RISE: A Case Study for Design Research in Informal Settlement Revitalisation Interdisciplinary Design Research in Informal Settlements

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Abstract

This paper reflects on the strategies and challenges of RISE (Revitalising Informal Settlements and their Environments), an on-site slum-upgrading program focusing on human and environmental health. RISE is a five-year action research program that adopts an integrated approach to water-sensitive revitalisation of informal settlements and investigates its environmental and human health impacts. Funded by the Wellcome Trust and the Asian Development Bank, the program's primary goals are to improve sanitation, mitigate flooding and improve dwelling and open space provision. Beyond health research and assessment, the program includes the development of a series of integrated urban design interventions for two pilot sites and 24 informal settlements in the cities of Makassar (Indonesia) and Suva (Fiji), based on a design philosophy of community engagement, multi-functionality, and adaptability. The solutions are co-developed with communities through an extensive process of co-design and engagement with work from a diverse interdisciplinary team, which includes experts from engineering, ecology, hydrology, architecture, landscape architecture and community engagement. The design interventions will take place in three rounds. The first round uses the pilot sites as a proof-of-concept to test the effectiveness of the design approach in informal settlement revitalisation. The second includes the development and implementation of interventions in six settlements in each of the cities. In the third, the design process is iterated for the remaining six settlements in each city. The paper examines aspects of the action research in the design and delivery of revitalisation projects, focusing on the pilot project in Makassar. It reflects on the development of the intervention for a small community located in the subdistrict of Batua in Makassar, Indonesia and the challenges that informed the final design.

Introduction

The challenge of informal urban settlements and health

Urbanisation is a major demographic trend globally. Informal settlements, which constitute much of the Global South's urban growth and one billion people worldwide, are generally established through processes that occupy undeveloped land.[1,2,3] The land can be high-risk, of ecological and biodiversity significance, and often unsuitable for residential development because of proximity to waterways and floodplains, steep hillsides, and interstitial spaces[4]. Along with poor environmental and socio-economic conditions, informal settlements are especially vulnerable to ill health. Beardsley and Werthman remarked that beyond climate change, "there are few greater challenges to widespread planetary health and security than the vast proliferation of [informal] settlements".[5] Over the past decades, the predominant strategies for addressing informal settlements have shifted from relocation and clearance to on-site upgrading and improvement.[6] However, although there is broad agreement that on-site revitalisation has better social and community outcomes, a number of challenges emerge from supporting communities in place.

This paper discusses the strategies and challenges of RISE, an on-site slum-upgrading program focusing on human and environmental health. On-site revitalisation presents a combination of issues relating to land ownership and tenure, along with servicing challenges and environmental risks such as flooding.

A Global Challenge - Planetary Health

A growing body of evidence shows linkages between human health and the health of the environment.[7] The planetary health approach explores the interdependency of the health of human civilization and the state of natural systems.[8,9] The RISE Project takes planetary health principles as its modus operandi, exploring the interlinking and interdependencies of changes to the built environment vis-à-vis health outcomes.

Human and Environmental Health Challenges in Urban Slums

Human health issues in slums are significant. UNICEF and WHO have reported that more than 663 million people lack access to safe drinking water, and 159 million rely on surface water for their water consumption.[10] 2.4 billion people lack access to sanitation facilities. Inadequate water supply, sanitation and drainage in crowded environments lead to faecal contamination of soil and water,[11] which predisposes residents to diseases, intestinal inflammation, stunted growth, and poor cognition.[12] Studies have shown that drinking water and sanitation facilities at the household and community level affect diarrhoea prevalence among children under five,[13] along with mothers' behaviours (such as handwashing) and education levels.[14] Though subsistence agriculture and animal keeping can benefit low-income families, sources of bacteria and contamination within the environment - such as soil in chicken coops, and greywater used for irrigation - can cause ill-health.[15,16] Meanwhile, settlements close to waterways and water-logged or poorly drained areas are subject to mosquitoes, rats and other vectors, increasing risk of vector-borne diseases.[17,18,19] As urban populations expand, the prevalence of vectors and their related diseases does too.[20]

The RISE Project

The RISE project seeks to repair informal settlement environments by providing an alternative, water-sensitive approach to their revitalisation. It examines informal-settlements and the conditions affecting human and environmental health and proposes integrated strategies for their revitalisation. The project, comprising an interdisciplinary team working in partnership with local communities, NGO's and Governments, focuses on 26 informal settlements in Makassar (Indonesia), and Suva (Fiji). The project sites are variously characterised by combinations of tidal inundation with occasional storm surges, fluvial and pluvial flooding, and poor drainage. In addition, sites suffer from intermittent water supply of varied quality and inadequate or absent sanitation systems. This results in high rates of exposure to environmental faecal contamination.

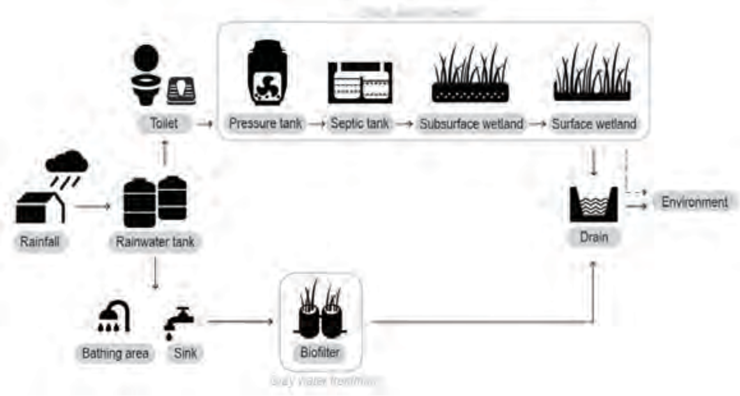

Figure 1: The RISE water sensitive cities system.

