IHPH Institute for Hygiene and Public Health
WHO Collaborating Centre for Health Promoting
Water Management and Risk Communication
University of Bonn

Newsletter
No. 31
January 2021

WATER & RISK

Dear reader,

I guess all of you would agree that the year 2020 has been very challenging and we started the new year hoping for a change for the better.
While the COVID-19 pandemic continues to be the dominating topic in the news, different health and environmental risks shouldn´t be forgotten. The year 2020 has been the second warmest year ever recorded and we are observing increasing disruptions from droughts, heatwaves, floods and other extreme events globally. Extreme events are impacting human health and we can no longer "prevent dangerous anthropogenic interference with the climate system" as agreed already back in the 1994 Rio Convention.
Even in these difficult times, we can take action and research can help to raise awareness for health risks, identify vulnerable groups, develop coping mechanisms and sustainable solutions and disseminate information. In this newsletter edition our authors will shed some light on current research on heat and drinking behaviour of the elderly, floods and risk communication, and rain water harvesting as part of water resource management. We hope you enjoy reading it and look forward to hear from you.

Stay motivated and safe!

Dr. Andrea Rechenburg
WHO CC for Health Promoting
Water Management &
Risk Communication
Bonn, Germany
andrea.rechenburg@ukbonn.de

Heat-Health Action – Illustrating the link between heatwaves and drinking behaviour of older adults

Heatwaves are a well-known threat to public health and lead to an increase of morbidity and mortality especially in older age groups of the population. For the last decades, excess mortality has been well documented, e.g. during the extremely hot European summer of 2003 which led to about 75,000 deaths, most of them in France (Kovats & Kristie, 2006). In Germany, there is no real-time monitoring of mortality to date, but regional systems in the federal states of Berlin and Hesse showed an increase of excess mortality in the summer of 2018. In accordance with previous research, heat related mortality in 2018 was highest in the group of adults with an age of 84 years and older (Robert Koch-Institut, 2019). To link public health institutions with meteorological forecasts of health-threatening weather, heat health warning systems (HHWS) were installed in many European countries (Casanueva et al., 2019). The German system provided by the German Weather Service (Deutscher Wetter Dienst, DWD) offers information for the population as well as public health authorities. According to WHO, HHWS is one component of a Heat Health Action Plan (HHAP) (World Health Organization, 2008). Further components are: the identification of vulnerable population groups, communication and information strategies, and the installation of long-term mitigation strategies (Casanueva et al., 2019). Whereas a nation-wide HHAP is well established in France, in Germany there are regional and local flagship initiatives, for instance, the project Heat Health Action Plan for Elderly People in Cologne, emerging on the basis of policy recommendations of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Mücke & Straff, 2017).

Drinking water is the most important adaptive strategy during episodes of heat and dehydration is one of the main causes for heat-related morbidity and mortality (Fouillet et al., 2006). Thus, this article wants to point out the preliminary results of the local project which shows the deficit of fluid intake and low tap water consumption during heatwaves among the vulnerable population group represented by older adults. The article outlines the relevance due to the increased occurrence of heatwaves and its consequences due to climate change; it introduces the vulnerable population group considered in the study; and it presents the preliminary results of the project. In conclusion, guidance to increase tap water consumption for the daily fluid intake among older people is suggested.

The increase of heatwaves due to climate change and the most affected population

Climate change has led to an increase of heatwaves in terms of frequency, duration and intensity (Patz et al., 2005; Watts et al., 2020). Heatwaves are "understood to be periods of unusually hot and dry or hot and humid weather that have a subtle onset and cessation, a duration of at least two to three days and a discernible impact on human activities" and they are assessed as a major burden to human health (McGregor et al., 2015). Even in colder western and northern European countries, heat waves have already led to excess morbidity and mortality (Scherer et al., 2013). Research shows that the population in these regions could be even more vulnerable than the well-adapted population of warmer countries (Pirard et al., 2005; Whitman et al., 1997).

The most vulnerable groups to suffer from severe health effects during heatwaves are older adults, pregnant women, children, people with a chronic condition or people with mobility and cognitive constraints, outdoor workers and deprived people (Balbus & Malina, 2009). Individuals 65 years of age or older are more sensitive to heat than the younger population as the thermoregulation through sweating and thirst sensation are decreased. These and other age-related changes are illustrated in figure 1. As Kenney and Munce (2003) pointed out, it isn't ageing per se which increases mortality in older men and women but also the effects of chronic diseases and a sedentary lifestyle.

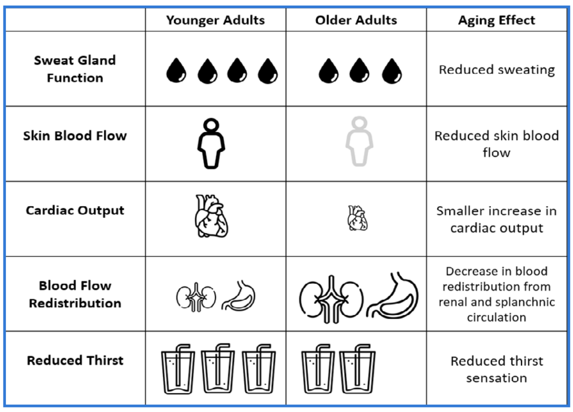


Figure 1: Age-related changes in thermo-regulation and thirst sensation (adapted from Kenney & Munce, 2003)

A case-control study (with 20 cases and 60 control persons) after the heatwave of 2003 in Bari, Italy, showed several demographic and health-related risk factors for deaths during heatwaves such as: living alone, fragility, recent hospitalization, limitations in social or daily activities. Observed protecting factors were: high water consumption, drinking water with ice cubes and air conditioning (Ciancio et al., 2007). These findings were confirmed by a case-control study with 82 individuals who died during a heatwave in 2009, which identified "air conditioning in bedrooms" and "participating in social activities more than once a week" as highly protective factors, whereas a "chronic heart disease" and "living alone" were associated with very high risk (Zhang et al., 2017). A review of six case-control studies came to the same conclusions, adding that being confined to bed, not leaving home daily and being unable to care for oneself are also among the highest risk factors. Pre-existing psychiatric and cardiovascular illnesses were also associated with high risk. The study added activities such as taking extra showers or baths and fan use to the protecting factors (Bouchama et al., 2007).

Dehydration as a main cause of heat-related mortality

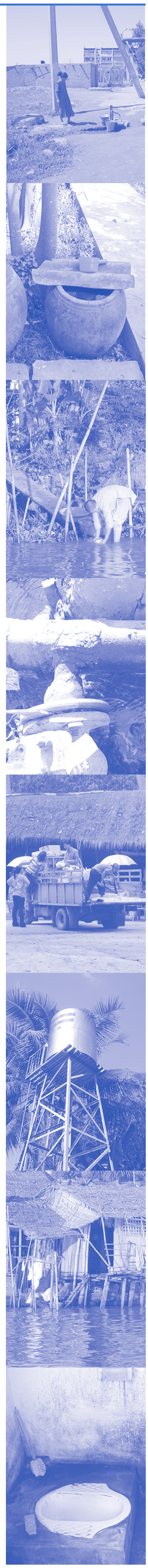
Looking at the excess mortality of the heat event of 2003 in France, of the 15,000 excess deaths observed, 3.306 were directly linked to the heatwave (1628 by dehydration, 1313 by heatstroke and 354 by hyperthermia) (Fouillet et al., 2006). As dehydration is linked to many morbidities, it is very likely that a sufficient amount of fluid intake could have prevented at least some of these deaths.

According to the German Nutrition Society (Deutsche Gesellschaft für Ernährung, DGE), the ideal fluid intake for adults above 65 years is 2250ml on average. This amount should be composed of 1310 ml uptaken through drinking, 680ml through solid food and 260ml through oxidation processes. The DGE also recommends an average fluid intake of 30ml per kg and day. The hydration requirements vary depending on physical activity, thermal conditions, nutrition, health status and of course age (German Nutrition Society, N.Y.).

The heat-health action plan for elderly people in Cologne

The transdisciplinary project Heat-Health Action Plan for Elderly People in Cologne (2019-2021) follows an innovative approach which combines public health research with municipal knowledge and the capacities of a water supplier at the local level. The project is conducted in Cologne, Germany, and it is based on a literature review as well as qualitative and quantitative research methods. Two quantitative surveys were conducted, addressing on the one hand managers of retirement homes and, on the other hand, community-dwelling older adults in four areas of Cologne targeting the population with an age of 65 years and above. Both studies addressed knowledge, information flow, heat perception, coping strategies and health aspects. This article will focus on the water-related aspects addressed in the survey on community-dwelling older adults.

We conducted a representative quantitative survey via structured interviews with 258 randomly chosen independently living older adults. The study areas varied in terms of social deprivation and heat strain. Figure 2 shows the selected areas based on spatial analysis with ArcGIS. Figure 3 reflects typical views of each of the four study areas. So-called "Social Areas" are socially



deprived areas with particular support through the local government. The participants were interviewed in their homes from August to October 2019.

