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Community Adoption of Ecotechnology: A participatory study of rainwater harvesting initiatives in Mexico City

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Executive Summary

With rapid urbanization and an ongoing climate crisis, water insecurity is becoming an increasingly global concern – one which disproportionately impacts vulnerable and underserved communities. Like other megacities, Mexico City is confronted by this challenge particularly in unplanned peri-urban settlements, where reliable centralized municipal water services are often lacking. It is vital to improve water access and sanitation in these underserved areas, as the lack of reliably clean water can lead to higher risks of waterborne diseases, including cholera and hepatitis A.

A transdisciplinary approach that engages multiple stakeholders and integrates scientific innovations, hydrological data, government policies, local community adaptation and behavioural change remains necessary to tackle water insecurity. On this front, multiple mitigation strategies have emerged to improve water management and access to safe drinking water. However, further research is necessary to address concerns around safe management and long-term sustainability of these strategies.

In this CRI, we report on a study that promotes evidence-based policy recommendations on rainwater harvesting in Mexico City. As a decentralized tool for collecting and storing rainwater, this strategy presents a public policy option to address growing water security challenges in megacities in the Global South. Covering the opportunities and barriers to responsible and sustainable adoption of this decentralized technology, this report addresses gaps in guidance policies and public awareness on water management, quality, and safety and it highlights the importance of evidence-based solutions that consider community engagement, municipal regulations, and technical support.

Credits: Isla Urbana

ISSUE AT A GLANCE

Mexico City

As the largest metropolitan area in North America and the largest megacity in the world (with a population of over 22 million), Mexico City continues to face enormous water security challenges that are exacerbated by hydrological disequilibrium, infrastructural deterioration, service provision deficiency, and institutional inefficiency.

The city's water supply relies on ground water and imports from external sources.[1] However, this pattern is highly unsustainable with sources estimating that by 2030 the urban water use will overdraft the groundwater, leading to an increased level of water pollution and damage to water pipelines and the drainage system.[2] External water sources are also threatened by drought events that may become more frequent due to climate change.

Although access to piped water is almost universal in the city, qualitative deficits remain high in terms of service frequency and water quality. Vulnerabilities relating to water shortage remain uneven, with low-income and socially-marginalized communities experiencing high levels of water insecurity, while subsidization schemes continue to disproportionately benefit higher-income households.

Low-income households with no access to piped water resort to public or private water truck delivery, which is not only time-consuming and laborious, but also often imposes an enormous financial burden on these households.

As such, decentralized solutions present a promising approach to improving water access and resilience in these communities with inadequate infrastructure; mitigating groundwater overdraft; and reducing the costs associated with private water trucking.

1. Between 2005 and 2017 58% of the water supply in Mexico City came from local aquifers, and 42% was imported from adjacent basins. (Sistema de Agua de la Ciudad de México, 2018, p.51)