The RISE Approach

Within the context of planetary health, the team views the cumulative effects of the water cycle in informal settlements as a critical factor aggravating the associated challenges of poor environmental quality and human health. Funded by the Wellcome Trust's 'Our Planet Our Health' initiative and the Asian Development Bank, RISE will address these challenges by developing and implementing precinct-based interventions resulting in a sustainable water-supply, increased sanitation, improved flood protection, environmental stewardship, and greater resilience to effects of climate change. Design is a common ground for scientists and practitioners to bring scientific knowledge into decision making about landscape change.[21] The project will use a range of tools and methods from both science and design practice to design and implement this adaptive water-sensitive urban infrastructure (Figure 1). These include environmental modelling (i.e. catchment hydrology) and action research supported by design research principles. Action research - a method used for improving practice – involves action, evaluation, and critical reflection. Changes in practice are implemented, based on the evidence gathered. [22,23] This is particularly appropriate for the RISE project, which involves the site-specific improvement of environmental conditions - specifically related to factors influencing the health of the community. The design interventions of the RISE project operate on varying scales – from dwelling, to neighbourhood, to precinct. They include built elements, such as sanitation and rain harvesting facilities, green infrastructure, and community engagement models for households, focus groups and communities. Through these multi-scalar, site-specific water-management systems, the project targets human and ecological health challenges to mitigate water-borne disease.

The paper examines aspects of the action research into the design and delivery of revitalisation projects, focusing on a pilot project in the subdistrict of Batua, Makassar. The following sections reflect on the development of a small community pilot project and the challenges that informed the final design. The work discussed is the result of a collaboration between RISE researchers and practitioners in Melbourne and the RISE team in Makassar between August 2017 and May 2018.

The Makassar City Context

The city of Makassar is located in South Sulawesi in Indonesia. The city has a land area of 17,577 hectares and a population of 1.4 million people,[24] expected to increase 20% by 2020.[25] High population density and limited land availability place constraints on the city's existing sanitation system.[26] Water supply is also a major challenge, with distribution infrastructure limited and supply intermittent.[27] When mains water is unavailable households use alternative sources such as rainwater, bore water and shallow wells for non-potable uses. Population growth and urbanisation exacerbate these conditions. Water cycle management is particularly important to the outlook of Makassar's informal settlements, with many of them located in tidal areas, along the coast or rivers,[28] and who are even more vulnerable to the above issues.

The Batua Pilot Project

The Batua pilot project was developed to demonstrate the types of interventions envisioned in the RISE program to its key partners: central and local government, ADB, academia and the communities. The pilot helped the project team and stakeholders understand the processes required to deliver the intervention, and the implications, costs, construction timelines, and other operational aspects. The lessons from the pilot will guide the design and implementation of the project in the main twelve sites in Makassar.

The site context

The local water catchment defines the precinct-scale (Figure 2). It is bounded on three sides by canal inspection roads, which service a city water supply canal (wrapping around from North to East), and a stormwater canal (running East-West and framing the site to the South). The neighbourhood (Figure 3) has 47 residents, with an average household size of 4.27 with an average of 2.45 children per household. Most men are employed as day-labourers and women are homemakers. The site is informally subdivided into 22 parcels, half are developed with housing (Figure 3). This is mixed in quality, and most are raised on stilts for flood protection.

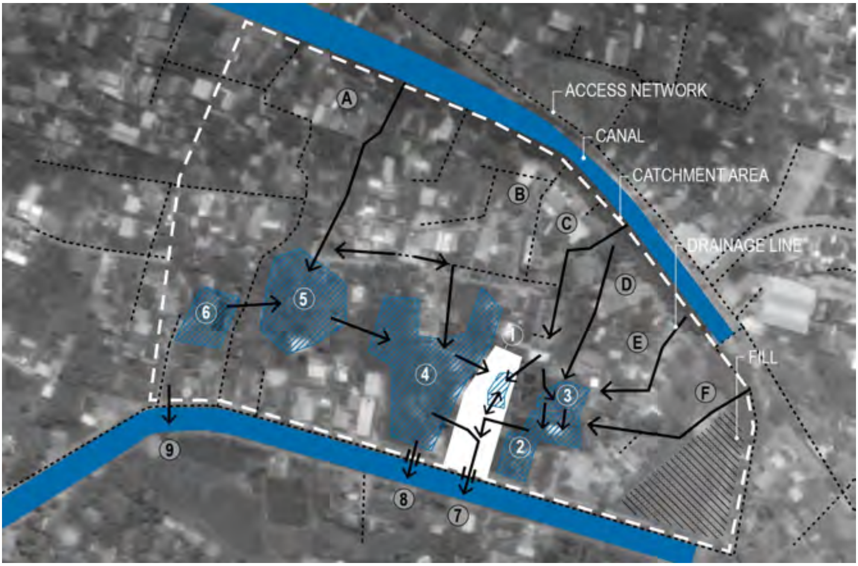

Figure 2: The Precinct is marked with a dashed white line, and the pilot site is shaded in white. Waterways and catchments are indicated in solid and hatched blue, respectively, and existing culverts discharging to stormwater canal (not all functional) are shown at 7, 8, and 9.