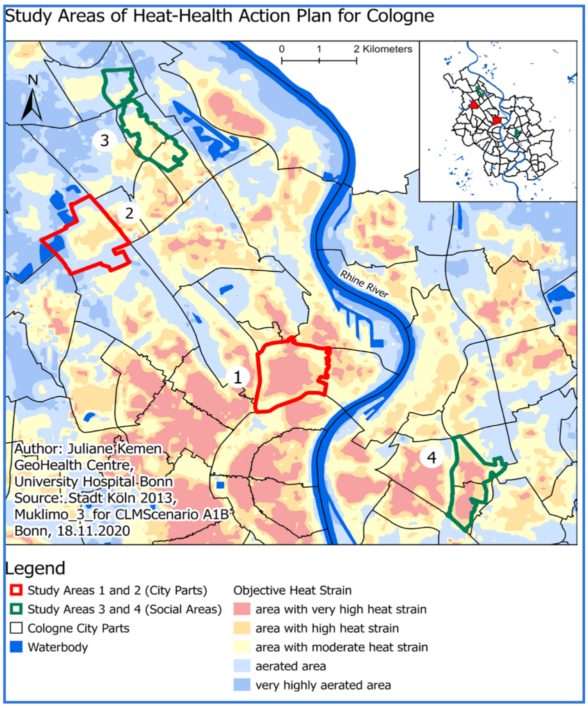


Figure 2: Study areas of Heat-Health Action Plan (Source: J. Kemen)

Selected preliminary results of the project

We interviewed 258 people - 131 women and 127 men-, from 65 to 93 years old with a mean age of 74.1 years. 37.5% were living alone, whereas 57.6% were living with one other person and 4.7% with two or more persons (n=256). Self-reported health was measured by the question "How is your health in general?" and the LUCAS functional ability index taking 12 different health risks and resources into account (Bruin et al., 1996; Dapp et al., 2014). The share of rather healthy participants was high, with only 12.1% considering their health as bad or very bad (n=253). In terms of functional ability, 63,6% were categorized to be robust with many health resources and few risks, the remaining being frail or at preliminary stages of frailty. As health risks, we considered: the loss of weight in the last six months, the change of walking or climbing of steps, or the event of falling to the floor.

Figure 3: Study areas (Source: J. Kemen 2019/2020)

As health resources, we considered: the ability to walk 500 metres on their own, participating at sportive activities, or community service and a specific amount of days during the week outside the house or flat (Dapp et al., 2014).

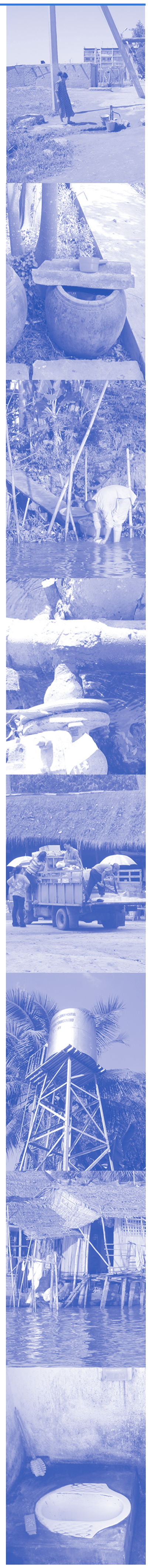
There are a number of heat-coping strategies to adapt to heatwaves:

- body-related strategies, such as wearing less or thinner clothes, drinking more, changing diet, showering more frequently, cooling arms with water, using a wet towel and cooling feet with water;
- home-protective strategies, such as opening windows for ventilation, closing blinds/shutters, turning on the fan and/or the air conditioning; and
- activity-related strategies, such as reducing physical activity and rescheduling activities to cooler hours of the day or other days.

Looking at these strategies, we found that respondents adopted several adaptation strategies, with a mean of 8.7 different strategies per person. Wearing less or thinner clothes or opening windows for ventilation was applied by almost all respondents, whereas water-related strategies - such as using wet towels, cooling feet with water, cooling arms with water or showering more frequently -, were used by a smaller share. 80% claimed they would drink more water during heatwaves. Those participants would not drink more during episodes of heat commented they already drink a sufficient amount of water or gave other reasons such as "obliviousness", "health conditions" or "medical instructions".

To understand the adaptation through water consumption, we asked about the fluid intake in glasses or litre(s) in a day with moderate temperature (about 20°C) and in a hot day, defined as a day with temperatures of 30°C or more. To determine whether participants' daily fluid intake was high enough, we used the formula of the DGE considering the respondents' body weight. We were only able to calculate the ideal amount for moderate temperature, as there is no formula for hot days to our knowledge. Results show that almost two-thirds of the participants were not drinking a sufficient amount of fluid on a moderate day. The difference between ideal fluid intake and actually reported intake could be one of the reasons for many participants suffering from various heat symptoms, such as fatigue, sleeping disorders, immense thirst, concentration issues, dizziness, headache and dehydration.

Interestingly, more than 80% of the participants stated that they would drink bottled water on a daily basis, whereas only 40% would drink tap water. Some satisfied their thirst also with coffee, tea, juice or other beverages. As the vast majority of the interviewed older people tend to use bottled water, it implies that they have to buy and bring them home, which can be assumed to be a rather strenuous activity during heatwaves. As the tap water quality in Germany is very well monitored and of very high quality, we would recommend drinking tap water, at least during the hot summer (Umweltbundesamt, 2018).



Concluding remarks and recommendations

Episodes of extreme heat during summer are dangerous to health, especially for vulnerable population groups. Older adults are the most sensitive group, not only because of age-related changes in thermo-regulation and thirst sensation but also because increasing age is often associated with multiple co-morbidities and a sedentary lifestyle.

This article showed the underutilization of water-related heat coping strategies from "cooling arms with water" or "showering more frequently" to the most fundamental strategy, namely "drinking sufficient amount of water". The study showed that many older adults preferred to drink bottled water to tap water even if the tap water quality in Germany is high. In Germany, the Drinking Water Ordinance (TrinkwV) provides the thresholds of pathogens and substances and the provision of tap water is monitored by the local water provider and local health authorities. These thresholds are set very low to reduce the risks of infections through tap water to practically zero (Umweltbundesamt, 2018). As the provided tap water has such high quality, it could be the perfect source for daily fluid intake. To relief older adults from the costs and strain of buying bottled water, particularly during heatwaves, there should be a focus of the provision of information about the quality of tap water in Germany. More research could lead to a better understanding of drinking preferences and barriers to drinking tap water. A possible reason could be the fear that drinking water may be contaminated with lead through obsolete pipes in old buildings. Information about the state of pipes and plumbing system should be provided by landlords without being asked for to avoid further underutilization of tap water.

Another option to avoid strenuous shopping activities during heat, it is the provision of a water delivery service or the utilization of one of the existing food delivery services. An intervention study with 508 older adults was able to show that the subjects' fluid intake increased when heat health warning was combined with water delivery, compared with a group which only received information and a control group (Takahashi et al., 2015). For older adults with a persistent preference for bottled water, these services could be a great relief.

As we are talking about community-dwelling elderly adults, there is no possibility of a continuous motivation to drink as it is for older adults living in sheltered accommodations. It would be beneficial if the right amounts of fluid intake and other coping strategies are mentioned and recommended in consultation hours at the general practitioner (GP). The GP would be able to calculate the adequate fluid intake also taking health and medical conditions under consideration. Furthermore, the social network can also be very helpful during heatwaves, as relatives, neighbours and friends can increase their personal or telephone contacts and remind elderly people of adaptation strategies, including drinking water. One humorous but still purposeful measure developed and implemented in the Cologne project is to release a popular song about coping strategies during heat. Created by the local band Klabes, sung in the local dialect ("Kölsch"), the song has a catchy chorus that reminds the audience to drink water every thirty minutes. The song will be released in summer 2021 and aims to transport information through this emotional medium.

The share of older adults profiting from the high standards of drinking water in Cologne is small. Even though the study included a rather small sample, because of the variety of cultural and social characteristics considered, it can be assumed that numbers are similar for other cities and regions. The provision and distribution of local information about the high quality of tap water and the adequate amount of fluid intake are a favourable possibility to support a climate-friendly, low-cost and practical fluid intake of community-dwelling older adults.

Acknowledgment

The study was made possible through the funding from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU) as part of the funding programme "Adaptation to climate change" within funding priority 3 "Municipal lighthouse projects". Parts of this article are based on the author's PhD project conducted at the Institute for Hygiene and Public Health (IHPH). The author wants to express gratitude to her supervisors and all team members at IHPH and project partners, especially Dr. Silvia Schäffer-Gemein from the IHPH, Johanna Grünewald and Yvonne Wieczorrek from the Agency for Environment and Consumer Protection of the city of Cologne; as well as all participants of the study.

References

Balbus, J., & Malina, C. (2009). Identifying vulnerable subpopulations for climate change health effects in the United States. Journal of occupational and environmental medicine, 51(1), 33–37.

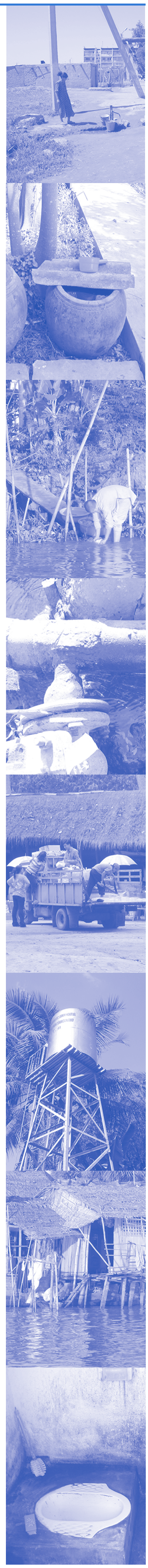
Bouchama, A., Dehbi, M., Mohamed, G., Matthies, F., Shoukri, M., & Menne, B. (2007). Prognostic factors in heat wave related deaths: A meta-analysis. Archives of internal medicine, 167(20), 2170–2176.

