

# UNDERSTANDING URBAN VULNERABILITIES TO CLIMATE CHANGE IMPACTS IN KHON KAEN AND MUKDAHAN IN THAILAND

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## Abstract

In 2050, more than 60 percent of the projected increase in urban population is expected to be in Asia while half of that growth will occur in secondary cities. Rapid urbanization and changes of rainfall patterns and intensity pose a high risk of flood, heat waves and drought. City authorities are challenged in delivering efficient infrastructure and services and defining effective and adequate responses to build resilience and mitigate vulnerability. This paper aims to identify and analyse key urban vulnerabilities to climate change impacts in two secondary cities, Khon Kaen and Mukdahan, in the northeast of Thailand. It wants to understand ways of building urban climate resilience cities using shared learning dialogues as major data collection tool and the climate resilience framework as analysis tool. Practices in both cities towards tackling climate risks were found to lack comprehensive and inclusive planning as well as an essential understanding of how unplanned urban growth without a long-term approach that considers climate sensitive land use and urban planning as well as sufficient and adequate water availability – both quantity and quality – currently exacerbates and will influence climate change related impacts in future.

**Keywords:** Urbanization, Climate Change, Resilience, Vulnerability, Thailand

## 1. INTRODUCTION

Secondary cities with less than 500,000 inhabitants are expected to experience half of the projected increase in urban population between now and 2050 while more than 60 percent will occur of the growth in Asia (United Nations, 2015). Thailand's current course towards broader regional economic integration sets a brisk pace for industrial and urban development wherein secondary cities

in the Northeast, including Khon Kaen and Mukdahan, are envisioned to become economic key hubs through the expansion of infrastructure and logistic systems (National Economic and Social Development Board, 2012). If poorly planned and controlled, regular exposure to climate hazards with more frequent and more intense extreme weather events such as floods and droughts (Busapathumrong, 2013; Lebel et al., 2011) will cause difficulties for the two cities in

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delivering efficient infrastructure and services.

Urbanization is a transformative process that is closely interlinked with growth, vulnerability, poverty and climate change (Friend et al., 2016). It triggers dependencies on critical systems, such as infrastructure, food, water, and energy (Friend & Moench, 2013) while failures can have enormous implications for the urban and rural population (Friend & MacClune, 2013). It is crucial for city leaders in Khon Kaen and Mukdahan to understand urban vulnerabilities to climate change impacts in order to enable climate resilient urban planning and growth.

This article aims to identify and analyse urban key vulnerabilities to climate change impacts in the two secondary cities of Northeast Thailand – Khon Kaen City (KKc) and Mukdahan City (Mc) – and to create an understanding of ways of building climate resilient cities using Shared Learning Dialogues (SLD) as a major data collection tool and the Climate Resilience Framework (CRF) as analytical tool. The SLD represents an essential tool to break up structural barriers, including widely centralized and top-down paternalistic decision-making processes in Thailand that disregard local engagement and the political voice of communities (Kelly et al., 2012). The CRF offers a conceptual approach for assessing vulnerabilities and risks, identifying resilience strategies and initiating an inclusive learning process to formulate measures and actions that can tackle the uncertainties of climate change in an urban environment (Reed et al., 2013).

It was found that the two key urban vulnerabilities to climate change impacts are as following: In KKc, i) water use, supply and allocation, and ii) land use and urban planning; and in Mc, i) water quality and supply, and ii) land use planning. However,

local government actors in KKc rather focus on addressing problems of traffic congestion and air pollution through greening activities and the introduction of a light train system, instead of introducing a valid and climate sensitive land use regulation that could mitigate and prevent severe flooding. Similarly, Mukdahan targets the establishment of the Mukdahan Special Economic Zone (MSEZ) to promote its economic significant geographical position as a border city to Lao PDR but masks out that unplanned urban growth with new infrastructure that could block the natural floodway may exacerbate possible climate hazards. At the same time, despite growing concerns of severe drought and projected climate change induced water shortage by 2050 (McDonald et al., 2011), the need to guarantee sufficient water availability and accessibility - both quantity and quality – for urban consumption has gained less significance among local authorities in both cities.

KKc and Mc lack an efficient long-term strategy with clear considerations of the two key urban vulnerabilities to climate change and therefore require a comprehensive and inclusive approach of planning and governance that understands the critical issues of climate change and urbanization, and involves actors at all levels.

