infestation indexes (IIV), Breteau Index (IB) and vessel Infestation Index (IIR) associated with some confirmed cases and case numbers Suspects added by urban neighbourhoods and peri-urban neighbourhoods. In each category, the capacities of health centres (infrastructure, equipment, laboratory and health personnel were assessed).

Also, we assessed the confidence of people in health services by applying qualitative methods to evaluated the adaptive capacity of health system.

The application of the MHVA to human health made it possible to recognise the systemic relationships between health and different biophysical, socioeconomic and environmental factors. The observed differences in exposure and vulnerability are related to climate and non-climate factors and they are the result of multidimensional inequalities produced by a disparate and inequitable development process, as discussed in previous works by the authors (e.g. Aparicio-Effen et al. 2016b; Nagy et al. 2018) evident in the following levels.

Political-Administrative

The V_{CCD} in the municipalities of Department of Tarija shows that in Yacuiba climatic factors prevail over non-climatic factors. The meteorological variables are optimal for vector development, so seasonally Aedes *aegypti* finds favourable conditions for

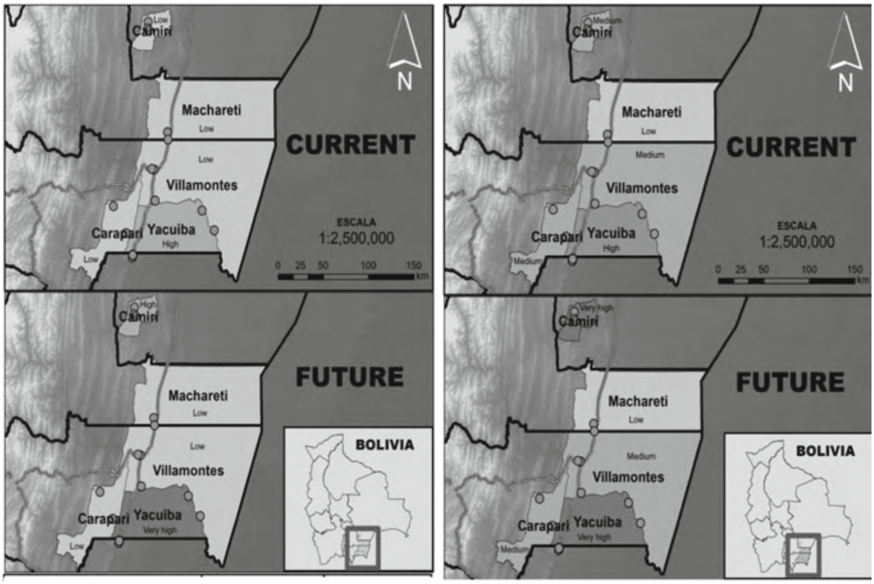

Fig. 3 Current and future climate-related health vulnerability for Dengue (V_{CCD}) for urban (left) and peri-urban (right) areas evaluated with MHVA methodology at the five studied municipalities

its reproduction, particularly in the rainy season. Future climate scenarios will accentuate the current changes in maximum and minimum temperature increases, associated with a 12% decrease in precipitation, which will generate water accumulation by population, and other human and municipal management factors. In Villamontes and Carapari, non-climatic factors prevail, but greater climatic pressures are expected in the future.

The current V_{CCD} of urban area is high in Yacuiba and low in urban Camiri. The V_{CCD} is high in the peri-urban area of Yacuiba and average in Villamontes and Camiri. Under the 2030 future climate scenario, the urban V_{CCD} will become very high for Yacuiba and high for Camiri. In the evaluated peri-urban neighbourhoods, the V_{CCD} will become very high for Yacuiba and Camiri and will remain average in Villamontes. The future V_{CCD} due to the effect of the changing climate 2020–2030, added to population growth in urban and peri-urban area, increases it from high to very high, so it is urgent to implement adaptation measures that reduce the degree of vulnerability (Fig. 3).