Figure 3: [Left] Aerial view showing site layout. The stormwater canal (at top) shows signs eutrophication caused by the presence of excess nutrients, such as sewerage; [Right] Typical view of dwellings within the pilot site.

Integrated Urban Design Approach

The project team conceived the design as a holistic and integrated approach to improving access to water, wastewater treatment, flooding and access simultaneously. The team included experts from engineering, ecology, hydrology, architecture, landscape architecture and community engagement. Figures 4 and 5 capture the final proposed intervention, developed by the project team with the community and local government.

The participatory process ensured community support of the proposal, and resulted in community contributions – such as land donation and community contracting for construction works. As a result, the access easement is extended from three- to five-metres through land donation to accommodate the green infrastructure, vehicular access, and to support future growth of the settlement. The community reviewed the design, ensuring project delivery without demolition of existing structures.

The process also resulted in the local government funding elements outside the scope of the RISE program. These are part of a second construction phase, completed in the remaining one and a half metre-wide strip of donated land (Figure 5). The works include permanent access (stairs and ramps) to houses and undercrofts; trees, benches and open spaces for improved public amenity; path lighting; a solid waste management system; and the sanitation management system for the anticipated future development.

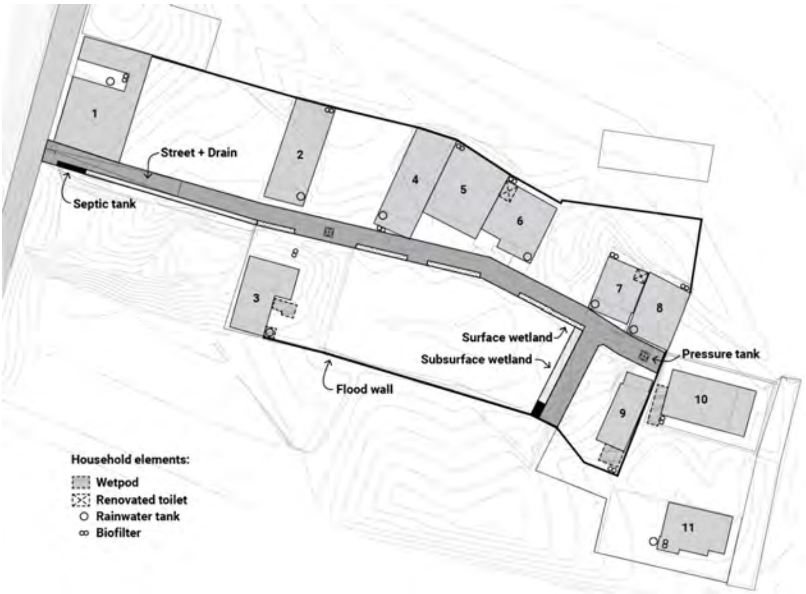

Figure 4: Plan of the water-sensitive cities approach for Batua, Makassar. (North oriented to right).

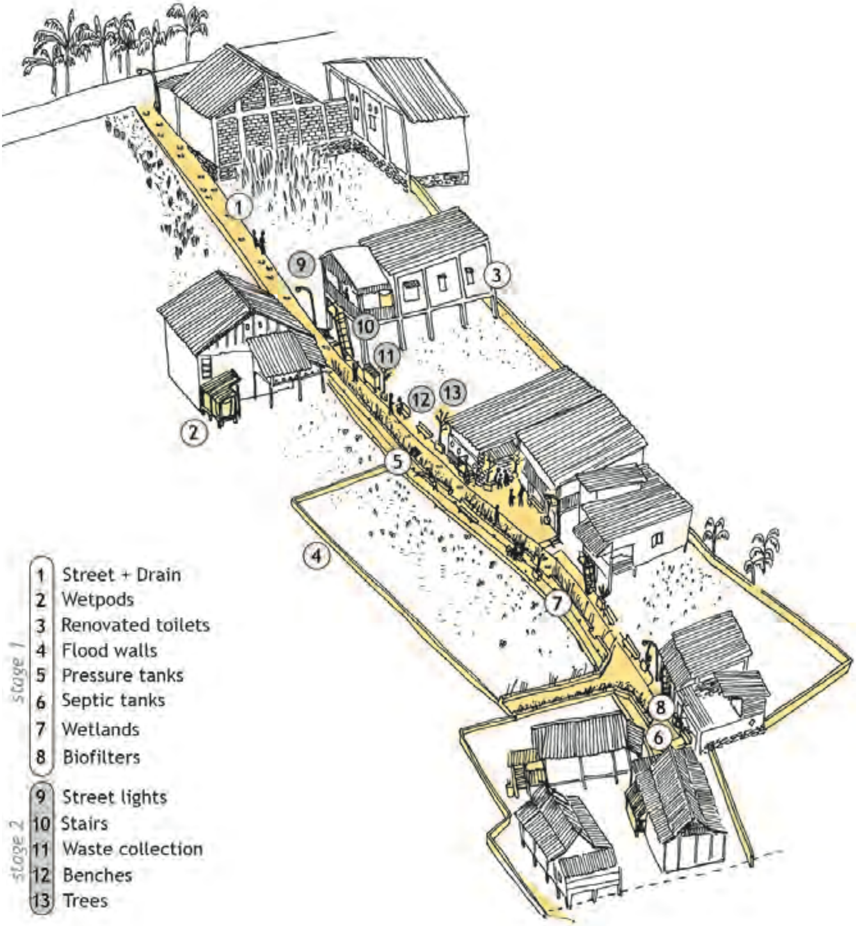

Figure 5: Axonometric of the water-sensitive cities approach for Batua, Makassar. Intervention in yellow, illustrating Stage 1 elements funded by ADB and Stage 2 elements funded by local government.