## 2. MATERIALS AND METHODS

This research was based on a mix of primary and secondary sources, drawing on following: i) Extensive literature research, including the reviewing of historical data on urbanization, as well as current development and climate change policies and plans; ii) preliminary meetings with in-depth interviews held in both cities with the provincial environmental offices and municipality offices as well as the provincial

industrial office in Mc to identify suitable SLD participants and to verify and collect further information; and iii) SLDs – one in each city - to enable public discussions which support learning and understanding of a range of different stakeholders from various sectors on the climate change - urbanization nexus in KKc and Mc.

The research results are based on an analysis of the collected data against the presented concept of urban climate resilience, with respect to the three core components of the applied framework and their characteristics for resilience: i) Systems (flexibility, substitutability and diversity, redundancy and modularity as well as safe fair); ii) agents (responsiveness, resourcefulness and capacity to learn); and iii) institutions (rights and entitlements as well as decision making). These key findings are further discussed by highlighting gaps and needs of the presented results.

## 2.1 Climate Resilience Framework

The research adopted the CRF to guide the analysis of urban key vulnerabilities to climate change impacts in the two study sites, KKc and Mc. The framework draws on resilience than adaptation to point to the interaction of i) urban systems (both ecosystems and infrastructure systems) which experience climate impacts linked to the effect on people, the actions of ii) social agents (both individuals and organizations) who can plan and address climate effects directly, and to the iii) institutional structures that can restrict and support actions of agents (Moench et al., 2011).

The definition and measurement of the notion “resilience” in an urban context varies in different disciplines. Resilience is not about robustness but about advancing and fulfilling aspirations of development (Friend & MacClune, 2012). The Resilience Alliance (2002 cited after Moench et al., 2011: 34)

defines resilience as ‘the ability to absorb disturbances, to be changed and then to re-organise and still have the same identity (retain the same basic structure and ways of functioning).’

Despite some disagreement there is clear consensus among scholars that cities must obtain a resilience approach to counter a wide range of shocks and stresses, interlinked with efforts towards more urban development and sustainability (Leichenko, 2011). Urban vulnerability is understood as the degree to which fragile systems and marginalized agents are ‘exposed to impacts from climate change and limited in their ability to adapt by constraining institutions’ (Moench et al., 2011: 36).

Academic literature (Friend et al., 2015; Pervin et al., 2013) suggests to mainstream climate resilience into city planning such as in land use planning and management but urban governance often lacks in transparency and technical capacity which disconnects planning and actual implementation of climate adaptation or resilience strategies. Hence, mutual learning processes such as SLDs could enable a stronger recognition of the direct linkage between urbanization and climate change that is required to tackle climate risks effectively. In this context, the CRF provided an ideal framework to identify and analyse key urban vulnerabilities to climate change related impacts, reflected in current practices and perceptions of relevant stakeholders. It further allowed to enable a comprehensive learning process to create resilient agents who are determinant to adapt to climate change induced conditions.

## 2.2 Shared Learning Dialogue

Typical constraints of certain localities such as “silo-thinking” that “locks-in” people of different sectors in their own perspective as well as short-term thinking that might

ignore essential considerations for the future were aimed to overcome using the SLD as a core data collection tool. The SLD was piloted and first tested by the Institute for Social and Environmental Transition (ISET) together with local partners in Southeast Asia to identify climate change risks, impacts and resilience, and to enable proactive local responses (Moench et al., 2011). Inspired by ISET's approach, this research applied the SLD in both cities.

A broad group of stakeholders with different background knowledge - scientific and/or local -, different interests and power were brought together, and enabled fruitful and transparent discussions with an inclusive problem-approach delivered. A range of participatory rural appraisal tools were employed such as hazard matrices and maps, problem or solution preference ranking and strength and weakness analysis.

Although several private sector and civil society groups had been invited to the dialogues, the majority of attending stakeholders came from governmental agencies. This may have reflected structural constraints that are still prevailing in largely centralized and paternalistic Thailand (Kelly et al., 2012) wherein civil society groups often experience less opportunities to raise their voice.