Bruin, A. de, Picavet H. S., & Nossikov, A. (1996). Health interview surveys : towards international harmonization of methods and instruments. Copenhagen.

Casanueva, A., Burgstall, A., Kotlarski, S., Messeri, A., Morabito, M., Flouris, A. et al. (2019). Overview of Existing Heat-Health Warning Systems in Europe. International journal of environmental research and public health, 16(15).

Ciancio, B., Di Renzi, M., Binkin, N., Perra, A., Prato, R., Bella, A. et al. (2007). Risk factors for mortality during a heat-wave in Bari (Italy), summer 2005.

Dapp, U., Minder, C., Anders, J., Golgert, S., & Renteln-Kruse, W. von (2014). Long-term prediction of changes in health status, frailty, nursing care and mortality in community-dwelling senior citizens—results from the Longitudinal Urban Cohort Ageing Study (LUCAS). BMC geriatrics, 14, 141.



Fouillet, A., Rey, G., Laurent, F., Pavillon, G., Bellec, S., Guihenneuc-Jouyaux, C. et al. (2006). Excess mortality related to the August 2003 heat wave in France. International archives of occupational and environmental health, 80(1), 16–24.

German Nutrition Society (DGE) (N.Y.). Wasser. Retrieved November 20, 2020, from https://www.dge.de/wissenschaft/referenzwerte/wasser/?L=0.

Kenney, W., & Munce, T. (2003). Invited review: Aging and human temperature regulation. Journal of applied physiology (Bethesda, Md. : 1985), 95(6), 2598–2603.

Kovats, R., & Kristie, L. (2006). Heatwaves and public health in Europe. European journal of public health, 16(6), 592–599.

McGregor, G., Bessemoulin, P., Ebi, K., & Menne, B. (2015). Heatwaves and health: Guidance on warning-system development. WMO-No. 1142 (WMO). Geneva.

Mücke, H.-G., & Straff, W. (2017). Bund/Länder-Handlungsempfehlungen für die Erstellung von Hitzeempfehlungen zum Schutz der menschlichen Gesundheit.

Pirard, P., Vandentorren, S., Pascal, M., Laaidi, K., Le Tertre, A., Cassadou, S., & Ledrans, M. (2005). Summary of the mortality impact assessment of the 2003 heat wave in France. Eurosurveillance, 10(7), 7–8.

Robert Koch-Institut (Ed.) (2019). Schätzung der Zahl hitzebedingter Sterbefälle und Betrachtung der Exzess-Mortalität; Berlin und Hessen, Sommer 2018 (No. 23).

Scherer, D., Fehrenbach, U., Lakes, T., Lauf, S., Meier, F., & Schuster, C. (2013). Quantification of heat-stress related mortality hazard, vulnerability and risk in Berlin, Germany. Die Erde, 144(3-4), 238–259.

Stadt Köln (2013): Muklimo_3_for CLMScenario A1B. In: LANUV- Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen (2013): Klimawandelgerechte Metropole Köln. Recklinghausen.

Takahashi, N., Nakao, R., Ueda, K., Ono, M., Kondo, M., Honda, Y., & Hashizume, M. (2015). Community trial on heat related-illness prevention behaviors and knowledge for the elderly. International journal of environmental research and public health, 12(3), 3188–3214.

Umweltbundesamt (Ed.) (2018). Bericht des Bundesministeriums für Gesundheit und des Umweltbundesamtes an die Verbraucherinnen und Verbraucher über die Qualität von Wasser für den menschlichen Gebrauch (Trinkwasser) in Deutschland 2014 – 2016.

Whitman, S., Good, G., Donoghue, E., Benbow, N., Shou, W., & Mou, S. (1997). Mortality in Chicago attributed to the July 1995 heat wave. American journal of public health, 87(9), 1515–1518.

World Health Organization (WHO) (Ed.) (2008). Heat-Health Action Plans. Kopenhagen.

Zhang, Y., Nitschke, M., Krackowizer, A., Dear, K., Pisaniello, D., Weinstein, P., et al. (2017). Risk factors for deaths during the 2009 heat wave in Adelaide, Australia: A matched case-control study. International journal of biometeorology, 61(1), 35–47.

Juliane Kemen

GeoHealth Centre
Institute for Hygiene and Public Health
University Hospital Bonn

Juliane.Kemen@ukbonn.de

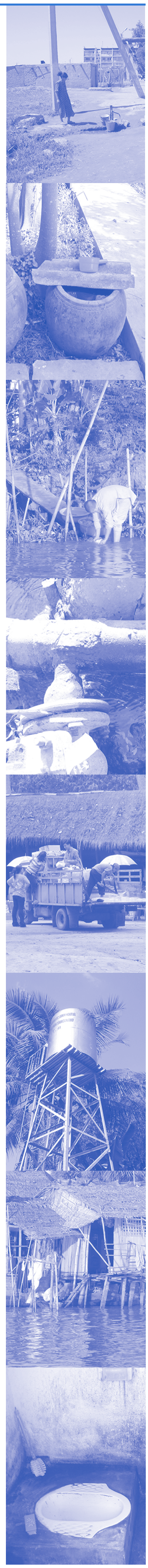
Rainwater harvesting: an underestimated resource for sustainable access to water for all

In an era of the COVID-19 pandemic, the Water Supply, Sanitation and Hygiene (WASH) sector is gaining much more (deserved) attention due to its importance in containing and mitigating the spread of the deadly virus. But despite the importance and recognition of the sector globally, many low- and middle-income countries are still far away from reaching the Sustainable Development Goals (SDGs) for Water and Sanitation. Accelerated and sustained coverage of WASH services for all have been the source of debate over the last decade, particularly because of the difficulty of bringing these services to rural and dispersed populations in cost-effective ways and under tight fiscal constraints.

Accelerating, sustaining and universalizing WASH must rely on multiple options that can be scaled up at reasonable costs to the government, the providers of maintenance and, ultimately, users (Anthonj & Borja-Vega, 2020). One of the many potential solutions that deserve attention and could help meet these objectives are rainwater harvesting (RWH) solutions. The debate of whether RWH is a viable option within the menu of solutions available to accelerate, sustain (both environmentally and economically) and universalize access to safe water is still open. Because of that reason, this short narrative literature review can provide a clearer "picture" of the features and characteristics of RWH options.

What we mean when we talk about rainwater harvesting and co-benefits

Rainwater harvesting, defined as the accumulation and deposition of rainwater in specially prepared collection and catchment areas, such as roofs, or areas on the ground (Lee et al., 2016), has numerous benefits. It has



proven useful in improving water security at household and personal scales. Rainwater can act as a buffer against shortfall (Lee et al., 2016; Mohd-Shahwahid et al., 2007), as an alternative primary source in rural areas that lack conventional water supply systems, and as a backup supply source in urban areas (Campisano et al., 2017; Mashood et al., 2011). RWH systems can mitigate service interruptions from centralized water distribution systems, or overuse of water from wells (Che-Ani et al., 2009). RWH can also be used to store rainwater for emergencies such as earthquakes, and as an adaptation strategy to cope with climate extremes such as droughts (Campisano et al., 2017). RWH can help reduce the impacts of flooding (da Costa Pacheco et al., 2017, Wambui, 2020) and reduce urban runoff (Campisano et al, 2017).

Rainwater is considered an 'improved water source' according to the WHO & UNICEF Joint Monitoring Programme (WHO & UNICEF, 2019). Therefore, investments in upscaling RWH count towards meeting the targets agreed by national governments for WASH as part of the Sustainable Development Goals (SDGs).

Setting up rainwater harvesting systems

RWH systems can be built relatively easily with local skills and resources, using simple and easy-to-maintain technologies and are inexpensive once installed (Che-Ani et al., 2009; Staddon et al., 2018). RWH systems can be modular in nature, allowing expansion, reconfiguration or relocation, and can easily be retrofitted to an existing structure or built during new construction (da Costa Pacheco et al., 2017). However, despite the many benefits, households often find it difficult to implement rainwater harvesting. The initial installation cost of RHW systems on residential housing is relatively high and a common barrier to adoption (Bui Thi Thuy et al., 2019; Mashood et al., 2011; Matto & Jainer, 2019; Staddon et al., 2018). The payback time could take years, and such a cost-benefit trade-off makes the installation of RWH systems uneconomical for households in view of its low return of investment (Lee et al., 2016). Installing RWH systems is not attractive to marginalized households, or those who do not own the land they reside on such as leaseholders and occupants of 'disputed land' (Staddon et al., 2018).

Safe rainwater requires careful maintenance of harvesting systems

Another reason for low adoption of RWH is that water quality can be compromised if not properly managed. Rooftop catchments are usually contaminated with dust, dirt, leaves, bird droppings or dead animals, all of which can jeopardize the quality of rainwater. The material used for tanks can also affect microbial quality of the water. Storage tanks for rainwater can develop a sludge layer that attracts mosquitoes and insects. Bacteria and other contaminants can be removed with debris screens and filters, and with first-flush diversion, and stored was can be filtered and disinfected, but these measures are often not used (Bui Thi Thuy et al., 2019; Campisano et al., 2017). In order to properly design RWH systems, an understanding of rainfall patterns and other technical parameters is required, but these are often lacking. If any such parameters are overlooked, RWH systems may be ineffective, or insufficient to hold reliable supply (Bui Thi Thuy et al., 2019; Lee et al., 2016).