Watershed, Ecosystem, and Production

The impacts of extreme events (e.g. droughts, forest fires) highlight the exposure and vulnerability of Chaco ecosystems and their human systems to the current climate

(Aparicio-Effen et al. 2016b). Extreme events produce alteration of ecosystems, loss of biodiversity (with impacts on health, for example, the almost extinction of the guild of insectivorous birds in Yacuiba), disorganisation of food production and water supply (continuity of services and availability), damage to infrastructure and settlements, impacts on agricultural production, favouring Dengue. Both climatic and non-climate factors, the former predominantly indirect on health, have a summative effect on health vulnerability.

The Site of Residence and Culture

The project has studied urban and peri-urban (indigenous and peasant) groups, evidencing that peri-urban areas with precarious housing, service deficits, and unplanned population growth are exposed to Dengue, and now to Chikungunya and Zika. The lower educational and socioeconomic levels reduce the possibility of using preventive measures for dengue and access to health services.

These results evidence that the Pilcomayo watersheed, in particular at the five prioritised municipalities, which show high climate-related health vulnerability, V_{CCD} will be very high by 2030, agreeing with the assertions made by the IPCC (IPCC 2007, 2014). The methodology implemented allowed to identify climate and non-climate factors, with different effects and graduations for studied municipalities and different degree of vulnerability for Dengue.

Methodological Contributions for Adaptation Prioritisation

> Adaptation can contribute to well-being of populations, the security of assets and the maintenance of ecosystem goods, functions and services now and in the future. Adaptation is place- and context-specific. The first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability. Integration of adaptation into planning, including policy design, and decision-making can promote synergies with development and disaster risk reduction. Building adaptive capacity is crucial for effective selection and implementation of adaptation options. (IPCC 2014)

Climate change will affect species distribution, demography and life histories, with consequences for human livelihoods including changing patterns of human disease distribution (McNeely and Mainka 2009). Until the middle of the century, the impact of projected climate change will affect human health mainly due to the aggravation of existing health problems. Throughout the 21st century, climate change is expected to cause an increase in poor health in many regions and especially in low-income developing countries, compared to the reference level without climate change (IPCC 2014).

Adaptation can reduce the risks of climate change impacts, but there are limits to its effectiveness, especially with greater magnitudes and rates of climate change. Taking a longer-term perspective, in the context of sustainable development, increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness (IPPC 2014).

Climate change and social, economic and environmental determinants of health (SDH) are the first acknowledged root-causes of infectious diseases. Controlling for SDH would reduce disease burden and promote adaptation. The most effective short-term health vulnerability reduction measures are programs that implement and improve necessary public health measures such as providing clean water and sanitation, ensuring essential health care that includes immunisation and child health services, higher capacity for preparedness and response to disasters, and poverty alleviation (IPCC 2014).

These and other measures to reduce vulnerability and to adapt are developed within a temporal and spatial context, which are addressed through the MHVA methodology. Once the current and future V_{CCD} was estimated for the Project area, the approach was continued focused on transcending the health sector, quantifying the degree of responsibility of non-health sectors, and transferring the scientific findings in sustainable public policies and actions.

The results were presented to the different stakeholders of the Pilcomayo basin, to prioritise participatory adaptation measures, trying to avoid the implementation of reactive adaptation measures, which in most cases mean a loss of economic and human resources, pollution of waters, soils, and loss of biodiversity.

The Methodology Followed for the Participatory Prioritisation of Adaptation Measures in the Bolivian Chaco

The implementation of knowledge management tools facilitated the assessment of progress of direct, key and strategic actors concerning:

- Changes promoted by the Project (Diaries and Scope Reports).
- Map of Actors and Map of Actors of Trust.
- Communication of results (e.g. triptychs, comic strips, radio series, and press activities).

For participatory prioritisation of local climate adaptation measures, we developed workshops in each municipality, as follows.

Before the Workshop

Step 1 Identify and summon the actors.

The scope diary progressively allowed knowing the actors and their progress on study problem (object), their knowledge and behaviour. The updating of actors map and the construction of trustworthy actors map oriented the identification of those that should be summoned to participatory process of prioritisation. The workshops involved decision makers, municipal, local, departmental, health network personnel, hospitals, civil society, two indigenous ethnic groups, and peasants. The development of various communication products supported the change process, contributed to raising awareness, levelling information and knowledge, and motivating the participation of actors in the prioritisation process.