Notwithstanding that, the SLDs were able to provide a space for dialogue of government stakeholders from various offices who usually do not interact directly with each other with respect to issues around urbanization and climate change and give community groups an opportunity to engage into discussions. The SLDs created learning and co-production of knowledge and supported cross-sectoral network and partnership-building.

### 3. RESULTS AND DISCUSSION

#### 3.1 Results

The two key urban vulnerabilities to climate change impacts were found to be i) water use, supply and allocation, and ii) land use and urban planning in KKc, and i) water quality and supply, and ii) land use planning in Mc.

KKc's water use, supply and allocation system were found to have a good physical conditions to perform in the event of severe drought but the spare capacities of water resources have yet to be fully enabled in order to provide water in a fair and adequate manner to all citizens (Table 1). Local government actors, however, lack in capacities – financial and human - to be responsive enough to carry out proper water monitoring of efficient and just water supply and use (Table 2). Weak law enforcement of relevant policies point to a lack of transparency and participation of civil society in the decision making processes (Table 3). KKc's land use and urban planning system was found to be too inefficient to absorb severe flooding and requires a revision of the related land use plan regulation that considers the natural floodway and restricts the establishment of new infrastructure in flood plain areas (Table 1). Local government actors tend to understand the interlinkage of land and urban planning (Table 2) and flooding but have yet to fast-track necessary policy making processes (Table 3). Table 1 to 3 present the analysis of the resilience characteristics of the two identified key urban vulnerabilities to climate change impacts in KKc.

Mc's water quality and supply system has similar characteristics as in KKc given its abundant water resources but improper water

supply development (Table 4). This may hinder local government actors to be able to guarantee water availability – both quality and quantity – to its citizens in the event of extreme drought, particularly in view of the expected increasing water demand through the MSEZ. Priorities for an efficient water management have yet to be taken up and necessary financial resources mobilized (Table 6). The land use planning system in Mc is similar to Kkc lacking in the ability to absorb sudden shocks (Table 4) such as severe floods despite the afforestation initiatives by local government actors (Table 5). The missing consideration of effective land use planning for the MSEZ (Table 6) are indicators for the lack of awareness of implications of land use changes and establishment of new infrastructure – roads and buildings – in floodplain areas. The low confidence of civil society actors (Table 6) into the local government emphasize poor responsiveness of the latter (Table 5) to climate risks that can be exacerbated through inefficient land use planning. Table 4 to 6 present the analysis of the resilience characteristics of the two identified key

urban vulnerabilities to climate change impacts in Mc.

It was found that both cities have capacities to strengthen resilience to climate change impacts of the described key urban systems but have yet to enable relevant policy revision and planning processes. Local government actors still face significant structural constraints – financial and human – that hinder them of implementing necessary policies effectively. Civil society actors are also limited in their involvement in important decision-making processes despite having the right to participate. This is mostly due to the still widely centralized and paternalistic structured society system in Thailand.

### 3.2 Discussion

The country’s aim to turn both cities into economic hubs of the Northeast implies further urbanization driven by activities and plans that should attract more investors such as the cities’ connection to the national high-speed train (Siam Commercial Bank, 2015), the renovation of Kkc’s public transportation

**Table 1.** Kkc: System resilience characteristics analysis (Source: SLD Kkc)

<b>Characteristic</b>	<b>Flexibility, Substitutability &amp; Diversity</b>	<b>Redundancy &amp; Modularity</b>	<b>Safe Failure</b>
<b>Water use, supply and allocation</b>	Well-planned water detention basins but still low water storage capacities during dry season (dam and reservoirs).	Unjust regulated water supply (hotels and industry preferred over household and agriculture), in particular in dry season.	Water allocation lacks in proper monitoring in order to have balanced water allocation under conditions of climate stress.
<b>Land use and urban planning</b>	Natural floodplains in some areas not recognized in land use planning (e.g., Pralab).	Emergency response and disaster mitigation plan not sufficient in the event of flooding.	Further blockades of natural floodplains through inefficient infrastructure is likely to lead to severe flooding.