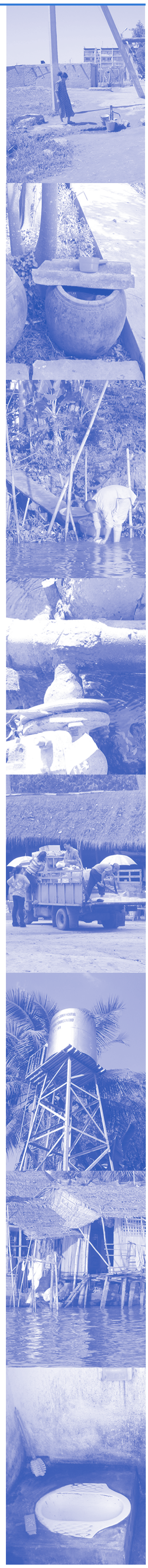
How governments can encourage rainwater harvesting

There are many ways to encourage rainwater harvesting, and to improve its implementation, and governments can play a strong role. The use of government subsidies as incentives for the installation of RWH systems can encourage the installation of RWH systems and increase the number of users, particularly among poorer households (Dumit Gómez & Girard Teixeira, 2017; Lee et al., 2016; Mohd-Shawahid et al., 2007; Staddon et al., 2018). The Government of India, for example, provides financial assistance for the installation of RWH systems. The Surat Municipal Corporation has made RWH mandatory for new buildings with a plot size of >4,000 m², and provides up to 50% (up to Rs. 2,000) subsidy to the citizens to encourage rainwater recharging. In Gwalior and Jabalpur, a 6 % rebate in property tax in the year of completion of RWH construction is provided to the building owner as an incentive (CSE, 2019).

Promoting rainwater use through housing regulations that stipulate that all newly built buildings and structures must include rainwater roof catchment is common in Taiwan, Texas and Brazil (Campisano et al., 2017; Che-Ani et al., 2009). In India, the Central Ground Water Authority has directed group housing societies (low-cost mass housing schemes for groups acquiring land together), institutions, schools, hotels, industrial establishments and farm houses outside of New Delhi, where ground water levels are more than 8 meters below the ground surface, to adopt RWH systems on their premises. The Ministry of Urban Development and Poverty Alleviation has made RWH in all new buildings on plots of 100 m² or larger in New Dehli mandatory. Building plans are not sanctioned unless such provision is provided. Moreover, buildings with plots of 200 m² or larger extracting groundwater through tube wells or boreholes need to implement RWH (CSE, 2019).

Barriers to the implementation of rainwater harvesting systems

Although laws and other governmental policies are the key driver for the implementation of RWH, overall, robust policies to systematically promote the installation of RHW are often lacking or scattered (Lee et al., 2016; Mashood et al., 2011; Mohd-Shahwahid et al., 2007). In Brazil for example, RWH is barely covered in legislation at the federal level, but more common at the local level. In absence of a national policy regulating RWH, some state laws and mainly municipal regulations have taken the task of covering this legislative gap, as local authorities may be more aware of specific problems for the region and thus implement specific legislation for



the municipality. Large numbers of different laws and regulations at different scales complicate the process of implementation. Besides, the scattered legislation does not cover all aspects of RWH: the main goal of regulations is usually encouraging the installation of RWH systems, but incentives for the implementation are rare, and no legislation exists that addresses treatment to improve the water quality of rainwater (da Costa Pacheco et al., 2017). Besides, coordination between state and non-state stakeholders in RWH, and residents lacking awareness or knowledge of policies, are common challenges (Bui Thi Thuy et al., 2019; Matto & Jainer, 2019).

Collaboration between governments, communities and households

Governments can support households with advice on optimal system design, operation and maintenance to meet the required supply and demand network at optimal reliability (Campisano et al., 2017; Che-Ani et al., 2009). Authorities can inform and train RWH adopters on precipitation and other technical parameters that are relevant, including catchment area (roof area), cistern storage size, rainwater demand and overall water use pattern (Lee et al., 2016). Local authorities can also train RWH users on how to safely manage their RWH systems, including regular microbiological and chemical water quality testing, assistance with water safety planning monitoring and evaluation particularly in remote communities (Gwenzi et al., 2015; Kohlitz and Smith 2015). Governments can also work with community-based organizations (e.g., women's groups and faith groups) and community leaders (especially clergy and medical staff), which can be instrumental in promoting RWH uptake (Staddon et al., 2018).

Conclusions

Wherever feasible, rainwater harvesting solutions hold great promise in contributing to achieve SDG 6 to ensure availability and sustainable management of water and sanitation for all. Thus, investments in upscaling RWH will be one important step to reach this goal. However, investments in RWH technologies alone are not enough. They must be combined with careful management and maintenance of these systems, and with proper training of users, to ensure that the harvested rainwater really is safe for drinking.

References

Anthonj C, Borja-Vega C (2020): Roofs, rain and life: Rainwater harvesting for safe water supply and sustainable co-benefits. World Bank Water Blog Post. Published on 10 November 2020. Available at: https://blogs.worldbank.org/water/roofs-rain-and-life-rainwater-harvesting-safe-water-supply-and-sustainable-co-benefits.

Bui Thi Thuy, Anh Dung Dao, Mooyong Han, Duc Canh Nguyen, Viet Anh Nguyen, Hyunju Park, Pham Dang Manh Hong Luan, Nguyen Thi Thanh Duyen, Hong Quan Nguyen. (2019). Rainwater for drinking in Vietnam: barriers and strategies. Journal of Water Supply: Research and Technology-Aqua. jws2019054. https://doi.org/10.2166/aqua.2019.054

Campisano, A., Butler, D., Ward, S., Burns, M.J., Friedler, E., DeBusk, K., Fisher-Jeffes, L.N., Ghisi, E., Rahman, A., Furumai, H., Han, M. (2017). Urban rainwater harvesting systems: Research, implementation and future perspectives. Water Research 115: 195-209. https://dx.doi.org/10.1016/j.watres.2017.02.056.

Centre for Science and Environment (CSE). (2019). Rainwater Harvesting. Laws and Policy. Available at: https://www.cseindia.org/laws-and-policy--1161.

Che-Ani, A.I., Shaari, N., Sairi, A., Zain, M.F.M., Tahir, M.M. (2009). Rainwater harvesting as an alternative water supply in the future. European Journal of Scientific Research 34(1): 132-140.

da Costa Pacheco, P.R., Dumit Gómez, Y., Ferreira de Oliveira, I., Teixeira, L.G. (2017). A view of the legislative scenario for rainwater harvesting in Brazil. Journal of Cleaner Production 141: 290-294. http://dx.doi.org/10.1016/j.jclepro.2016.09.097.

Dumit Gómez, Y., Girard Teixeira, L. (2017). Residential rainwater harvesting: Effects of incentive policies and water consumption over economic feasibility. Resources, Conservation & Recycling 127: 56-67. http://dx.doi.org/10.1016/j.resconrec.2017.08.015.

Gwenzi, W., Nothando, D., Pisa, C., Tauro, T., Nyamadzawo, G., 2015. Water quality and public health risks associated with rainwater harvesting systems for potable water supply. Review and perspectives. Sustainability of Water Quality and Ecology 6: 107-118. https://doi.org/10.1016/j.swaqe.2015.01.006.

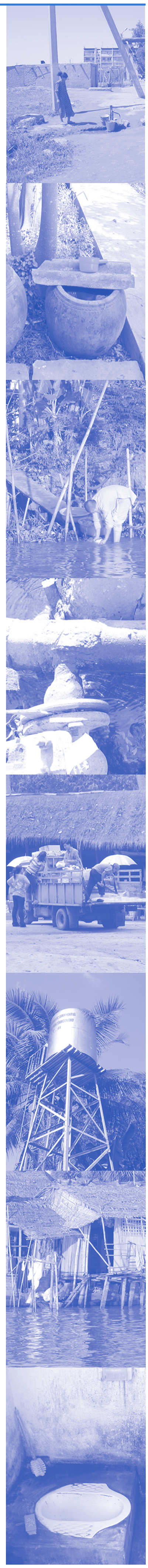
Kohlitz, J.P., Smith, M.D. (2015). Water quality management for domestic rainwater harvesting systems in Fiji. Water Supply 15 (1): 134-141. https://doi.org/10.2166/ws.2014.093.

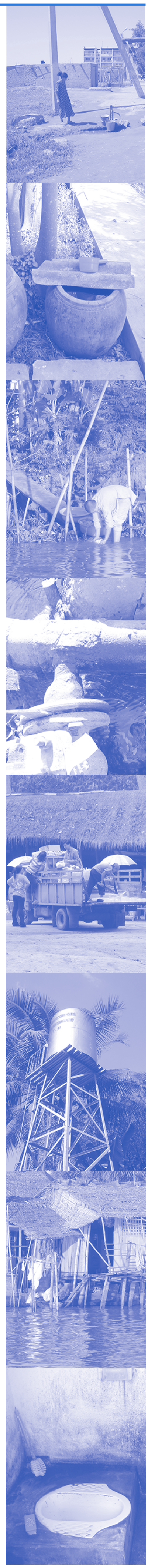
Lee, K.E., Mokhtar, M., Hanafiah, M.M., Halim, A.A., Badusah, J. (2016). Rainwater harvesting as an alternative water resource in Malaysia: potential, policies and development. Journal of Cleaner Production 126: 218-222. https://dx.doi.org/10.1016/j.jclepro.2016.03.060.