Drainage Strategy

The precinct-level hydrological analysis shows several connecting areas drain into the site, with water discharged to the canal through a culvert. The site is regularly flooded during the wet-season, which residents report occurs during heavy rains when the canal overtops. Floodwaters reach a maximum depth of 120cm, and remain up to three days before draining. During the wet-season residents use rafts and erect a makeshift elevated pathway constructed of bamboo.

Figure 6: The neighbourhood [left] is flooded during the wet-season [right].

Although the project team acknowledged that flooding was a larger regional challenge, beyond the scope of the RISE intervention, a series of external (precinct) and internal (neighbourhood) changes could improve the situation and reduce contamination pathways.

The hydrological analyses inform a range of water management interventions for precinct flood protection and drainage (Figure 7). These include a flood diversion wall to the western side of the site, and a series of new culverts with floodgates to control drainage into the canal. Meanwhile, water management interventions for the settlement are integrated, including a flood-wall, a raised path with covered drain, an improved culvert to the canal, and natural surface drainage (Figure 7). These strategies are complemented by the precinct-level improvements.

The path is elevated one-metre above the lowest point of the site (Figure 8). This allows its surface to be trafficable most of the time - for pedestrians and motorcycles, and for emergency vehicles. It also recognises community aspirations for neighbourhood development, which include future access extension to the east and the process of infill.

Figure 7: Flood protection strategies at Precinct and site levels. The Precinct is marked with a dashed white line, and the pilot site is shaded in white. Waterways and catchments are indicated in solid and hatched blue, respectively, and improvements such as floodwalls and culverts in yellow.

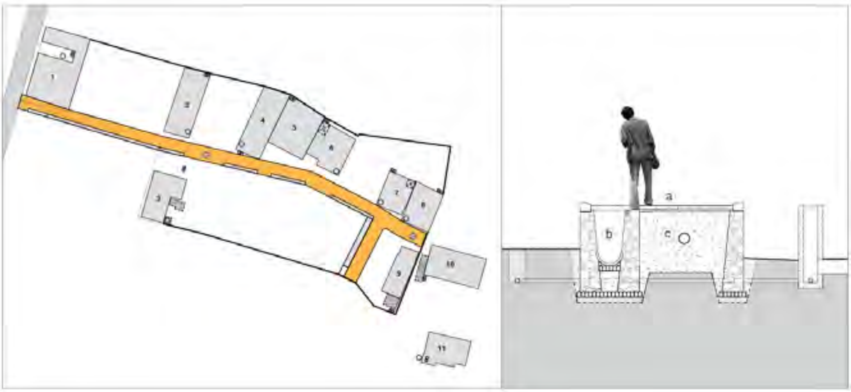

Figure 8: Integrated drainage within path and at-grade drains for surface water.

Sanitation Management Strategy

While most of the houses have private toilets with manual flush, some are in poor condition. The blackwater runs into belowground tanks, which are unsealed and allow effluent to leach into the soil contributing to the contamination of shallow wells. Greywater and solid waste are discharged to the surrounding environment. They mix with floodwaters during heavy rains, compounding the risk of well contamination and overall public health impacts.

The project includes toilet improvements to two dwellings and three new ‘wetpods’ (consisting of a toilet, a bathing area, hand basin and rainwater tank). A range of different wetpods were developed to suit access requirements, and orientation of dwellings. Through the co-design, these were discussed with households and adapted to suit houses on the site (see Figures 9 and 10).

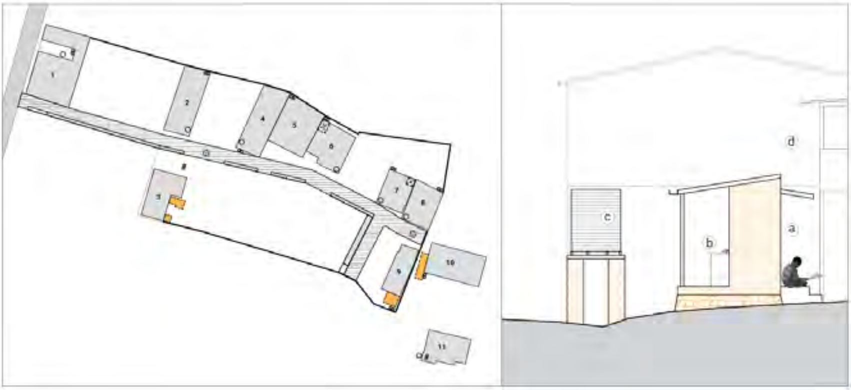

Figure 9: [Left] Wetpod strategy illustrated in plan shows new wetpods in orange, provided to buildings 3, 9 and 10. [Right] Section showing a wetpod with detached rainwater tank adjacent to an existing building.