**Table 2.** KKc: Agent resilience characteristics analysis (Source: SLD KKc)

<b>Characteristic</b>	<b>Responsiveness</b>	<b>Resourcefulness</b>	<b>Capacity to Learn</b>
<b>Water use, supply and allocation</b>	The monitoring system for water use is not coherent as thresholds are often exceeded.	Local government actors have the capacity to identify problems around water use and supply. Mobilization of financial resources are difficult due to dependency on central government.	<ul style="list-style-type: none"> <li>- Local government actors: The experiences of droughts are recognized as essential for future planning and implementation activities.</li> <li>- Community actors: Awareness for efficient water use and value needs to be raised for local communities.</li> </ul>
<b>Land use and urban planning</b>	<ul style="list-style-type: none"> <li>- Local government organizes and responds slowly to disasters such as floods.</li> <li>- Monitoring of implementation of land use planning and zoning is ineffective.</li> </ul>	<ul style="list-style-type: none"> <li>- Local government actors understand issues around land use and urban planning but set no effective long-term measures.</li> <li>- Economic interests dominate relevant decision-making processes.</li> </ul>	Local government actors: The experiences of floods are recognized as essential for urban planning but revision of relevant plans have yet to be materialized.

**Table 3.** KKc: Institution resilience characteristics analysis (Source: SLD KKc)

<b>Institution Characteristic</b>	<b>Rights and Entitlements</b>	<b>Decision Making</b>
<b>Water use, supply and allocation</b>	Community groups have the right to access water supply at same amount as private sector groups (hotels, industry) but may not be practiced.	<ul style="list-style-type: none"> <li>- Weak law enforcement of water allocation due to lack of punishment mechanisms (e.g., fees) for inefficient water use and no formal or informal systems are in place to mediate water use related disputes.</li> </ul>
<b>Land use planning</b>	Community groups have the right to participate in decision-making of land use plans but may not be practiced.	<ul style="list-style-type: none"> <li>- Weak law enforcement leads to neglect of existing Town Planning Laws and Regulations.</li> </ul>

**Table 4.** Mc: System resilience characteristics analysis (Source: SLD Mc)

<b>System Characteristic</b>	<b>Flexibility, Substitutability &amp; Diversity</b>	<b>Redundancy &amp; Modularity</b>	<b>Safe Failure</b>
<b>Water quality and supply</b>	<ul style="list-style-type: none"> <li>- Abundant natural water resources (riverine wetlands, lakes and swamps) and artificial reservoirs.</li> <li>- Insufficient water supply for domestic consumption and agriculture during dry season due to improper water resource development.</li> <li>- One wastewater treatment plant established in Mc but whole city is not covered.</li> </ul>	<ul style="list-style-type: none"> <li>- Planned water treatment plant and enhanced water supply systems to regulate increased water demand and prevent further water contamination through establishment of MSEZ.</li> <li>- Water gate required in order to store the needed water supply.</li> <li>- Promotion of bio-friendly agriculture to minimize usage of chemicals planned in Mc.</li> </ul>	<p>Wastewater from livestock farms and agriculture (e.g., rubber plantation) and direct discharge of domestic wastewater from households affect small water streams and lead to fish stock reduction.</p>
<b>Land use planning</b>	<p>Deforestation due to degradation of forests, logging and land conversions for agricultural production.</p>	<p>Local government conducts afforestation projects in MSEZ public areas.</p>	<ul style="list-style-type: none"> <li>- Flood occurs due to residential building constructions that block natural waterways and poor drainage system.</li> <li>- Shallow natural waterways due to soil erosion along riverbanks resulting from estate development.</li> </ul>

**Table 5.** Mc: Agent resilience characteristics analysis (Source: SLD Mc)

<b>Agent Characteristic</b>	<b>Responsiveness</b>	<b>Resourcefulness</b>	<b>Capacity to Learn</b>
<b>Water quality and supply</b>	Local government and civil society groups conduct water quality monitoring activities of natural water and tap water as a baseline for the MSEZ.	The mobilization of financial resources have been initiated by local government agencies for the establishment of a check dam but more resources have yet to be mobilized to establish the required water gate.	Local government actors: Water quality monitoring initiatives and measures for higher water supply during dry season are included in planning.
<b>Land use planning</b>	Local government actors have initiated tree planting campaigns to raise public awareness for natural conservation, and collect database of community forests.	Access to information on new technologies for more sustainable and environmental friendly agricultural practices are limited for civil society actors such as farmers.	Local government actors: The implications of land use changes are less recognized in land use planning policies.