2. Sistema de Agua de la Ciudad de México, 2018, p.56, 58

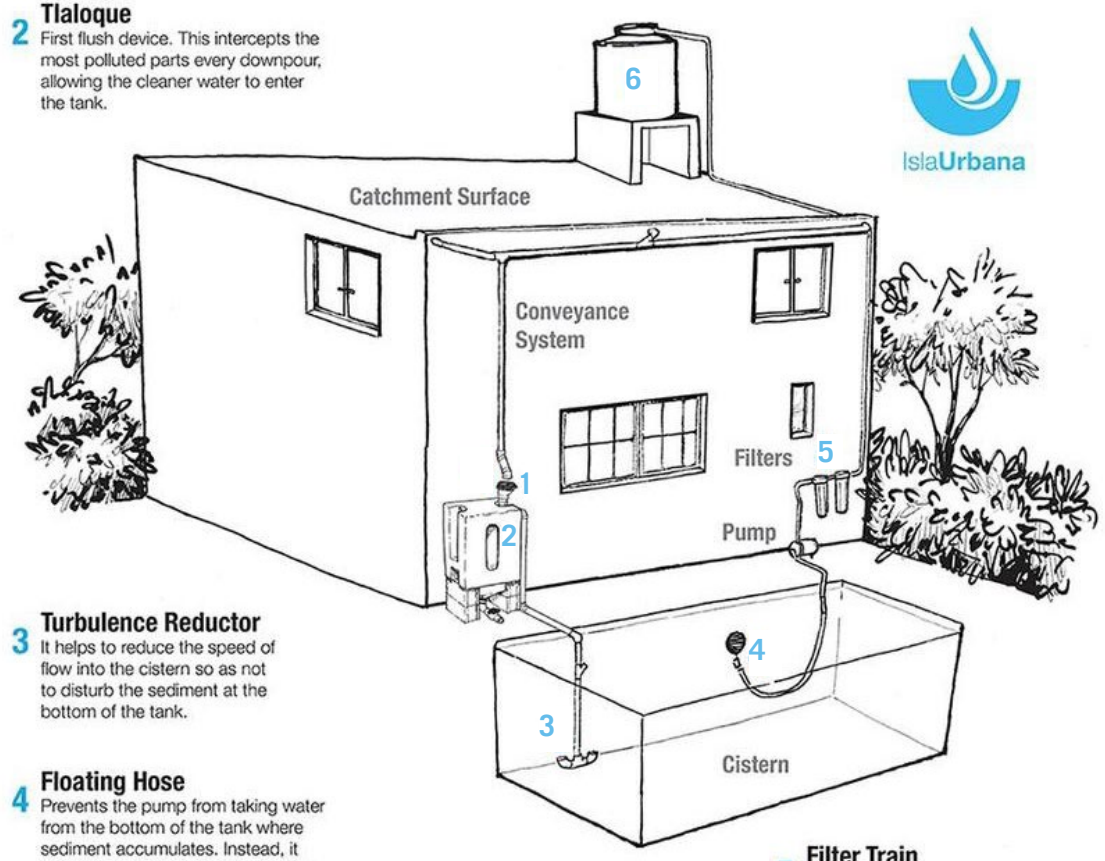
Project Team:

- **Yu Chen, Centre for Global Engineering (CGEN)**
- **Amy Bilton, Dept. of Mechanical and Industrial Engineering**
- **Ronald Hofmann, Dept. of Civil and Mineral Engineering**
- **Karlye Wong, Dept. of Civil and Mineral Engineering**

This City Research Insight (CRI) features the work of four University of Toronto researchers - Dr. Yu Chen, Associate Professor Amy Bilton, Professor Ronald Hofmann, and PhD Candidate Karlye Wong - who have been collaborating on the project "Community Adoption of Ecotechnology and Grassroots Approach to Climate Change Adaptation: A Participatory Study of Rainwater Harvesting in Mexico City" with support from a School of Cities Urban Challenge Grant 2.0.

Rainwater harvesting systems

Harvesting and storing rainwater has enabled communities and households to be self-reliant, economical, and have local control of their water resources. As a decentralized mechanism, a rainwater harvesting system allows households to collect, store, and use rainwater as part of their daily household activities. The system is usually comprised of **four main components**:



Credits: Nolan, N. P., & Lartigue, C. (2017). Evaluation of the performance of rainwater harvesting systems for domestic use in Tlalpan, Mexico City. Civil Engineering Journal, 3(3), 137-151

Rainwater harvesting system diagram

1. ***Rooftop catchment surface*** **where rainwater is captured**

2. ***First flush diverter*** **where rainwater is filtered from debris and intial contamination**

3. ***Primary storage cistern*** **where rainwater is collected, stored, and disinfected using chlorine dispensers**

4. ***Further sediment filters*** **that rainwater is pumped through for household use**

Methodology

An Urban Challenge Grant (2.0) from the University of Toronto's School of Cities supported the initiation of this collaborative project between the Centre for Global Engineering and Isla Urbana in January 2022. As a local social enterprise, Isla Urbana specializes in the development and promotion of rainwater harvesting technologies while also focusing on the operational socialization of technology, including technical support, follow-up visits, community meetings and education workshops. Since its founding in 2009, Isla Urbana has installed 34,000 rainwater harvesting systems across Mexico.