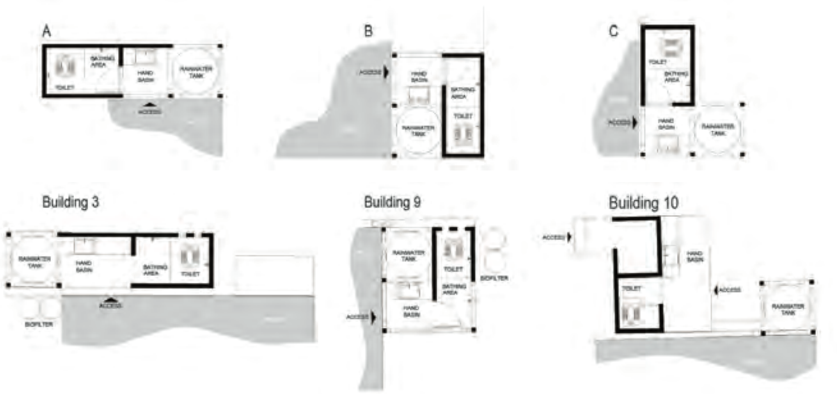

Figure 10: A, B and C demonstrate the original wetpod types and the plans for buildings 3, 9 and 10 illustrate how the wetpods were adapted to address the existing configuration and household requirements.

All existing, new and improved toilets are connected to the blackwater treatment system (Figure 11). This purifies the effluent before discharge to the environment. Effluent from household toilets flows by gravity into two community pressure tanks (each servicing five to six houses, Figure 12), and is pumped to a community septic tank (Figure 13). Effluent then flows by gravity into sub-surface wetlands for secondary treatment, and to surface wetlands for final treatment before discharge into the covered drain along the elevated path. The core infrastructure - pressure tanks, septic tanks, subsurface and surface wetlands - are located along the path, safe from regular inundation. The wetlands are in narrow, easy to maintain, boxes along the road (Figure 14) with breaks accommodating access to existing, and future houses. Household greywater is piped to individual biofilters for purification, then to the covered drain. The biofilters are two joined 200-litre drums, which are readily available and allow compact, replicable treatment (Figure 15).

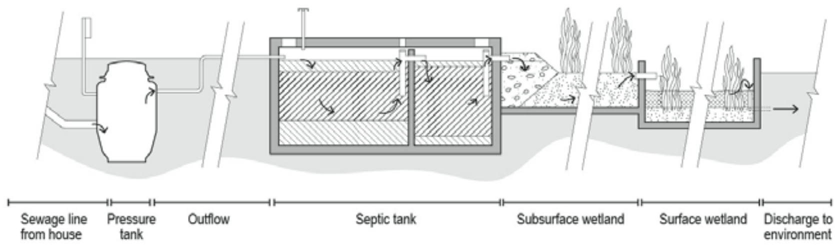

Figure 11: RISE blackwater treatment train.

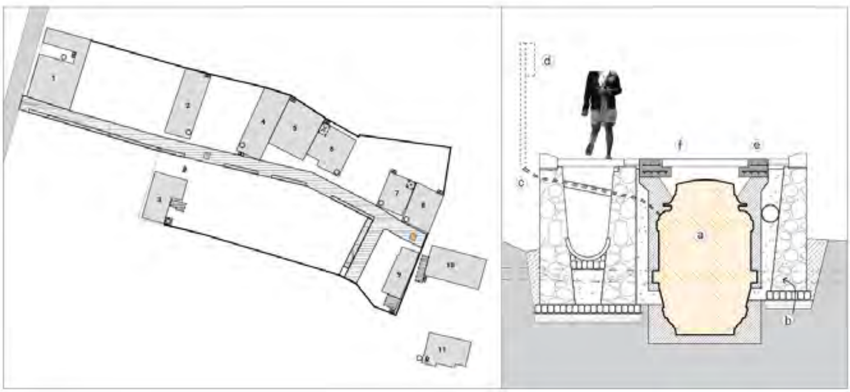

Figure 12: [Left] The settlement receives two pressure tanks within Phase 1; [Right] Community pressure tank within path profile.

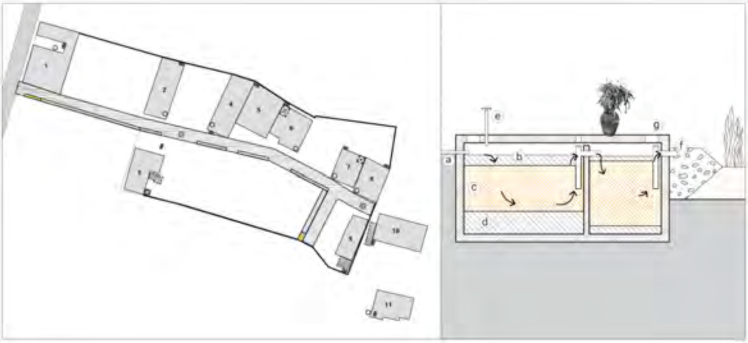

Figure 13: The septic tank is located in the donated one-metre strip to the West of the path.

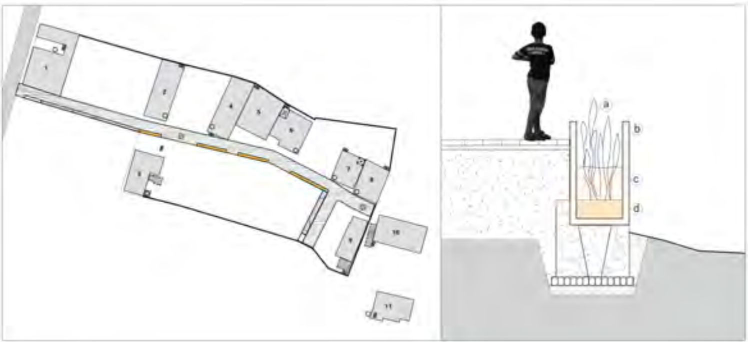

Figure 14: The surface wetlands are located in the donated one-metre strip to the West of the path.