**Table 6.** Mc: Institution resilience characteristics analysis (Source: SLD Mc)

<b>Institution Characteristic</b>	<b>Rights and Entitlements</b>	<b>Decision Making</b>
<b>Water quality and supply</b>	Civil society actors have the right to access information regarding water quality and monitoring initiatives but may not be practicable.	<ul style="list-style-type: none"> <li>- The local government prioritizes the improvement of the transportation system instead of the water resources.</li> <li>- Formal or informal monitoring systems for water supply regulations have yet to be set up.</li> </ul>
<b>Land use planning</b>	Community groups have the right to participate in decision-making of land use plans but may not be practicable.	<ul style="list-style-type: none"> <li>- Ineffective enforcement of land use plan.</li> <li>- Civil society actors have low confidence in local government’s ability to manage natural resources.</li> </ul>

system with the introduction of a light rail transit system (Khon Kaen City Development, 2016), and the establishment of the targeted MSEZ (Board of Investment, 2015). At the same time, KKc and Mc are

highly vulnerable to the impacts of climate variability (Climate Data, 2016; Northeastern Meteorological Center, n.d.) such as floods (Promphakping et al., 2015) and droughts with implications of severe water shortage



(InterRisk Asia Thailand, 2016). These natural hazards can lead to widespread damage of infrastructure, livelihoods and settlements, crop failure, health issues, diseases, and exacerbated poverty and inequalities (Hijioka et al., 2014). Climate change related impacts have hereby a distinct interconnection with urban processes as they largely influence the extent of the implications of natural hazards.

### 3.3 Khon Kaen City

Governments often apply standard approaches to plan for climate adaptation by adjusting policies, practices and plans in order to avoid negative impacts of climate change (Tyler & Moench, 2012). In KKc, the Provincial Climate Change Master Plan (2016-2020) is widely reduced to short-term oriented mitigation initiatives, including greening activities such as tree planting and recycling in public spaces. Although the plan provides a clear focus on adaptation, mitigation and even resilience, the major strategies of the plan are in the first place targeting greenhouse gas reduction (Khon Kaen Provincial Climate Change Master Plan, n.d.) and not directly tackling the most critical climate risks of urban flood and drought as well as urban key vulnerabilities as identified in this research.

This might be related to the general perception of flooding in Thailand as a seasonal problem and natural phenomenon (Friend et al., 2016) than an issue that requires a long-term approach. However, in order to build urban resilience, KKc has to move away from applying short-term “predict and prevent” approaches (Tyler & Moench, 2012) towards targeting weak institutions and their implementation that are relevant for long-term climate change resilience. Future climate conditions will be variable, dynamic, uncertain and therefore difficult to predict (Tyler & Moench, 2012).

If these kind of approaches are adopted, KKc may be incapable of coping with surprise events and not able to address indirect effects of systemic weakness or institutional constraints.

KKc’s land use regulation had been suspended since 2006, allowing investors to develop flood prone areas such as Pralab municipality (Promphakping, 2015); a new land use plan had been drafted and submitted in 2015 (Promphakping, 2015) but may take another several years until its approval. The 2011 flood in KKc’s Pralab is a profound example of the urbanization-climate change dimension and weak urban management of vulnerable urban systems. Urban development with improperly built roads and new residence real estate projects have widely shaped Pralab’s vulnerability to climate change related impacts. The new land use plan needs to be climate sensitive, i.e. it has to consider the natural floodway and risk of building in flood-prone low-land. Local authorities were found to be aware of ensuing implications in the event of heavy rainfall but emphasized that their decision-making power is limited by institutional and financial restrictions. More transparency of and access to information for the civil society on possible consequences of land use changes have to be enabled and their participation guaranteed in order to strengthen the their capacities to influence more proactive policy actions towards urban climate resilience.

A study on urban growth, climate change and freshwater availability (McDonald et al., 2011) reported that in 2000 already 150 million people lived in cities with perennial water shortage and forecasts but in 2050 993 million people will live in cities with significant water scarcity. In the light of this, KKc will not only have to guarantee water availability but also a just allocation wherein agriculture and domestic households receive higher priority than

private sector entities. A proper monitoring of water allocation and water use under conditions of climate stress is required to absorb sudden shocks and to prevent possible cascading failures of the urban water system.