The project focuses on six key aspects of rainwater harvesting:

1) Enhancing user adoption and long-term use of rainwater harvesting technology
2) Exploring advanced treatment methods, especially through UV-LED
3) Assessing the contribution of rainwater harvesting to reduction in carbon emissions
4) Improving community capabilities in water quality testing
5) Developing community-led water management strategies
6) Promoting a bilateral exchange of knowledge on rainwater harvesting, with a focus on Indigenous communities in Mexico and Canada

School Rainwater harvesting system. Isla Urbana.

The One Water team constructing a rainwater harvesting system for a local restaurant in Oaxaca, September 2023.Isla Urbana.

The research is structured as an interdisciplinary effort, combining laboratory-based work (such as sensor development) with extensive fieldwork, leveraging Isla Urbana's expertise. The field component includes on-site observations, household surveys to understand water-related challenges, household water quality testing, and in-depth interviews with Isla Urbana staff. Additionally, insights from Isla Urbana's existing baseline data and follow-up user surveys have been incorporated to provide a comprehensive understanding of the impacts and effectiveness of rainwater harvesting systems.

Key Findings

1 Rainwater harvesting holds significant potential and effectiveness in alleviating water stress, addressing infrastructural deficiencies, and bolstering the water resilience of urban environments

- These systems play a pivotal role in augmenting community engagement and fostering local stewardship of water resources.

- As a low-impact infrastructure solution, these systems hold promise for reducing carbon emissions by diminishing reliance on energy-intensive water distribution methods, such as water truck deliveries.

2 Long-term uptake and correct operation and maintenance are key to effective rainwater harvesting initiatives

- Social enterprises such as Isla Urbana play a key role in fostering user adoption and sustained engagement with rainwater harvesting technology by providing comprehensive user training, community engagement, and post-installation technical support.

3 Mismanagement of rainwater harvesting systems and the captured rainwater pose a major challenge to rainwater harvesting initiatives

- Operations and maintenance of installed systems: harmful contaminants can be introduced into harvested rainwater if installed systems are inadequately designed and maintained. The deterioration of water quality can also be related to the environmental conditions, including water storage in rooftop tanks exposed to direct sunlight and the presence of domestic animals and livestock in the household.

- Disinfection practices: Chlorination is the conventional method for disinfecting captured rainwater, which typically requires maintaining a specific concentration of free chlorine residual at the point-of-use. An aversion to the altered taste and odor that chlorination imparts to the water, as well as accurately determining the necessary dosage and storage of chlorine, are amongst the encountered challenges.

Key Findings

4 Perception and attitudes towards rainwater are a major influence in households' willingness to use rainwater harvesting systems

- There is confusion among users around rainwater quality attributed to regulatory gaps in practical and enforceable guidelines. For example, there is confusion around differentiating the potable and non-potable uses of rainwater.
- Misconceptions about water quality might lead to underutilization of available water sources or pose significant health risks.
- There is a significant gap in water quality monitoring, as users, community water committees, and NGOs involved in rainwater harvesting lack the resources and capacity to test the quality of captured rainwater.

5 User feedback remains important in strengthening community engagement and informing iterative improvements in the organization's design and implementation strategies

- Social enterprises, such as Isla Urbana, play key roles in systematic collection of user feedback, playing a pivotal role in bridging government agencies and users in local communities.
- Traditional survey-based methods for follow-up and feedback collection encounter several challenges, including survey biases and logistical difficulties in executing widespread surveys.
- Innovative technological approaches (e.g. embedded sensors) can be integrated with direct household visits to improve user feedback.

Policy Recommendations & Implications

Initiatives of rainwater harvesting should be implemented with a holistic approach that incorporates partnerships among multiple stakeholders. Below are suggested policy guidelines and recommendations:

1. Develop *clear and accessible technical guidelines* addressing the design and installation of harvesting systems and water disinfection practices.