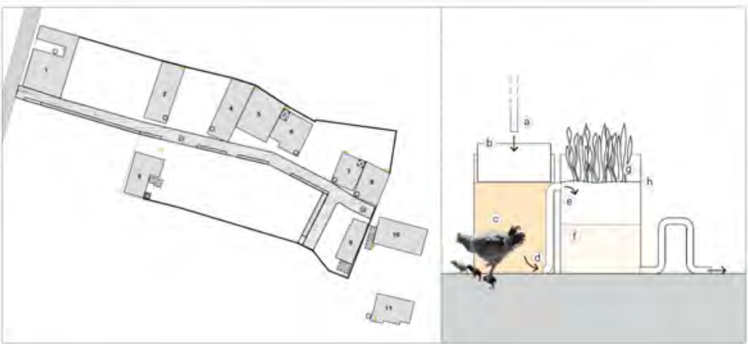

Figure 15: The greywater treatment biofilters are located adjacent to each house and constructed from readily available 200-litre drums.

Water Supply Strategy

Only a few houses have direct connection to municipal water, others have connections via other households or businesses. Although households drink bottled water and boiled mains water, residents have identified this as a significant cost.

The project improves access to potable water. Municipal supply is piped to lot boundaries, and households are responsible for their own connection. Each house receives a rainwater tank, which supplies water for washing, bathing and flushing toilets (Figure 16). The tanks can reduce both the costs of water supply and surface water runoff to the site.

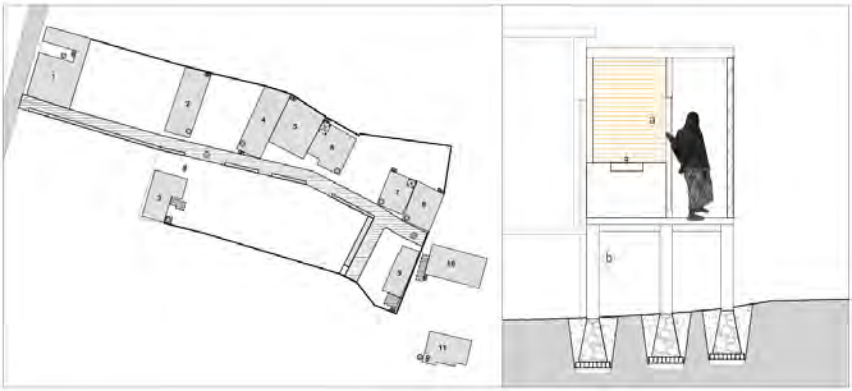

Figure 16: Households receive rainwater tanks to diversify water supply and reduce stormwater runoff.

Challenges

The RISE pilot project in Makassar responds to a range of challenges at play when conducting design research within the informal settlement context. These include a combination of socio-political, technical and environmental issues. The following section outlines some of the challenges encountered and how the response to these informed the design approach and decision-making process for the pilot site.

Socio-political challenges

The socio-political issues encountered vary in scale, from the local community, and the local government, to the capital works funding.

Ambiguous land ownership and title boundaries

The complicated land tenure and ownership arrangements within the site - resulting from an informal subdivision process – meant that property boundaries were neither orthogonal nor legible, and in some cases exceeded. The project team approached this in a number of ways: establishing a common understanding of property boundaries through an onsite boundaries mapping exercise, and through community visioning sessions to understand the community’s aspiration in terms of public infrastructure and amenity.

Lack of public land

There was little available land for public amenities and for infrastructure delivery in the pilot site, a condition typical of resource-constrained settlements. In this setting, donation was required for the provision of green infrastructure and public amenities beyond the private realm. While the community were enthusiastic and supportive from the outset, the team encountered some resistance due primarily to a lack of comprehension of the overall benefits. To guide this process and the tensions associated with land donation, effective communication and engagement with community was essential. Through this process, households voluntarily donated one-metre of land adjoining the path, so the path could accommodate vehicular traffic, public amenity and water and sanitation infrastructure.

Exemplar slum upgrading programs

Reference to and alignment with similar existing government programs proved to be helpful in delivering the design. The Neighbourhood Upgrading Shelter Program (NUSP) projects,[29] implemented in Indonesia since 2005 has established a positive precedent of community land donation and co-contribution to projects. Referring to NUSP and understanding its operations facilitated the process of community consultation leading to boundary delineation and land donation.

Government stakeholder engagement

Like many informal settlements in developing cities, the neighbourhood established on low-value land caused by difficult access and hazardous flood conditions. Because of the infrastructural focus of the intervention, the team engaged with multiple government groups to resolve planning issues: from State level, such as land-use change, to Provincial level, such as flood gate implementation along a canal under Central Government jurisdiction. In addition, engagement with sub-district authorities was important to understand operations and maintenance of public infrastructure. It has been important to develop good partnerships with Government ministries from the beginning to ensure support of the strategies and vertical coordination between government levels to achieve a good outcome.