The impact of water scarcity on urban water supply may currently be even less clear-cut for residents and policy-makers as immediate impacts are less recognizable in the urban areas. However, in view of further urbanization and growing water scarcity in KKc, the city's water demand may increase, posing a challenge to local authorities to provide water adequately and justly. Weak governance and centralized decision-making structures could still set limitations to necessary policy planning and implementation. The proposed water resource management act (Department of Water Resources, 2015) may be a first step towards resolving the stated issues as it would draw on water tariffs and water rights (Franzetti, 2015).

### 3.4 Mukdahan City

Mukdahan's Provincial Natural Resources and Environmental Management Plan (2016-2021) focuses on tackling deforestation, degradation of freshwater ecosystem, insufficient water supply for domestic consumption and agriculture respectively (Office of Natural Resources and Environment Mukdahan, 2016) but activities have yet to include the emerging challenges that will come with the establishment of the 578.5 square kilometres MSEZ (Mukdahan Department of Public Works and Town Planning, 2016). Implications of land use changes affiliated with potential blockades of natural floodplains due to MSEZ's location along the Mekong River and enabling of sufficient and clean water supply have also gained only little significance at the policy agenda.

Stakeholders from both government and civil society claimed that due to the neglect of relevant land-use and zoning plans as well as improper estate development, infrastructure is already blocking natural waterways and cause soil erosion along riverbanks. The proposed land use plan for the MSEZ, however, locates areas for infrastructure construction— both buildings and roads - in floodplains (Mukdahan Department of Public Works and Town Planning, 2016) which may intensify flooding. In order to prevent severe flood damage, planners would need to set adequate measures and carry out an adequate risk assessment before new infrastructure is developed but these are usually poorly implemented or even absent in Thailand (Tingsanchali & Karim, 2010). A land use plan that considers flood risks is essential as well as information on flood-protection has to be available for projected investors, developers and communities. Fluctuation in rainfall patterns are likely to affect the ability of Mc to meet a growing demand of water, particularly in view of the planned MSEZ. The proposed water resource management act (Department of Water Resources, 2015) may also be an essential institutional milestone for Mc to fast-forward efficient water resource management that allows better drought management with a decentralized approach to increase water supply and strengthening water rights. Natural hazards such as floods and droughts may trigger serious impacts on both water quantity and quality (Franzetti et al., 2017). Degraded surface water that emerges as a result of contamination with toxic substances, direct discharge of domestic wastewater from communities and livestock farms and agriculture may also present possible health threats to residents, especially in the event of severe flooding.

#### 4. Conclusions

The pathway towards urban climate resilience in KKc and Mc still lacks essential understanding of how unplanned urban growth without a long-term approach that considers climate sensitive land use and urban planning and sufficient and adequate water availability and accessibility currently exacerbates and will further influence climate change-related impacts such as flood and drought in future. Both cities require a comprehensive and inclusive approach of planning and governance with resilient agents, including communities, private and public sector, who understand the critical issues of climate change and urbanization and are enabled to participate in decision-making processes.

KKc's current greening practices and introduction of smart transportation systems are an essential step to tackle greenhouse gas emissions. However, city authorities need to draw stronger focus on defining resilience strategies to address the most critical natural hazards impacting KKc such as floods and drought. The impacts of the 2011 flood particularly emphasized the need for a new climate sensitive land use plan for KKc. Mc's distinctive location along the Mekong River and as a border city to Lao PDR's Savannakhet gives Mc an important economic position but also poses a high flood risk as parts of the propose MSEZ are planned to be established in floodplain areas.

A revision of the respective land use plan will be necessary to avoid possible flood damage as well as sufficient urban planning to avoid blockades of the natural waterway.

In view of growing urbanization, industrialization and changing patterns and intensity of rainfall, the urban water demand is expected to increase in KKc as well as Mc, and, thus, a just and adequate water supply and allocation system is required. The proposed Water Resource Management Act

for Thailand could hereby be crucial to improve the water management. Financial and institutional constraints, however, still hinder local governments in KKc and Mc to take up proactive and immediate actions to tackle the most critical climate hazards due to prevailing hierarchical structures in Thailand. These structures also put limitations to the participation of the civil society in important decision-making processes that may affect their livelihoods. The SLD as a data collection tool that brings stakeholders from all levels together to learn and discuss critical issues has proven to be an effective tool to break up these barriers.

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