Step 2 Preparation of the workshop

Before the workshop, the research team prepared two types of materials: PowerPoint presentations with the objectives and results of research, explaining the workshop dynamics and investigation results, and participatory instruments for prioritisation of adaptation measures.

The participatory instruments included the preparation of a prioritisation matrix and cards with adaptation measures list. Previously, the research team, together with health authorities and networks, defined the most critical adaptation measures, which would be consulted in the workshop, based on research results. Once the measures were defined, we identified the most relevant analysis dimensions for measures set, including, for example, changes in behaviour (in people), political will (in the authorities), institutional changes and new legal frameworks.

At the same time, different types of activity were defined, corresponding to main change involved in the implementation of each type of activity, and each one received a different colour. All activities were transcribed into colour cards (one activity per card) according to their type and for all measures. Finally, all participant stakeholders designed a large prioritisation matrix that included as columns: the measure, the activities, who leads each action, who will participate in its execution, who will finance the actions, the scale of intervention, the time scope and the score (for prioritisation).

All the researchers assumed their role in the workshop: facilitate the groups, help identify the cards in the matrix, take notes and clarify doubts.

During the Workshop

Step 3 Presentation of research results: levelling knowledge and promoting collaborative spaces

At the beginning of each workshop, the research team announced the key findings to stakeholders, reporting on objectives and expected results of workshop, levelling the information and knowledge product of research, and preparing for participation in the activity.

The systemic approach of process allowed to socialise research results related to levels of water pollution, type, and distribution of the solid waste, diseases to which they face, the role of different sectors in diseases prevention, the possible reasons that originate them, deficiencies of infrastructure and management. A round of questions after each presentation allowed to exchange points of view and to satisfy doubts of participants.

Box 2 Prioritised adaptation measures for Dengue selected by the stakeholders in the Project area (Table 1).

1. Safe water
2. Water for hygiene
3. Integrated solid waste management
4. Early Warning System for Dengue
5. Improvement of the management of protected areas
6. Sectoral and intersectoral capacity that encompassed: Organising awareness workshops and strengthening health networks.

The measures mentioned above were followed by the implementation of a massive campaign and the implementation of a multisectoral platform to address health issues. The discussions held with the stakeholders allowed knowing which would be the activities that would have more significant support, besides the type of measure, showing the vision that actors have about problem and solutions. The construction of dialogue and consensus and the organisation of awareness campaigns were essential actions to generate behavioural changes. Regarding safe water, water boiling was the activity with the highest consensus, followed by water filtering, monitoring, and maintenance of the distribution network and tank construction. This result shows that prioritised activities highlight those that demand behavioural changes in people and families, and those that require infrastructure works in charge of municipalities and families themselves.

The prioritised adaptation measures respond to research results that show the population contribution, health sector, and other health-related sectors, and how the deficiencies or well-performed sectoral work are made explicit in environmental and social determinants, that will favour or prevent the presentation of Dengue cases.

Step 4 Prioritisation of adaptation measures: incorporation of all perspectives

Due to the socio-cultural characteristics of participants, we decided to implement a methodology based on debate and consensus, and not on numerical weighting of measures. Although numerical weighting could contribute to objectivity of decision, there was a risk of transforming the process into a technical exercise of validation of opinions instead of being a moment of knowledge dialogue that would allow expressing the participants opinion in their complexity (idiomatic, worldview, educational, social position and perception).

Table 1 A matrix of participatory prioritisation of the adaptation measures

Measure	What is?	Leaders	Participants	Funding	Scale of application	Initiation	Prioritisation
Safe water	Access to safe water at homes & schools. Monitoring and alliances	Municipal government	Government users	Government	Quarters community	Short-term	1
Water for hygiene	Water at homes and schools; hand washing	Families	Representatives of civil society (ROSC)	Government corporate social responsibility	Family	Short-term	2
Solid waste integrated management	Garbage and sanitary landfill management	Municipal government	Municipal government ROSC families	Municipal government	Municipality	Short-term	3
Early warning system (EWS) for dengue	Observation network strengthening and EWS normative	National government	Municipal and departmental governments ROSC families	Municipal government	National	Medium-term	4
Improvement of natural protected areas management	Installation of municipal dumps; recycling; ordinances	Managers	Departmental Governor and Deputy Governor	Departmental government	Regional	Short-term	5
Sectoral and intersectoral capacity	Building capacity for change; citizens for health	Managers	Community peasants unions of health professionals	Municipal Government	Departmental Government	Short-term	6