2. Resource allocation in implementing rainwater harvesting initiatives:

- Allocate adequate resources for rigorous installation follow-up, technical support and training, and water quality monitoring.
- Increase allocated funds toward effective communication strategies around standard operating procedures for appropriate chlorination and alternative disinfection methods.

3. Promote safe water management practices:

- Support and empower households and community organizations through the deployment of targeted public campaigns to raise awareness and improve understanding around water quality, potential risks, appropriate potable and non-potable use, and safe water storage.
- Clarify the confusion and mistrust surrounding decentralized water

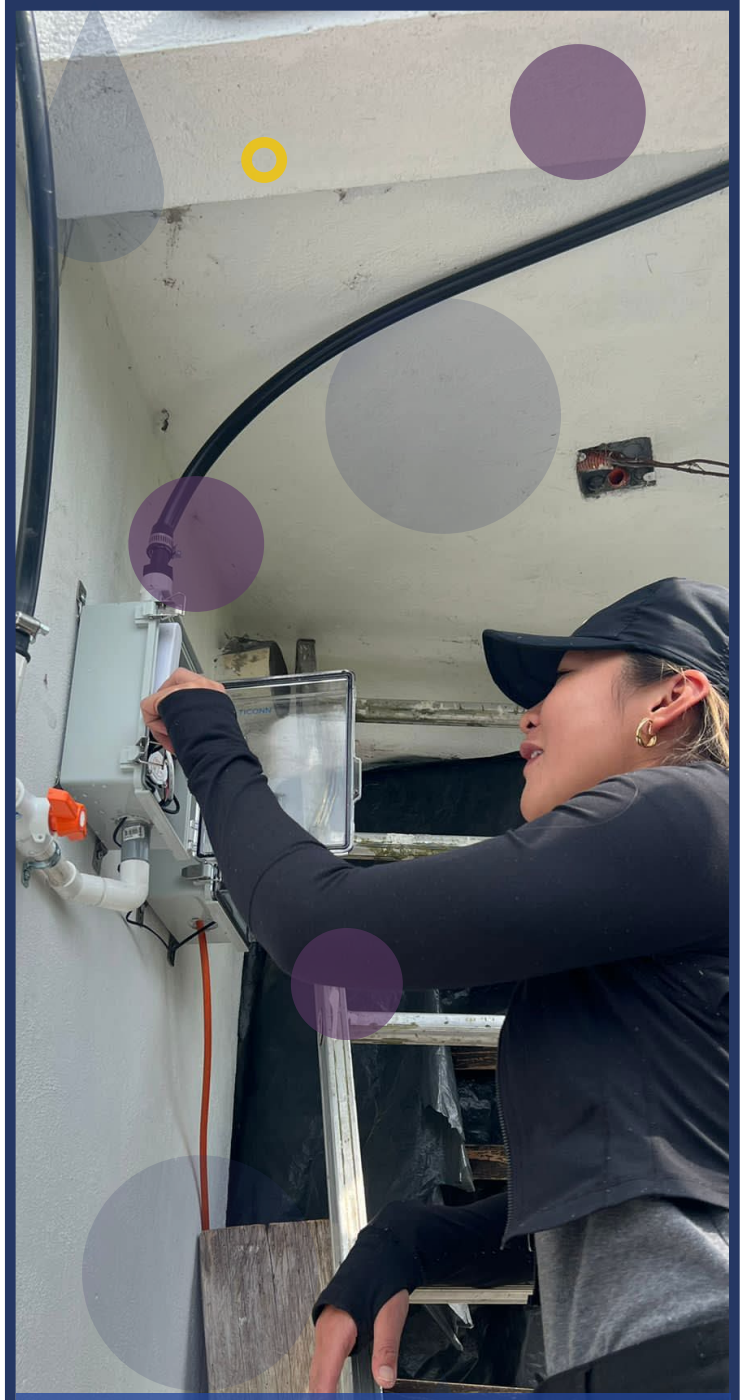
Eren Rudy, an MIE MSc student, installs sensors to monitor critical parameters of rainwater harvesting systems. Mexico City, August 2023.

4. Invest in climate-resilient and innovate approaches for rainwater harvesting that can scale up and adapt to future challenges.