Mashood, J., Ampadu-Boakye, J., Laryea, N.O.A. (2011). Rainwater Harvesting (RWH) as a Complementary Approach to Improving Water Supply in Ghana. 3rd Ghana Water Forum Water and Sanitation Services Delivery in a Rapidly Changing Urban Environment. 158-162.

Matto, M., Jainer, S. (2019). Potential of Rainwater Harvesting in Rwanda. A deep-dive into Best Management Practices of Rainwater Harvesting Systems in Kigali. Centre for Science and Environment, New Delhi.

Mohd-Shawahid, H.O., Suhaimi, A.R., Rasyikah, M.K., Jamaluddin, S.A., Huang, Y.F., Farah, M.S. (2007). Policies and incentives for rainwater harvesting in Malaysia. In: Rainwater Utilization Colloquium 19-20 April 2007, Selangor, Malaysia, pp. 1-15. Available at http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.188.1252&rep=rep1&type=pdf





Staddon, C., Rogers, J., Warriner, C., Ward, S., Powell, W. (2018). Why doesn't every family practice rainwater harvesting? Factors that affect the decision to adopt rainwater harvesting as a household water security strategy in central Uganda. Water International 43(8): 1114-1135. https://doi.org/10.1080/02508060.2018.1535417.

UNICEF and WHO (2019). Progress on household drinking water, sanitation and hygiene 2000-2017: Special focus on inequalities. New York: WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene.

Wambui, C. (2020). Water harvesting has added benefit for Kenya: less flooding. Thomson Reuters Foundation. Available at: http://news.trust.org/item/20200103134727-yineo/.

UN World Water Assessment Programme (2017). The United Nations World Water Development Report 2017. Wastewater, The Untapped Resource. https://doi.org/10.1017/

Dr. Carmen Anthonj

ITC
University of Twente
Enschede, The Netherlands

c.anthonj@utwente.nl

Cities at risk: Flood risk, public awareness, institutional preparedness and risk communication in Yangon, Myanmar

Cities at risk in Southeast Asia

While in 1990 about 2.3 billion of the world's population (43%) lived in urban areas, in 2030 more than 5.1 billion people (56%) are expected to live as urban residents in cities worldwide (WBGU, 2016; UN DESA, 2019). In Southeast Asia, since about 2020, more than half of the population is living in urban areas. Countries like Indonesia, Malaysia, the Philippines, Singapore and Thailand are highly driven by urbanisation (UN DESA, 2019). Even in still relatively rural countries like Cambodia, Laos, Myanmar and Vietnam the trend towards accelerating urbanisation is evident (UN DESA, 2019).

Urbanisation is fundamentally transforming societies and landscapes. Cities in developing countries, currently transforming at a high pace, are particularly complex systems with high transformation dynamics. Megacities and large metropolises provide key functions for growing global and local networks as they are centres of power, innovation and decision-making processes as well as transit points for products and food supply, where large parts of the national GDP are generated mainly by industries and services (Kraas, 2007; Garschagen, 2015; Butsch et al., 2016; Kraas et al., 2019). At the same time, they are characterized by high growth dynamics, fast expansion, strong socio-economic disparities and growing fragmentation which leads to increasing numbers of vulnerable people.

Fast-growing cities in developing countries are particularly challenging with respect to the provision of critical infrastructure. The provision of basic goods and services – i.e. food, water and medical supply, wastewater and solid waste management, transportation and electric power supply, information technology and telecommunication, finance and insurance industry, culture and media (broadcasting TV and radio, print and electronic media, cultural properties as well as buildings and places with identity-forming functions) (BBK, 2020) - is a major challenge to government institutions and public administration. Social fragmentation, increasing poverty, and advanced vulnerability, complicate the provision of comprehensive infrastructure and services (Bohle and Sakdapolrak, 2008; Kraas et al., 2019). This leads to momentous vulnerability of at least increasing parts of the urban population with respect to crises and disasters. Thus, fast-growing cities in developing countries can be regarded as "global risk areas" (Kraas, 2003). Rapid and uncontrolled urbanization, including informal settlements, require adequate approaches of disaster risk reduction (DRR) as well as sustainable preparedness and agile disaster response mechanisms (UNDRR, 2005), let alone appropriate laws and regulations. Against this background, improving resilience with resilience education and with improved communication within the administration, with and between the different stakeholders in society, including the citizens, is of crucial importance for successful risk management, disaster response management (mitigation), institutional preparedness and risk communication.

Research project on "Multiple risks management in Yangon"

The international and transdisciplinary research project "Multiple risks management of extreme events in fast growing (mega)cities in Myanmar" addresses topics of disaster risk management with a holistic approach. The project is funded by the German Federal Ministry of Education and Research (BMBF) within the scope of "Sustainable Development of Urban Regions" (NUR) under the framework programme "Research for Sustainable Development" (FONA). The project aims to establish a comprehensive and integrative multiple risks management for the megacity Yangon, Myanmar (https://riskurbmyanmar.uni-koeln.de/home). Four additional fast-growing cities in Myanmar are actively involved in the project as observing partners. The transdisciplinary collaboration focuses on the exchange of knowledge and experiences for a multiple risks management and involves: the University of Cologne (UoC), Yangon City Development Committee (YCDC), the Cologne Fire Department (AFRB), the Flood Protection Centre of the Municipal Drainage Operation Cologne of the City of Cologne (StEB Köln), the German Committee for Disaster Reduction (DKKV), the Department of Urban and Housing Development, Ministry of Construction (DUHD, MoC), Yangon Region Government (YRG), the University of Yangon (UY) and Myanmar Environment Institute (MEI), together with further governmental institutions and universities.

A holistic multiple risks management is based on the principles of inclusion of all parts of the society in a participatory and inclusive way so that no one is left behind (BMZ, 2013; Lafrenière and Walbaum, 2017). The project is focusing on the management of the natural disasters of flooding, tropical cyclones and earthquakes. The recent COVID-19 pandemic was added as a new threat. The approach assesses the exposure of people and assets to risks and informs people about possible hazards and risks with respect to all individual requirements.

The research design comprises four phases: during the preparation phase of six months, a stakeholder analysis was conducted, the project consortium was defined and the project partners were connected. In the following 18 month-long definition phase (currently ongoing), joint objectives are defined and first research campaigns are being conducted. The next research and development (R&D) and the final implementation phases will conclude the joint work.

During the definition phase, four focal points are addressed:

- establishment of an effective and reliable (meta) data collection, digitisation and dissemination of information about multiple risks (including a reliable risk map collection);
- conceptualisation of an efficient, culturally adapted awareness and prevention programme to prevent losses of personal and relevant documents (e. g. certificates and items of personal importance);
- conceptualisation of a prevention programme for losses of the economic basis (e. g. assets in shops, small family jobs); and
- conceptualisation of an awareness programme to ensure basic access to water, food and electricity supply and health services.

This article focuses on the focal point (2) of the project in which the civil society is addressed for disaster preparedness, especially in the case of flooding. This goal is highly intertwined with the status of the institutional preparedness because disaster preparedness of the general public requires a proper risk communication of official institutions. Risk communication should provide knowledge to empower citizens for decision making in times of disasters (Renn, 2008), thus, it should be inclusive and multi-lingual in order to involve all parts of society. This implies that the official institutions for communication are trusted by the general public (Bronfman et al., 2016; Terpstra, 2011).

Flood risk in Yangon

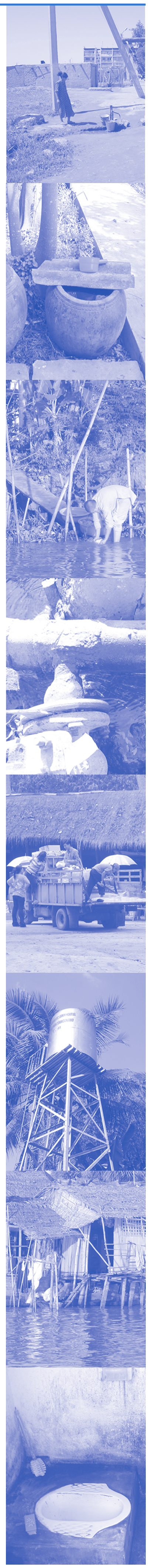
The City of Yangon is located in tropical Southeast Asia. The metropolitan area with 5.1 million inhabitants is spreading on 1,061 km2 in the southwest of Myanmar (Kraas et al., 2017). Since the country's political transformation process to democracy started in 2011, Yangon is growing economically and spatially at a high pace. After the country's capital city was shifted from Yangon to Nay Pyi Taw in 2005, Yangon is developing as Myanmar's first and foremost economic hub.

Due to its geographical location, Yangon is exposed to multiple risks, among them primarily the natural risks of earthquakes, floods and tropical cyclones. The annual monsoon usually brings heavy rainfall (from June to October) after partially long dry seasons (from November to May). Floods frequently occur due to high tide or heavy precipitation during monsoons and in pre- and post-monsoonal periods in the context of tropical cyclones (Kraas et al., 2017).