Donor funding requirements

The capital works funding, supported by the Asian Development Bank (ADB), was constrained to elements directly relating to the delivery of the water infrastructure and had a number of protocols relating to its use (for example, exclusion of works to houses). Because of the community visioning exercises and workshops with local government, co-funding with the city of Makassar was explored for financing additional infrastructure and elements. To ensure timely delivery of the works, unaffected by political cycles, the team developed delivery through two separate civil works packages with clearly marked responsibilities and funding lines.

Technical challenges

The pilot project revealed a range of technical issues relating to the detailed engineering design and delivery of the project and its timeframes.

Working in data poor environments

Limited data is available on the physical environment, for example cadastre information, water quality, groundwater condition and recharge levels, river flows, and water consumption patterns. In most cases, data record periods are not continuous, or are inaccurate.[30]

Construction constraints

The water-sensitive approach within the informal settlement context is novel and requires a high degree of construction precision in specific locations to ensure achievement of effective gravity flows.

Environmental challenges

The pilot project revealed a range of environmental issues relating to the locations of settlements and their physical environment.

The project highlighted the environmental impact of urban settlements, particularly when considering improvement in-situ versus relocation. The process of informal development in the pilot site, land reclamation via infill, caused the loss of a retention basin. The neighbourhood remains vulnerable to climate change impacts on the hydrology of the larger catchment. The project team developed a precinct-wide hydrology response to ensure the minimisation of catchment impacts on the site, while ensuring that responses would not exacerbate hydrological issues in the region.

Some conclusions and strategies for further work

The challenges encountered in the pilot project in Makassar, alongside a similar pilot project in Suva not discussed in this paper, provide valuable lessons for future work in the 24 RISE settlements in Indonesia and Fiji. In order to deliver a large number of interventions in these unknown and dynamic environments the team must develop cohesive methods and tools for action. The final section outlines some of these strategies.

Build strong technical and community engagement and co-design teams in country

As the intervention involves a new approach to decentralised infrastructure provision, the team is committed to procuring and training in-country technical staff for detailed engineering design, construction and supervision to meet requirements and specifications. In addition, without baseline information to inform hydrological modelling and design interventions, the team is developing tools and infrastructure for data collection and management. These include field mapping and documentation frameworks partnered with the community (to determine property boundaries, flood levels and contamination sources), and training the local teams to use drones to capture frequent geometrically corrected aerial photographs of the site which can be used to document changing conditions such as development and floods.

Develop early and continuous engagement frameworks with community and government stakeholders to ensure buy-in and ongoing support for the project

As resource constrained governments struggle to keep up with the pace of development of informal settlements, they often ignore new developments. Land regularisation and infrastructure provision in the context of informal settlements requires new planning approaches and communication and engagement frameworks with numerous public authorities (central, provincial, state and local).

Develop models or templates for adaptation to local context

The team is developing guidelines for the adaptation of nature-based water-sensitive technologies to dense, informal urban settings. This will include using hydrological models to understand catchment hydrology and dynamics to ensure appropriate responses. The process for adapting these responses to specific conditions across a diverse and complex array of contexts will require effective dialogue with communities and stakeholders. Co-design processes are integral to develop trust, common visions and ownership for the projects. The team is developing guidelines for these processes from lessons learned. These include tools and procedures for community engagement ensuring informed consent and inclusion. This should include a kit of parts for physical elements of water sensitive cities - wet-pods, wetlands, septics, flood mitigation and drainage - relating to site topography, land availability, water stressors and contamination exposure. Then, streamlined design options can easily accommodate community and household preferences.

This paper has reflected on the approach, challenges and strategies of the RISE project undertaken by the ICL. It examined aspects of the action research in the design and delivery of slum revitalisation projects, using as an example the pilot project in Makassar. Given the challenging project contexts and requirements, robust and resilient approaches are necessary. The lessons from this pilot phase have instituted a firm foundation and strategies that will be significant in the next round, which will iterate the process within the first 12 neighbourhoods across the two cities.

Acknowledgements

This paper draws on lessons learnt from the research activities of the ICL on the RISE project. It incorporates information from a range of project documents, including mission reports, technical drawing sets, and engagements with communities. These documents included contributions from the project team – Diego Ramirez-Lovering, Michaela Prescott, Hesam Kamalipour, Mohamed El-sioufi, Tony Wong, Peter Breen, Kerrie Burge, Christian Urich, Ashley Wright, Dasha Spasojevic, Brendan Josey, Erich Wolff, and Mahsa Mesgar - with support from the Makassar In-Country team including Ihsan Latief and Jane Wardani. The authors extend their sincere gratitude to local leaders, city and national government counterparts, and in particular, to the pilot project community for their time, support and contribution to the program.

References

[1] Nezar Alsayyad, "Squatting and culture: A comparative analysis of informal developments in Latin America and the Middle East." *Habitat International* 17, no. 1 (1993): 33-44.

[2] Jean-Louis Van Gelder, "Tales of deviance and control: on space, rules, and law in squatter settlements." *Law & society review* 44, no. 2 (2010): 239-268.

[3] José Gabriel Siri, "Sustainable, healthy cities: making the most of the urban transition." *Public Health Reviews* 37, no. 1 (2016): 22.

[4] Olumuyiwa Bayode Adegun, "Green infrastructure in relation to informal urban settlements." *Journal of Architecture and Urbanism* 41, no. 1 (2017): 22-33.

[5] John Beardsley and Christian Werthmann. "Improving informal settlements." *Harvard Design Magazine Spring* (2008): 31-34.