Once results were presented, the different stakeholders were organised in groups by type and sectors of activity (NGO, urban organisations, indigenous peoples, health sector and local governments), where the facilitators presented the set of selected adaptation measures, explaining their meaning and scope. Each measure was placed in the first column of the matrix.

Identification of Strategic Activities

The cards with activities were organised in groups and were placed in a visible place for all the participants. Participants were asked to select two activities for each adaptation measure. The possibility was left open for each group to incorporate new activities by consensus. Then, with the help of the facilitator, each group agreed on the main activities that should be implemented for each adaptation measure. The cards prioritised by each group are placed in the second column along with each adaptation measure.

Identification of Stakeholders

> Adaptation planning and implementation can be enhanced through complementary actions across levels, from individuals to governments. National governments can coordinate adaptation efforts of local and sub-national governments, for example by protecting vulnerable groups, by supporting economic diversification and by providing information, policy and legal frameworks and financial support. (IPCC 2014)

Each group was given cards in which the name of different institutions was written by type: Municipal government, national government, university Health networks, which were requested to identify, by consensus, the institutions that should or might

- Lead the implementation of activity.
- Be summoned to design activity.
- Follow-up of activities.
- Have potential or interest in funding them.

The cards with the names of the institutions identified by each group were placed in the third, fourth and fifth column of matrix together with each activity or group of prioritised activities with which they were related.

Subsequently, each group discussed the scale of intervention (family, neighbourhood, municipality, department, Country) and initiation of activities (short, medium and long term). The selected cards were placed in the sixth and seventh column.

Prioritisation of Adaptation Measures

The work in groups allowed building different matrices of prioritisation of measures and activities, which included the contributions of each type actor, placing together with each one, a number from 1 to 6 (there were six measures of adaptation) according to the assigned importance. Subsequently, a single matrix synthesis was consolidated.

After the Workshop

Step 5 Analysis of results

> Adaptation experience is accumulating across regions in the public and private sectors and within communities. There is increasing recognition of the value of social (including local and indigenous), institutional, and ecosystem-based measures and the extent of constraints to adaptation. Adaptation is becoming embedded in some planning processes, with a more limited implementation of responses. (IPCC 2014)

The research team and health sector counterparts, processed the information jointly constructed, emptying the prioritisation matrices in an analysis matrix of measures and activities prioritised by actor type. The analysis matrix allowed identifying the number of actors that prioritised each measure guiding those that are of greater consensus or importance at the local level.

As a final result of the project, climate adaptation measures for dengue were prioritised following Eco-health and watershed approaches. Then, adaptation options were participatory prioritised, designing a "Climate Change Health Strategic adaptation Plan", which implementation has already begun. The Plan initially designed for Dengue serves as the basis of adaptation for Chikungunya and Zika that share the same vector and that are new diseases in the Pilcomayo Watersheed.

Many adaptations and mitigation options can help address climate change, but no single option is sufficient by itself. Effective implementation depends on policies and cooperation at all scales and can be enhanced through integrated responses that link mitigation and adaptation with other societal objectives (IPCC 2014). In this sense, the use of MHVA and current adaptation experience would help in identifying the most vulnerable locations and target adaptation actions.

Conclusions

Based on current and future climate and non-climate scenarios, and participatory consultation process developed within the Methodology for climate change Health Vulnerability Assessment considering Eco-health and Watershed Approaches" (MHVA) framework, we highlight the following findings.

The climate-related health vulnerability resulted from the action of climate and non-climate factors and vulnerability dimensions related to the studied object (Dengue Fever: V_{CCD}) with time-space and magnitude variations.

The vulnerabilities are the result of multidimensional inequalities produced by a disparate and inequitable development process.