- Develop low-cost research tools to address the gap between scaling up decentralized solutions and the capacity to carry out effective follow-ups, including the integration of survey-based approaches with embedded sensors to better understand adoption on a household level and provide technical support.
- Develop cost-effective, portable, and user-friendly tools designed for community groups, non-profit organizations, and households, facilitating regular and accessible water quality testing at the point of use.
- Develop technologies that improve safe rainwater management and quality (e.g., UV-LED technology).

5. Take an inclusive, community-based approach in the implementation of rainwater harvesting initiatives.

- Prioritizing an inclusive, community-based approach that involves a diverse range of stakeholders.
- Engage households, local organizations, schools, water management committees, and community leaders.
- Address gender dynamics and introduce gender-sensitive policies in promoting safe rainwater management practices.



Collaboration between CIV PhD candidate Karlye Wong and the Isla Urbana field team in setting up a UV-LED device for disinfecting captured rainwater. Mexico, August 2023.

What's Next?

The research team is continuing to develop insights to better understand the challenges and long-term uptake of rainwater harvesting systems. Currently, ongoing fieldwork activities in Mexico City are focused on developing simplified water quality assessment protocols, evaluating the performance and long-term effectiveness of ultraviolet technologies (UV-LED systems), as well as developing a better understanding of community-based water management.

Moreover, the research team is currently facilitating knowledge exchange between Indigenous communities in Mexico and Canada, an initiative spearheaded by the Nipissing First Nation in Ontario and Isla Urbana. The project "One Water: An Indigenous-led Process to Increase Water Resilience for First Nations in Ontario through Rainwater Harvesting" is funded by the EJ4 Grant of the Commission of Environmental Cooperation (CEC). As an academic partner, the CGEN team will provide support for the design and implementation of a rainwater harvesting system tailored to the local context. On-site visits, interviews, and feasibility studies will be conducted over the next two years, aiming to develop a knowledge hub around Indigenous water initiatives.

Group photograph featuring members of the One Water Project Team in Oaxaca, September 2023. Isla Urbana.

Acknowledgements

So far, our research has engaged eighteen researchers from the University of Toronto, encompassing professors, postdocs, and graduate and undergraduate students.We extend special thanks to Professor Gisele Azimi, Dr. Nitish Sarker, Eren Rudy, Mistelle Haughton, Adriana Lozano, Jina Yazdanpanah, Gehna Karani, Yao Sheng Chai, Daniyal Adeel, Nadia Candler, Natalie Enriquez-Birch, Anastasia Hall, Jia Min Koh, and Kyra Nankivell for their invaluable dedication, expertise, and contributions to the research projects.

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Reference: Group photographs featuring members of the One Water Project Team in Oaxaca, September 2023. Isla Urbana.

Interview with Yu Chen (University of Toronto) & Enrique Lomnitz (Isla Urbana)

What are the major impacts this collaborative project has had to date?

Yu Chen: We started this collaboration two years ago and we built a gradual understanding of each other's capacities and how we can complement each other's work. But also, there is a general sense of solidarity and friendship that is organic. A project like this needs to be a transdisciplinary initiative that involves not only academics from different disciplines, but also practitioners and local communities. Academic institutions have the technology and the knowledge expertise, but that does not necessarily translate into social impact that meets the needs of local communities.

This collaboration has resulted in six joint community-based studies with Isla Urbana, focusing on key aspects of rainwater harvesting and community water initiatives such as water disinfection, water quality testing, user interaction with the system, among others. While most of these studies are ongoing, we have observed a significant interest in the findings when presented at conferences and workshops. We continue to learn a great deal from Isla Urbana. So far, the project has involved 2 professors, 2 labs, 4 graduate students and 9 undergraduate students in different capacities. For us it is a great educational opportunity for our students to have first-hand experience on eco-technologies and community-based research.

Another great learning from Isla Urbana is the capacity for research communication. Key personnel in Isla Urbana include many professional engineers. In the field, they are able to communicate terminologies and professional knowledge to the community members and learn from the community about how to work together on these water initiatives. This is a great example for our engineering students.