One of the most disastrous tropical cyclones, Nargis in 2008, caused more than 138.000 victims, particularly in the Ayeyarwady Delta, and led to broadly flooded areas in and around Yangon (Kraas, 2009). Later tropical cyclones – 'Giri' (Oct 2010), 'Komen' (Aug 2015), 'Maarutha' (May 2017) and 'Bulbul' (Oct 2019) (UNOCHA, 2017; Brakenridge et al., 2017; Brill et al., 2020) – caused heavy floods along the rivers, creeks and low-lying valleys in the coastal and delta areas of Lower Myanmar including large parts of Yangon.

Yangon is crossed by several rivers and has a number of large lakes. The river banks are functioning as retention areas in case of flooding. The loss of those retention areas due to urban expansion and inadequate drainage make several townships of Yangon prone to high tide flooding, especially along Yangon River, Bago River and Pazundaung Creek.

Hazard maps indicate areas at risk. A disaster management plan developed on such maps and information about potentially affected areas defines measures for appropriate action and allows a most efficient implementation. For Myanmar, hazard maps are available at MIMU (Myanmar Information Management Unit) (http://www.themimu.info/) and the Myanmar Unified platform for Disaster Risk Application (MUDRA) (www.mudra-ddm.info/). MUDRA is a digital interactive portal that provides disaster risk information for strategic planning and is used to develop, collaborate and to share disaster risk information. Thus, it contributes to the objectives of the Sendai Framework for Disaster Risk Reduction, the Paris Agreement on climate change and the Sustainable Development Goals (UN, 2015a; 2015b; 2015c). The information focuses on the most frequent hazards like riverine floods, coastal floods (storm surges) and cyclones. In addition, data of exposure is included, such as population density, number of buildings, agriculturally used areas and



critical infrastructure. Flood maps are not yet available at detailed scale in Yangon. A comprehensive digital elevation model would enable local administration to develop detailed and differentiated measurements for institutional preparedness and self-prevention for citizens.

Public awareness and exposure

Apart from heavy precipitation and high tides, weak solid waste management poses a further risk of flooding in Yangon (Zin Mar Than et al., 2020). Before 2011, super-markets did hardly exist and people relied mainly on locally produced agricultural products. Political transformation processes opened Myanmar's economy for international imports and new, industrially processed products. This fuelled the influx of plastic materials to enter the country. Up to now, many people are not aware of the impacts of plastic on the environment. Solid waste, in particular plastic waste in water bodies and drainage channels, blocks urban drainage and sewage systems, causing widespread flooding. The stagnant water provides habitats for disease-causing micro-organisms and invertebrates. Vector-borne diseases (such as dengue transmitted by *Aedes aegypti*) are seasonally common in Yangon (Oo et al., 2011). Rapid intervention to dry flooded residential buildings is thus inevitable as stagnant sewage water of drainage systems can contain contaminated water with pathogens and may cause water-borne diseases (Kistemann and Radtke, 2013).

While more than 90 % of the population in Yangon already experienced a tropical cyclone, 21 % (n = 1,336) of the households have already experienced flooding, i.e. about one million people (project's household survey, 2019/20). Future projections forecast an increase in flooding events in urban areas. Aggravated by urban heat island and thunderstorm effects and associated with rising occurrence and intensity of precipitation, shorter and heavier rainfalls are expected (Satyanarayana et al., 2019; Chen et al., 2015). These developments may make Yangon more prone to natural and human-made flood-associated hazards. Most likely, these growing urban floods will lead to multiple consequences, namely increasing damages of critical infrastructure and housing structures, increasing health risks and vulnerability of large population groups. Flooding in areas of informal settlements exhibit intrinsic vulnerabilities and will further harm the health and wellbeing of already marginalized people.

Institutional preparedness and risk communication

After Nargis, disaster risk management and preparedness in Myanmar was improved at all levels. In 2009, the Myanmar Action Plan on Disaster Risk Reduction was introduced. In 2017 it was updated based on the Natural Disaster Management Law of 2013 (Zin Mar Than et al., 2020). Since 2013, Disaster Management Committees at all administrative levels were set, including a committee for disaster risk management in each township (NDMC and Republic of Myanmar, 2017). Today all 45 townships in Yangon run a disaster management committee. These committees differ in their constitution and the number of involved members. In addition, the committee members perform different duties before, during and after a disaster (Zin Mar Than et al., 2020).

Various shortcomings are weakening institutional preparedness. Limited funds allow immediate disaster response but can support only a few measures for adequate preparedness. Data show that collaboration in case of disasters between committees and their members deserves improvement, including the closing of gaps between higher and lower institutional levels (Zin Mar Than et al., 2020). Further, the current political transformation process is characterised by transition deficiencies in the process from a centralised to a more deconcentrated or decentralised system.

Within the scope of the project, a households survey (2019/20) investigated the hazard preparedness of the people in Yangon. Amongst other questions, it was asked: "Who would you ask for help in case of a disaster?" (Fig. 1). The majority (68%) of the households would ask the ward or township administration for help. Lesser but still substantial portions would request the fire brigade and Red Cross, the community, family and/or local NGOs. In case of a disaster, this would particularly exceed the township office's available human resources and technical equipment. Further, this puts high pressure and expectation on the lowest level of administration.

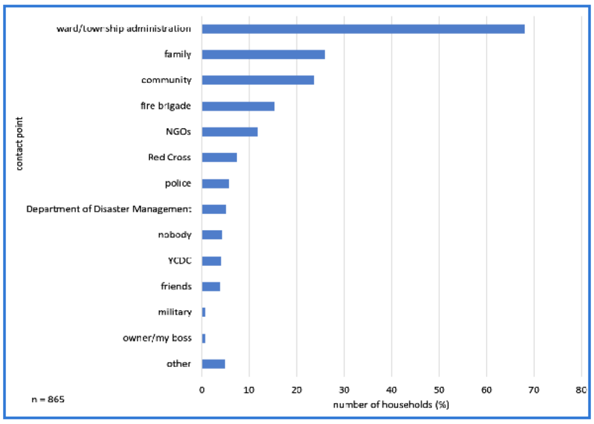
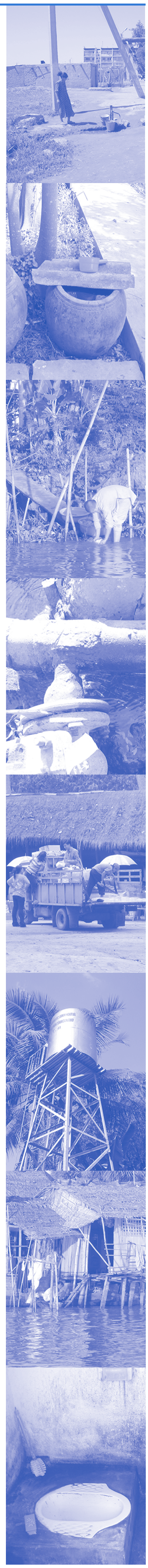
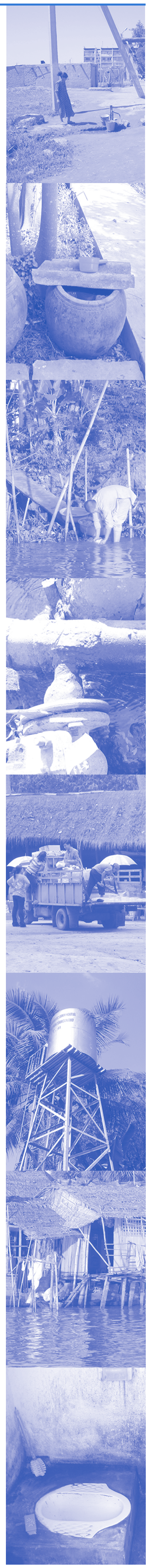


Figure 1: Who would you ask for help in case of a desaster?

In order to strengthen the efforts of implementing DRR approaches, the project partners developed five leaflets on the basis of individual needs and levels of awareness identified through the mentioned survey. Therefore, knowledge and ideas of the civil society, including vulnerable groups, were included in the leaflets' concepts. They provide basic information for the general population about the specific risks and information about recommended behaviour and preparation for earthquakes, tropical cyclones, flooding, evacuation and COVID-19, in English and Myanmar language. All information chosen and the final design were agreed upon by the Myanmar partners and stakeholders to reflect different perspectives and levels of knowledge and experience and to ensure cultural acceptance. The leaflet on floods (Fig. 2) summarises





Behaviour during the flood

1. Switch off the power supply at an early stage for areas affected by flooding.
2. Try to help others without endangering yourself. Take children and elderly people to safety.
3. Follow the news and weather forecast of the Department of Meteorology and Hydrology and share the information with others, do not believe or spread rumours.
4. Avoid shore areas and flooded streets.
5. Be aware of hazardous areas (lowlands, valleys, drains).
6. Prepare for evacuation.

Emergency numbers:
Police 199 or 01 549309
Fire Service, Rescue 191 or 01 252011
Ambulance (YGH) 192 or 01 295133

Behaviour after the flood

1. Check whether family members are affected and inform those responsible if any family member is missing.
2. Beware of damaged cables, power lines and tree branches. Inform the relevant authorities and help clarify.
3. Do not use electrical equipment until they have been checked.
4. Do not remove water residues and mud until the flood has totally receded. Cremate or burn animal carcasses systematically.
5. Check the building for damage.
6. Dry affected areas as quickly as possible to avoid building damage, mould or pest infestation.