Climate adaptation options for Dengue were prioritised based on Eco-health and Watershed approaches through a participatory workshop.

The primary outcome of the MHVA and participatory process is the "Climate Change Health Strategic adaptation Plan" initially designed for Dengue Fever, that serves as an adaptation basis for Chikungunya and Zika, two new diseases in Pilcomayo Watersheed that share the same vector.

As stated by the Intergovernmental Panel on Climate Change (IPCC), the effective implementation of adaptation measures depends on policies and cooperation at all scales and can be enhanced through integrated responses that link management options with other societal objectives. In this sense, the use of MHVA and current adaptation experience would help in identifying the most vulnerable locations and target adaptation actions for health and other health-related sectors.

References

Amarakoon D, Chen A, Rawlins S, Chadee DD, Taylor M, Stennett R (2008) Dengue epidemics in the Caribbean-temperature indices to gauge the potential for onset of dengue. Mitig Adapt Strat Glob Chan 13:341–357

Aparicio-Effen M, Arana I, Aparicio J, Ramallo C, Bernal N, Nagy GJ, Ocampo (2016a). Chapter 14: Climate change and variability health vulnerability in Bolivian chaco ecosystems. In: Leal Filho W, Azeiteiro Alvez F (eds) Climate change and health: improving resilience and reducing risks, 231–259. Climate change management series. Springer, Heidelberg, Germany. eBook ISBN 978-3-319-244660-4_14, Hardcover ISBN 978-3-319-24658-1, Series ISSN 160-2010. https://doi.org/10.1007/978-3-319-24660-4_14, http://www.springer.com/us/book/9783319246581, 480 pp

Aparicio-Effen M, Arana I, Aparicio J, Cortez P, Coronel G, Pastén M, Nagy GJ, Galeano Rojas A, Flores L, Bidegain M (2016b). Chapter 26: Introducing hydro-climatic extremes and human impacts in Bolivia, Paraguay and Uruguay. In: Leal Filho W, Azeiteiro Alvez F (eds) Climate change and health: improving resilience and reducing risks, pp 449–473. Climate change management series. Springer, Heidelberg, Germany. ISBN 978-3-319-24658-1, https://doi.org/10.1007/978-3-319-24660-4_26, 480 pp

Aparicio-Effen M, Arana-Pardo I, Ocampo M, Aparicio J, Roque S, Nagy GJ (2018). A successful early warning system for hydroclimatic extreme events: the case of La Paz City mega landslide. In: Climate change adaptation in latin America: managing vulnerability, fostering resilience. Climate change management series. Springer, Heidelberg, Germany, pp 241–265. https://doi.org/10.1007/978-3-319-56946-8

Charron DF (2012) Ecosystem approaches to health for a global sustainability agenda. EcoHealth 9:256–266 PMID: 22961374 https://doi.org/10.1007/s10393-012-0791-5, https://www.ncbi.nlm.nih.gov/pubmed/22961374

Hung N-V, Thi THT (eds) (2016) Ecosystem approach to health (Ecohealth): theory and practices in environmental health research in Vietnam. Medical Publishing House, Hanoi, Vietnam. https://cgspace.cgiar.org/handle/10568/77089

IPCC (2007) Climate change 2007: impacts, adaptation and vulnerability. In: Parry M, Canziani O, Palutikoff J, van der Linden P, Hanson C (eds) Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change. University Press, Cambridge, Cambridge, p 976

IPCC (2012) Managing the risks of extreme events and disasters to advance climate change adaptation. In: Field CB, Barros V, Stocker TF, Qin D, Dokken DJ, Ebi KL, Mastrandrea MD, Mach KJ, Plattner G-K, Allen SK, Tignor M, Midgley PM (eds) A special report of working groups I and II of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp

IPCC (2014) Climate change 2014 impacts, adaptation, and vulnerability: working group II contribution to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781107415379

Irwin A, Scali E (2010) Action on the social determinants of health: learning from previous experiences. Social determinants of health discussion paper 1 (Debates). World Health Organization, Geneva. https://www.who.int/social_determinants/corner/SDHDP1.pdf