[6] Beardsley and Werthmann. "Improving informal settlements."

[7] Sarah Whitmee, Andy Haines, Chris Beyrer, Frederick Boltz, Anthony G. Capon, Braulio Ferreira de Souza Dias, Alex Ezeh et al. "Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health." *The Lancet* 386, no. 10007 (2015): 1973-2028.

[8] Richard Horton and Selina Lo. "Planetary health: a new science for exceptional action." *The Lancet* 386, no. 10007 (2015): 1921-1922.

[9] Whitmee et al. "Safeguarding Human Health".

[10] UNICEF & WHO. "Progress on Sanitation and Drinking Water – 2015 update and MDG assessment". (2015). Retrieved from http://www.unicef.org/publications/files/Progress_on_Sanitation_and_Drinking_Water_2015_Update_.pdf

[11] A. Y. Katukiza, M. Ronteltap, C. B. Niwagaba, J. W. A. Foppen, F. Kansiime, P. N. L. Lens, Sustainable sanitation technology options for urban slums. *Biotechnology Advances*, 30, (2012), 964.

[12] Oliver Gruebner, M. Mobarak H. Khan, Sven Lautenbach, Daniel Müller, Alexander Krämer, Tobia Lakes, and Patrick Hostert. "Mental health in the slums of Dhaka-a geoepidemiological study." *BMC Public Health* 12, no. 1 (2012): 177.

[13] Ahmad Komarulzaman, Jeroen Smits, and Eelke de Jong. "Clean water, sanitation and diarrhoea in Indonesia: Effects of household and community factors." *Global public health* 12, no. 9 (2017): 1141-1155.

[14] Lindsey Watson, Tomoyuki Shibata, Ansariadi, Alimin Maidin, Ivan Nikitin, and James Wilson. "Understanding modifiable risk factors associated with childhood diarrhea in an eastern Indonesian urban setting." *International Journal of Health Promotion and Education* 53, no. 1 (2015): 42-54.

[15] E. C. Pehrsson, P. Tsukayama, S. Patel, M. Mejía-Bautista, G. Sosa-Soto, K. M. Navarrete, M. Calderon, L. Cabrera, W. Hoyos-Arango, M. T. Bertoli, D. E. Berg, R. H. Gilman, G. Dantas, Interconnected microbiomes and resistomes in low-income human habitats. *Nature*, **533**, 212 (2016).

[16] Courtney Maloof Gallaher, Dennis Mwaniki, Mary Njenga, Nancy K. Karanja, and Antoinette MGA WinklerPrins. "Real or perceived: the environmental health risks of urban sack gardening in Kibera slums of Nairobi, Kenya." *EcoHealth* 10, no. 1 (2013): 9-20.

[17] B. B. Campion, "Urban Wetland ecology and flood in Kumasi". Unpublished PhD Thesis. Institut für Geographiean der Universität Bremen. (2012).

[18] Meili Baragatti, Florence Fournet, Marie-Claire Henry, Serge Assi, Herman Ouedraogo, Christophe Rogier, and Gérard Salem. "Social and environmental malaria risk factors in urban areas of Ouagadougou, Burkina Faso." *Malaria Journal* 8, no. 1 (2009): 13.

[19] John Bosco Isunju, Christopher Garimoi Orach, and Jaco Kemp. "Hazards and vulnerabilities among informal wetland communities in Kampala, Uganda." *Environment and Urbanization* 28, no. 1 (2016): 275-293.

[20] Gwendolyn KL Wong and C. Y. Jim. "Abundance of urban male mosquitoes by green infrastructure types: implications for landscape design and vector management." *Landscape Ecology* 33, no. 3 (2018): 475-489.

[21] Joan Iverson Nassauer and Paul Opdam. "Design in science: extending the landscape ecology paradigm." *Landscape ecology* 23, no. 6 (2008): 633-644.

[22] Elizabeth Koshy, Valsa Koshy, and Heather Waterman. *Action research in healthcare*. Sage, 2010.

[23] Cal Swann, "Action research and the practice of design." *Design issues* 18, no. 1 (2002): 49-61.

[24] Ministry of Public Works and Human Settlements, Makassar. "Slum Improvement Action Plan". 2016.

[25] Nihon Suido Consultants Co. Ltd., Nippon Koei Co. Ltd and KRI International Corp. "The preparatory survey on the Makassar water supply development project (Stage II) in the Republic of Indonesia. Interim Report, Volume I, Main Report". Japan International Cooperation Agency, Ministry of Public Works, South Sulawesi Province, PDAM Makassar, PDAM Gowa, PDAM Maros and PDAM Takalar, The Republic of Indonesia. (2011).

[26] G. Tjandraatmadja, A. Ahmad, M. Selintung, D. Kirono, S. Larson, D. Salman, R. A. Barkey et al. M. Ismail and Maheepala, S. “Context and challenges in urban water and wastewater services for Makassar, South Sulawesi, Indonesia.” A report prepared for the CSIRO-AusAID Research alliance. (2012).

[27] Tjandraatmadja et al. “Urban Water”.

[28] Prio Sambodho, Rizki Fillaili, and Robert Justin Sodo. "Integrating Spatial Aspects of Poverty into Urban Spatial Planning: Solutions for Tackling Urban Poverty." (2013).

[29] The Neighborhood Upgrading and Shelter Sector Project in Indonesia, ADB, 2012

[30] Tjandraatmadja et al. “Urban Water”.