For further information check

The Myanmar Unified platform for Disaster Risk Application
https://app.mudra-ddm.info

Publisher of the pamphlet

Yangon City Development Committee
Urban Planning Department
www.ycdc.gov.mm

University of Cologne
Institute of Geography
www.geographie.uni-koeln.de/en/

Flood Protection Centre Cologne
Cologne Fire Department, Institute for Security Science and Rescue Technology
German Committee for Disaster Reduction
Department of Urban and Housing Development, Ministry of Construction
University of Yangon
Centre of Excellence for Urban and Regional Development
Myanmar Environment Institute

www.riskurbmyanmar.uni-koeln.de
November 2020

SPONSORED BY THE
Federal Ministry of Education and Research

Funding No. 01LE1904A
Funding line of sustainable development of urban regions joint projects (NUR)
DLR Project Management Agency, Germany

RiskUrb Myanmar

Recommendations for flooding

Photo: Frauke Kraas

Yangon risk profile

Yangon is exposed to a variety of hazards. These include earthquakes, floods, tropical cyclones and fire. Thus, it is **important to take precautionary measures.** This pamphlet contains information about what to do in case of **flooding.**

How does a flood occur?

(A) Caused by heavy rainfall: A flood occurs when large amounts of rain fall over a period of time. This rain can no longer be absorbed by the ground and therefore flows off into streams and rivers or wildly on the roads. Surfaces that have been sealed by buildings and roads increase this danger.

(B) Caused by a malfunction of the drainage system: Flooding can occur when drainage systems are blocked, e.g. by waste or by unregulated construction of buildings or roads.

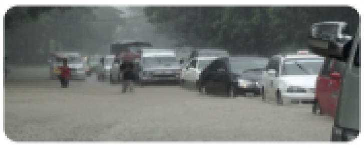
(C) Caused by tropical cyclones: Storm surges are high walls of water pushed on land by cyclones (e.g. Cyclone Nargis: 5m height, inundations reached 50km inland). In coastal areas, where tropical cyclones and their accompanying effects hit land, tropical cyclones become particularly dangerous.

(D) Caused by tsunamis: A tsunami causes a storm wave. This wave can flood large parts of the coastal region.

Flooding is most likely to occur pre-monsoon (April - May) or post-monsoon (October - November).

Possible hazards

- The water can flood and flush out buildings, paths, bridges or dams. There is also a danger of people drowning in the water masses.
- In addition, there is a danger caused by the wreckage carried in the water masses.



Heavy rain event in Yangon
Photo: Frauke Kraas

Precautionary measures

1. Keep the drainage clean to avoid blocking from waste.
2. Maintain a good drainage line to avoid drains being destroyed by new constructions.
3. Flood-affected parts of buildings should be flood-resistant, e.g. cement or tile floors or aluminum doors instead of wooden doors.
4. Make sure your exits are free and are clear from heavy objects that might block the exit during an emergency.
5. Keep important documents in a safe place and have copies of documents in other safe places.
6. Consider whether you can protect your building with sandbags. Please note that you need a warning time to set up these mobile protective devices.
7. Install electrical supply equipment in the upper floors.
8. Inform family members about preventive measures and behaviour before and during the flood.
9. For your protection and comfort, prepare an emergency backpack that could last for three days. The emergency supply backpack should be waterproof and easy to find.
10. Learn first-aid techniques and have a store of the necessary medications and equipment.

Flood protection by retaining wall in Dagon Myothit (North) Township
Photo: Department of Water Resources and Rivers Development

Behaviour before the flood

1. Follow weather reports and flood warnings on radio or TV or cell phones or newspaper.
2. Leave endangered water and shore areas.
3. Go to a safety shelter if you live near a river or in an area with danger of flood.
4. Try to seal your building, e.g. with sandbags or waterproof plywood panels and silicone.
5. Organize in advance accommodations for sick and care-dependent individuals (if possible with relatives and friends).
6. To prevent environmental damage, remove containers with used oil, chemicals, paints, varnishes, detergents and cleaning agents from rooms at risk of flooding.
7. Park your car outside the flood prone areas.

Flood protection by sandbags in North Okkalapa and Dagon Myothit (South) Townships
Photo: Drainage and Sewerage Management Department

Figure 2: Leaflet with recommendations for flooding to the civil society

recommended behaviour and preparedness measures for before, during and after a flood.

The information in the leaflets shall empower the lowest administrative levels in Yangon's townships to provide information and raise awareness on the importance of disaster preparedness. Finally, improved knowledge and awareness to raise capacities for individual preparedness and self-protection of the civil society would help relieving the pressure on local administration.

Conclusion

The international, transdisciplinary project has so far produced a number of findings and lessons learnt:

(1) Interviews and secondary data analysis revealed that after the mega-event of the tropical cyclone Nargis (2008), the risk-related preparedness and institutionalisation in the country was substantially upgraded and widened.

(2) Through the work of the international and transdisciplinary project consortium, the risk-related data collection was improved and the coordination between different government, administrative and academic institutions was expanded on national, regional and local scales.

(3) The internationalisation – with respect to an exchange of knowledge, experience and good practice in joint basic research and application-oriented projects – was intensified substantially by organising and participating international conferences. (4) Beyond official action plans, regular communication between stakeholders was initiated, including growing information to the wider public.

The research project also contributed to strengthening the information exchange with the civil society and to raise awareness of the local people and their involvement in DRR processes. Inclusive and culture-sensitive leaflets on evacuations, earthquakes, tropical cyclones, flooding and COVID-19 were developed jointly between project partners and stakeholders. They will be used to inform and sensitise the civil society for hazards and thus contribute to a better preparedness of institutions and the public in case of disasters.

With the said efforts, the research project is contributing to deepening the understanding of cities as risk areas, particularly in a situation of transformation processes (Kraas, 2003; Heinrichs et al., 2012; Kabisch and Kuhlicke, 2014). It is further in line with international research on sustainable transformation and development aiming at strengthening institutions at the national, regional and local levels as claimed by the Hyogo Framework for Action and the Sendai Framework for Disaster Risk Reduction 2015-2030 (Garschagen, 2015; Solecki et al., 2017).

References

BBK, 2020. 'Bundesamt Für Bevölkerungsschutz Und Katastrophenhilfe - Kritische Infrastrukturen'. https://www.bbk.bund.de/DE/AufgabenundAusstattung/KritischeInfrastrukturen/kritischeinfrastrukturen_node.html.

BMZ (ed.), 2013. Disaster Risk Management for All: The Inclusion of Children, Elderly People and Persons with Disabilities. BMZ Information Broschure, 1 / 2013e. Berlin; Bonn.

Bohle, H.-G., Sakdapolrak, P., 2008. 'Leben Mit Der Krise. Vertreibung von Slumbewohnern in der Megacity Chennai, Indien'. Geographische Rundschau 60 (January): 12–21.

Brakenridge, G. R., Syvitski, J. P. M., Niebuhr, E., Overeem, I., Higgins, S. A., Kettner, A. J., Prades, L., 2017. 'Design with Nature: Causation and Avoidance of Catastrophic Flooding, Myanmar'. Earth-Science Reviews 165: 81–109. https://doi.org/10.1016/j.earscirev.2016.12.009.

Brill, D., Seeger, K., Pint, A., Reize, F., Kay Thwe Hlaing, Seeliger, M., Opitz, S. et al., 2020. 'Modern and Historical Tropical Cyclone and Tsunami Deposits at the Coast of Myanmar: Implications for Their Identification and Preservation in the Geological Record'. Sedimentology 67: 1431–1459. doi: 10.1111/sed.12586.

Bronfman, N. C., Cisternas, P. C., López-Vázquez, E., Cifuentes L. A., 2016. 'Trust and Risk Perception of Natural Hazards: Implications for Risk Preparedness in Chile'. Natural Hazards 81 (1): 307–27. https://doi.org/10.1007/s11069-015-2080-4.

Butsch, C., Kraas, F., Namperumal, S., Peters, G., 2016. 'Risk Governance in the Megacity Mumbai/India – A Complex Adaptive System Perspective'. Habitat International, Special Issue: Configuring knowledge in urban water-related risks and vulnerability: Varieties, institutional arrangements and outcomes, 54 (May): 100–111. https://doi.org/10.1016/j.habitatint.2015.12.017.

Chen, S., Li, W.-B., Du, Y.-D., Mao, C.-Y., Zhang, L. 2015. 'Urbanization Effect on Precipitation over the Pearl River Delta Based on CMORPH Data'. Advances in Climate Change Research 6 (1): 16–22. https://doi.org/10.1016/j.accre.2015.08.002.

Garschagen, M., 2015. 'Urbanisierung Und Risiko - Herausforderungen Und Chancen'. In WorldRiskReport 2014 Focus: The City as a Risk Area, edited by Bündnis Entwicklung Hilft. Berlin.

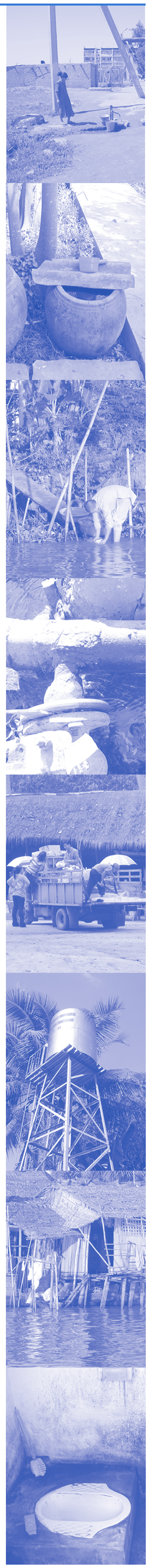
Kistemann, T., Radtke, K., 2013. 'Mit Sauberem Wasser Gegen Die Katastrophe'. In WeltRisikoBericht 2013 Schwerpunkt: Gesundheit Und Medizinische Versorgung, edited by Bündnis Entwicklung Hilft, 20–27. Berlin.