Enrique Lomnitz: As a non-academic, I think these partnerships are important because academics bring specific expertise to the table. Trying to understand what is going on when you install 10,000 rainwater harvesting systems requires an entire skillset that we don't necessarily possess. There is always an opportunity in these collaborations to explore important aspects of the work that our own lack of expertise and/or resources doesn't allow us to get into. Right now, for example, we are looking at long-term evaluation of rainwater harvesting systems. I think this can be enormously valuable and this only happened because we have been collaborating for a while, allowing us to build an understanding of each other's work and the trajectory of collaboration. So, these collaborations have increasing value over time.

Enrique Lomnitz is an industrial designer and the co-founder of Isla Urbana

Yu Chen is a postdoctoral research associate with CGEN's Sustainable Peri-Urbanization (SPUr) Initiative

What contributions does this collaborative project bring to the broader field of water justice and water security?

Enrique Lomnitz: There is a whole kind of ecosystem of things that need to be happening for a paradigm shift to occur. The interplay between propositional ideas, technologies, economies, conversations, discourses, and public policy, etc. That can't be only pushed by implementation-oriented organizations like Isla Urbana. You need buy-in from the different sectors collectively for this paradigm shift to happen.

Yu Chen: For CGEN, a key research area is sustainable water and sanitation. Specially, in the face of climate change, it is important to think about these paradigm shifts towards integrating decentralized infrastructure with centralized conventional infrastructure and to think of it as a flexible, more affordable, low impact, environmentally friendly approach to provide essential services. This will give prominence to community autonomy and to local governance. But to echo Enrique's comment, it has to involve different disciplines and sectors to be able to translate all the theories, conceptual frameworks and findings into actual social impact.

When it comes to rainwater harvesting, what are the challenges for policymakers to make tangible changes in the lives of equity-deserving groups?

Enrique Lomnitz: One of them is access to information that they can trust, upon which they can make decisions. You can make all kinds of claims about rainwater harvesting and those claims could be totally unrealistic in the absence of good data. I think there is an absence of good data and predictive data. If they want to build more sound public policy towards rainwater harvesting, politicians need information and that doesn't currently exist for them. We should be figuring if installed systems are used in the long-term by people, how they are used, and if they are being changed, if they are being expanded or whether people are using the water for different uses over time.

Yu Chen: Another challenge is that promoting decentralized systems requires a different paradigm of water governance. It is not just installing the systems and the government's role is done. There should be more investment in ongoing support training to make sure the systems can function in the long term.

Can you speak more about your ongoing work with indigenous communities in Canada? What is the transferability of the lessons learned to different contexts?

Enrique Lomnitz: This is part of the broader ongoing collaboration that involves the Nipissing First Nation in Canada and three indigenous communities in Mexico. The work has been about knowledge sharing around rainwater harvesting, but also autonomous and local water management more generally. Five representatives from the Nipissing First Nations came to Mexico and we did this tour of different places, organizations, communities and projects. It would be great to ask them what they feel they've integrated from this experience. I'm sure, yes more knowledge about rainwater harvesting, but I think a lot of it is more ideas about community organizations and the interplay between water management and culture. This kind of collaboration will help reveal where there is transferable or mutually fortifying or inspiring technologies or ideas.

Yu Chen: As academic partner in this knowledge mobilization effort, this year CGEN facilitates a capstone team working on this project with the Nipissing First Nation in Ontario. The capstone team is currently working with the Nipissing community and other project partners on designing and potentially installing rainwater harvesting system. I think Isla Urbana did enormous work in creating space for knowledge mobilization for indigenous communities. Isla Urbana has done a fantastic job facilitating this Nation-to-Nation dialogue around water security, water challenges and histories. For example, in our last trip to Mexico, all the participating indigenous communities shared their water stories, their relationship with water, the challenges they face, the initiatives they have taken in the past and their experience with rainwater harvesting. This I think is more important than installing a few systems. It is about seeing and developing a sense of connection to water and to the land.