Kraemer MU, Sinka ME, Duda KA, Mylne AQ, Shearer FM, Barker CM, Moore CG, Carvalho RG, Coelho GE, Van Bortel W, Hendrickx G, Schaffner F, Elyazar IR, Teng H-J, Brady OJ, Messina JP, Pigott DM, Scott TW, Smith DL, Wint GW, Golding N, Hay SI (2015) The global distribution of the arbovirus vectors Aedes aegypti and Ae. albopictus. eLife 4. https://doi.org/10.7554/eLife.08347

Leal Filho W, Boenecke J, Spielmann H, Azeiteiro UM, Alves F, Lopes de Carvalho M, Nagy GJ (2018) Climate change and health: an analysis of causal relations on the spread of vector-borne diseases in Brazil. J Cleaner Prod 177:589–596. https://doi.org/10.1016/j.jclepro.2017.12.144

McNeely JA, Mainka SA (2009) Conservation in a New Era. IUCN, Gland, Switzerland. https://portals.iucn.org/library/efiles/documents/2009-026.pdf

Nagy GJ, Coronel G, Pastén M, Báez J, Monte Domecq R, Galeano Rojas A, Flores, Ciganda C, Bidegain M, Aparicio-Effen M, Arana I, Aparicio J (2016) Impacts on well-being and health of excessive rainfall and floods in Paraguay, Uruguay and Bolivia. In: Leal Filho W, Azeiteiro U, Alvez F (eds) Climate change and health: improving resilience and reducing risks. Climate change management series. Springer, Heidelberg. https://doi.org/10.1007/978-3-319-24660-4

Nagy GJ, Cabrera C, Coronel G, Aparicio-Effen M, Arana I, Lairet R, Villamizar A (2017) Addressing climate adaptation in education, research and practice: the CliVIA-network. Int J Clim Change Strategy Manag 4(9). https://doi.org/10.1108/ijccsm-04-2016-0056

Nagy GJ, Leal Filho W, Azeiteiro UM, Heimfarth J, Verocai JE, Li C (2018) An assessment of the relationships between extreme weather events, health vulnerability and the impacts on human wellbeing in latin American countries. Int J Environ Res Public Health 15(9):1802. https://doi.org/10.3390/ijerph15091802

Rahaman MR, Varis O (2005) Integrated water resources management: evolution, prospects and future challenges. Sustain Sci Pract Policy 1(1):15–21. https://doi.org/10.1080/15487733.2005.11907961

Waage J, Banerji R, Campbell O, Chirwa E, Collender G, Dieltiens V, Dorward A, Godfrey-Faussett P, Hanvoravongchai P, Kingdon G, Little A, Mills A, Mulholland K, Mwinga A, North A, Patcharanarumol W, Poulton C, Tangcharoensathien V, Unterhalter E (2010) The millennium development goals: a cross-sectoral analysis and principles for goal setting after 2015. Lancet and London international development centre commission. Lancet 376(9745):991–1023

Watts N, Amann M, Ayeb-Karlsson S, Belesova K, Bouley T, Boykoff M, Byass P, Cai W, Campbell-Lendrum D, Chambers J, Cox PM, Daly M, Dasandi N, Davies M, Depledge M, Depoux A, Dominguez-Salas P, Drummond P, Ekins P, Flahault A, Frumkin H, Georgeson L, Ghanei M, Grace D, Graham H, Grojsman R, Haines A, Hamilton I, Hartinger S, Johnson A, Kelman I, Kiesewetter G, Kniveton D, Liang L, Lott M, Lowe R, Mace G, Odhiambo Sewe M, Maslin M, Mikhaylov S, Milner J, Latifi AM, Moradi-Lakeh M, Morrissey K, Murray K, Neville T, Nilsson M, Oreszczyn T, Owfi F, Pencheon D, Pye S, Rabbaniha M, Robinson E, Rocklöv J, Schütte S, Shumake-Guillemot J, Steinbach R, Tabatabaei M, Wheeler N, Wilkinson P, Gong P, Montgomery H, Costello A (2017) The lancet countdown on health and climate change: from 25 years of inaction to a global transformation for public health. The Lancet. https://doi.org/10.1016/S0140-6736(17)32464-9