Kraas, F., 2003. 'Megacities as Global Risk Areas'. Petermanns Geographische Mitteilungen 147 (4): 6–15.

Kraas, F. (2007): Megacities and global change: key priorities. Geographical Journal 173 (1): 79-82.

Kraas, F. (2009): Tsunami 2004 und Zyklon "Nargis" 2008. Katastrophenbewältigung in den Küstenregionen von Myanmar. Geographische Rundschau 61 (12): 50-58.

Kraas, F., Spohner, R., Aye Aye Myint, Aung Kyaw, Hlaing Maw Oo, Htun Ko, Khin Khin Han, et al., 2017. Socio-Economic Atlas of Myanmar. Franz Steiner Verlag. https://elibrary.steiner-verlag.de/book/99.105010/9783515116251.



Kraas, F., Hackenbroch, K., Sterly, H., Heintzenberg, J., Herrle, P., Kreibich, V. (eds.), 2019. Mega Cities, Mega Challenge: Informal Dynamics of Global Change: Insights from Dhaka, Bangladesh and Pearl River Delta, China. Stuttgart: Borntraeger Science Publishers.

Lafrenière, A., Walbaum, V., 2017. Inclusive Disaster Risk Reduction. Vol. Technical Resources Devision. Policy Paper 13. Lyon: Handicap International. https://www.preventionweb.net/publications/view/54324.

NDMC Republic of Myanmar, 2017. The Myanmar Action Plan on Disaster Risk Reduction 2017 | UNDP in Myanmar. MAP DRR 2017. https://www.mm.undp.org/content/myanmar/en/home/library/environment_energy/Myanmar_Action_Plan_DRR_2017.html.

Oo, T.T., Storch, V., Madon, M., Becker, N. (2011): Factors influencing the seasonal abundance of Aedes (Stegomyia) aegypti and the control strategy of dengue and dengue haemorrhagic fever in Thanlyin Township, Yangon City, Myanmar. Tropical Biomedicine 28 (2): 302-11.

Renn, O., 2008. 'Risk Communication: Insights and Requirements for Designing Successful Communication Programs on Health and Environmental Hazards'. In Handbook of Risk and Crisis Communication, edited by Robert L. Heath and Dan O'Hair, 80–98. Routledge Communication Series. New York: Routledge.

Solecki, W., Pelling, M., Garschagen, M. 2017. 'Transitions between Risk Management Regimes in Cities'. Ecology and Society 22 (2). https://doi.org/10.5751/ES-09102-220238.

Terpstra, Teun. 2011. 'Emotions, Trust, and Perceived Risk: Affective and Cognitive Routes to Flood Preparedness Behavior'. Risk Analysis 31 (10): 1658–75. https://doi.org/10.1111/j.1539-6924.2011.01616.x.

UN 2015a. The Sendai Framework for Disaster Risk Reduction 2015-2030. https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf.

UN 2015b. Transforming Our World: The Agenda 2030 for Sustainable Development. A/Res/70/1. https://sustainabledevelopment.un.org/post2015/transformingourworld/publication.

UN. 2015c. Paris Agreement. C.N.575.2019.TREATIES-XXVII.7.d. https://unfccc.int/process/the-paris-agreement/status-of-ratification.

UN DESA, 2019. 'World Urbanization Prospects: The 2018 Revision'. ST/ESA/SER.A/420. New York: United Nations. https://population.un.org/wup/Publications/.

UNDRR, 2005. Hyogo Framework of Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. A/CONF.206/6. https://www.unisdr.org/we/inform/publications/1037.

UNOCHA, 2017. 'Myanmar: Recent Natural Disaster Overview (as of 28 June 2017)'. Thematic Map. https://reliefweb.int/map/myanmar/myanmar-recent-natural-disasters-overview-28-june-2017.

WBGU – German Advisory Council on Global Change, 2016. 'Humanity on the Move: Unlocking the Transformative Power of Cities.' Berlin: WBGU. https://issuu.com/wbgu/docs/hg2016_en_highres.

Zin Mar Than, Tin Tin Kyi, Kraas, F., 2020. 'Institutional Preparedness for Multiple Risks in Yangon, Myanmar'. MAAS XVIII (5B): 61–74.

Project partners and Co-authors

Dr. Zin Mar Than, Prof. Dr. Frauke Kraas
Institute of Geography, University of Cologne
Cologne, Germany

Dr. Christian Miller, Stefan Martini, Annika Vinnemeier
Cologne Fire Department, Institute for Security Science and Rescue Technology (ISR)
Cologne, Germany

Dr. Marlene Willkomm
Flood Protection Centre of the Municipal Drainage Operation of the City of Cologne (StEB Köln)
Cologne, Germany

Dr. Toe Aung, Tin Tin Kyi, Win Lei Mar
Yangon City Development Committee (YCDC)
Yangon, Myanmar

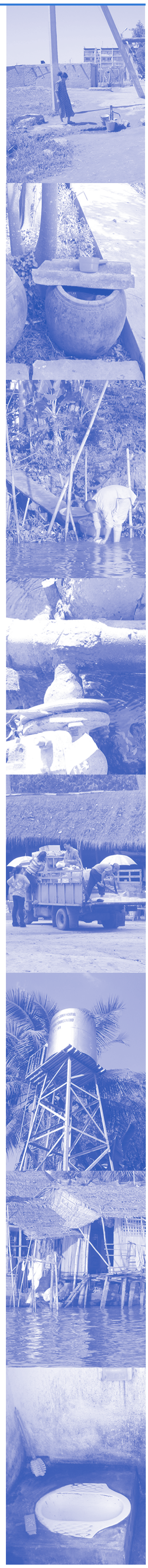
Dr. Win Maung
Myanmar Environment Institute (MEI)
Yangon, Myanmar

Dr. Benni Thiebes
German Committee for Disaster Reduction (DKKV)
Bonn, Germany

Dr. Sophie-Bo Heinkel

Institute of Geography
University of Cologne
Cologne, Germany

s.heinkel@uni-koeln.de



Publications

Policy Brief: Improving sustainable development in the North Western Sahara Aquifer System through a transboundary nexus approach

This policy brief highlights the main results of an assessment of the water-food-energy-ecosystems nexus in the North-Western Sahara Aquifer System (NWSAS), shared by Algeria, Libya and Tunisia. The assessment demonstrates that implementing a nexus approach to manage the NWSAS not only has multiple benefits, but also considerable potential to support further development of transboundary cooperation. The document is available in English and French.

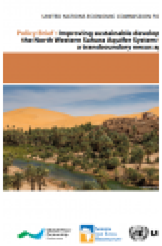
Safety guidelines and good practices for the management and retention of firefighting water

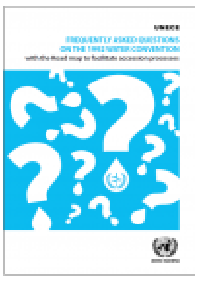
These safety guidelines and good practices have been developed to support governments, competent authorities and operators in minimizing the risk of fire and safely retaining firefighting water. They are intended to enhance existing practices and promote harmonized safety standards for firefighting water management and retention, in order to prevent accidental pollution of soil and water, including pollution that could cause transboundary effects. The document is available in English, French and Russian.

Frequently Asked Questions on the 1992 Water Convention

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) was adopted in 1992 and entered into force in 1996. This publication responds to the frequently asked questions about the Water Convention. It explains the obligations under the Water Convention and the way in which its institutional platform works, as well as the advantages for States to become Party to the Convention. It also addresses the relationship between the Water Convention and the 1997 United Nations Convention on the Law of the Non-navigational Uses of International Watercourses. The document is available in English.

All publications mentioned above can be found at: *https://unece.org/publications/environment-policy* Under this link all publications related to the Protocol on Water and Health can be retrieved as well.





WHO - Domestic water quantity, service level and health 2nd Edition

Sufficient quantities of water for household use, including for drinking, food preparation and hygiene, are needed to protect public health and for well-being and prosperity.

This second edition reviews the evidence about the relationships between water quantity, water accessibility and health. The effects of water reliability, continuity and price on water use, are also covered. Updated guidance, including recommended targets, is provided on domestic water supply to ensure beneficial health outcomes.

The document is available in English at: *https://www.who.int/publications/i/item/9789240015241*

To stay up-to-date with the latest WASH news by WHO, events and publications, send an email to LISTSERV@who.int with the text "subscribe WATERSANITATION" in the body of your email.

Imprint:

Publisher:
IHPH - Institute for Hygiene and Public Health
WHO Collaborating Centre for Health Promoting Water Management and Risk Communication
Venusberg-Campus 1
53127 Bonn, Germany
phone: +49 (0)228 - 287 19515
fax: +49 (0)228 - 287 19516

Editors: Dr. Andrea Rechenburg, Prof. Dr. Thomas Kistemann, Prof. Dr. Nico Mutters, Valentina Grossi, Felix Waßer

Layout: Farah Saad Alhyalie
Contact: whocc@ukbonn.de
ISSN: 2191-9674

Contributions reflect the opinion of the authors and are not necessarily in correspondence with the position of the IHPH.