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The School of Cities is playing a critical role in addressing climate change and justice, migration and belonging, inequality and democracy, and the world's collective ability to address urgent urban challenges.

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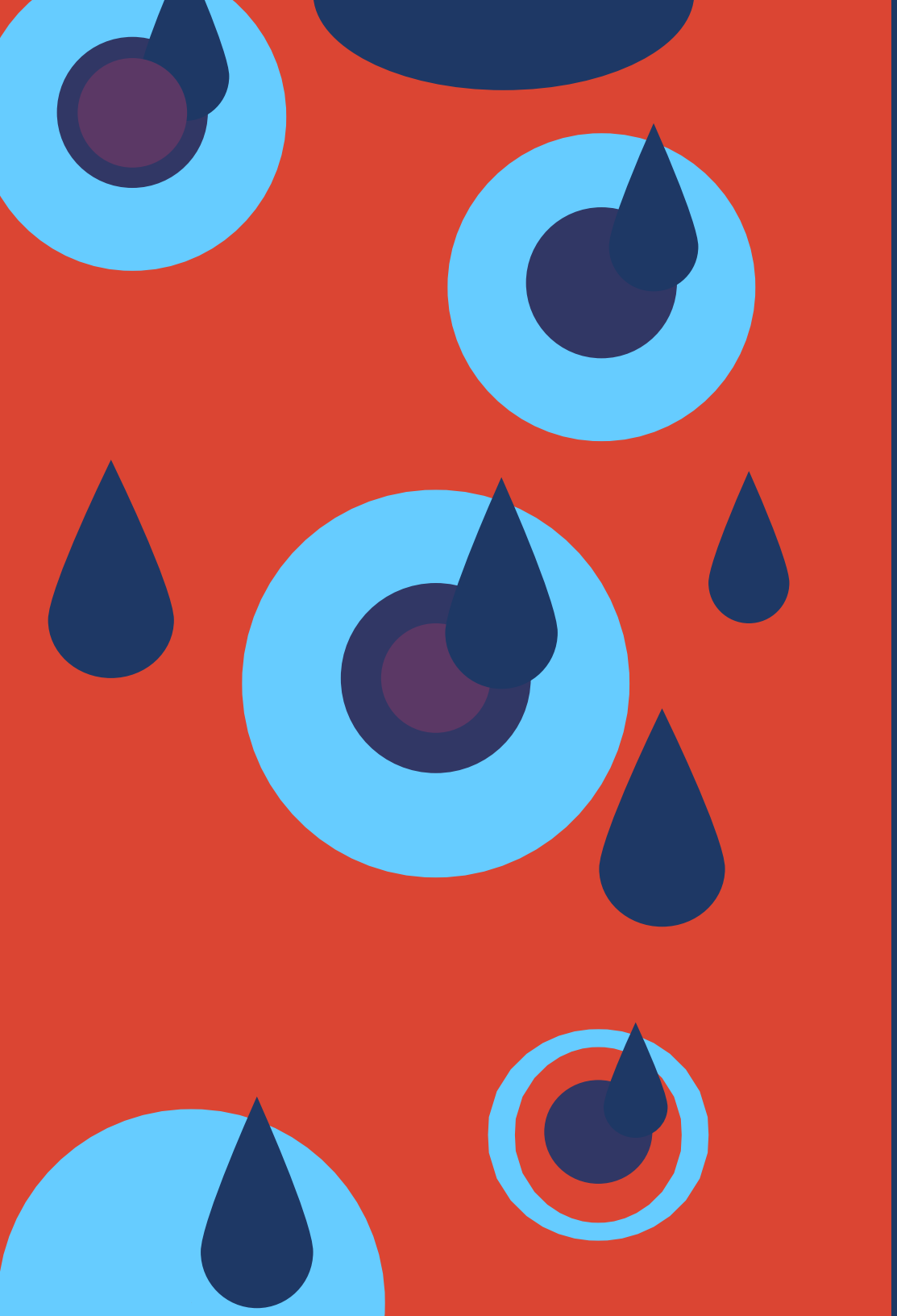

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