SUEUAA Strengthening Urban Engagement of Universities in Africa and Asia

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Impact of University engagement on environmental resilience of urban spaces in Asia and Africa

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Abstract

By 2030 most of the globes inhabitants will be living with cities. It is therefore important that cities are resilient to sustenance and energy challenge in the face of increasing demands from population expansion and increasing environmental variability and uncertainty brought about by intensifying climate change. The Strengthening Urban Engagement of Universities in Asia and Africa (SUEUAA) project aims to enhance university engagement capacity in this context and optimise engagement strategy to maximise impact in urban areas. We use the term 'environmental resilience' to encapsulate both energy and sustenance challenges. We believe these must be tackled in a holistic manner as there are intimate links between the production and usage of energy, food and water and consequent generation and disposal of waste. This paper focuses on the experiences and vision of SUEUAA partners in Johannesburg (South Africa), Dar es Salaam (Tanzania), Duhok (Iraq), Sanandaj (Iran), and Manila (Philippines), so it encapsulates views and solutions for engagement strategies on several environmental challenges facing cities in very different climatic situations.

Introduction

Over 50% of the world's population currently live in urban environments. By 2030 this value is projected to reach 60% and one in every three people will live in cities with over 500,000 inhabitants (UN 2016). Environmental resilience of these domains, in the face of the considerable dual stresses of increased migration to urban centres and climate change, is a massive global challenge that universities in these settings are trying to tackle through working with a wide range of stake holders from international governance to local inhabitants.

The Strengthening Urban Engagement of Universities in Asia and Africa (SUEUAA) project aims to enhance university engagement capacity in emerging economies and optimise methods of engagement so that they are strategically aligned with promoting sustainable cities. The authors of this publication are drawn from five partner intuitions within SUEUAA and the scope of the paper is to highlight strategies for environmental resilience interventions by

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higher education institutions. The following sections will focus on direct experience from partner universities, but will also discuss, were appropriate, the efforts of other academic institutions in the partner's respective cities.

Urban populations require abundant sustenance and energy in order to function, and often both of these requirements are gathered, or generated, using natural resources. We therefore consider 'Environmental Resilience' to encompass fuel for both the individual inhabitants (i.e. water, food) and the city at large (i.e. electricity, power, transport).

It is very often the case that impacts on urban environments contain elements of 'natural' and 'man-made' influences. It is beyond the scope of this paper to differentiate between the nuances of the causes of impacts according to these two end-member scenarios. For example, flooding could be contributed to climate change; which, despite extensive scientific endeavours, the degree of anthropogenic influence could still be the subject of debate. A major environmental disaster such as a volcanic eruption, or an earthquake, could be considered, in most cases, to be completely natural. However, a geologist could potentially point to man-made influences on subsurface stresses that could trigger such events; or one could consider that it's the man-made building that the earthquake has knocked over that has caused the true impact.

We will mainly focus on academic interventions in response to long-term chronic environmental stresses, such as increasing temperature and air quality degradation from fossil fuel emissions. Major disasters will also be addressed within that locations specific context.

Urbanism

What is a city? Well, as it turns out, this is a more philosophical question than one would initially think. Most would agree that cities are typically heavily urbanised locations that contain large numbers of inhabitants and act as hubs for a nation's or region's economy and governance.

City limits are open to interpretation as no standardized physical criteria exists for determining the boundaries of a city (UN 2016). Several terms exist which try to explain certain core city or extended urban zones, but a lack of consensus means that these descriptions can be somewhat non-definitive (Yang and Yu 2017). Generally speaking, urban populations tend to be defined in terms of administrative, functional or ecological boundaries (Frey and Zimmer 2015).

Definitions of 'zones' by the UN World's Cities in 2016 report provide guidance terminology that generally fits with the common methods of recording spatial urban population data. These include:

- **City Proper.** A city according to an administrative boundary

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- **Urban agglomeration**. The extent of the contiguous urban area, or built-up area, to delineate the city's boundaries.
- **Metropolitan area**. Boundaries according to the degree of economic and social interconnectedness of nearby areas, identified by interlinked commerce or commuting patterns.

These definitions stop short of including the overall influence of a city both nationally, and internationally, so for the purpose of this paper we will consider these influences out of scope and focus on the tighter geographical region of the city up to the extent of the Metropolitan (or 'Metro') Area. Table 1 provides some baseline physical and population information for SUEUAA partner cities across Africa and Asia. As can be seen from the table, statistics are limited in some locations as measurements have not followed a consistent format. For example, it appears that the City area measurement for Dar es Salaam incorporates what would be defined as the limits of the Urban area in other locations. This highlights the difficulty of applying the above definitions as multiple different boundary definitions can be available for any given city.

City	Country	Location (WGS 84)	Elevation (m)	City area (km^2)	Urban area (km^2)	Distance to coast (km)	City population	City density (km^2)	Urban population	Urban density (km^2)	Metro population
Johannesburg	South Africa	26°12'S 28°2'E	1,753	334.81	3,357	460	957,411	2,900	7,860,781	2,300	9,616,000
Dar es Salaam	Tanzania	6°48'S 39°17'E	13	1,393	-	0	4,364,541	3,100	-	-	-
Duhok	Iraq	36°52'N 43°0'E	565	24.7	10,000	605	330,600	13,385	1,252,300	125.2	-
Sanandaj	Iran	35°18'N 46°59'E	1,538	3,033	-	612	412,767	136	-	-	-
Manila	Phillipines	14°35'N 121°00'E	6	42.88	1,474.82	0	1,780,148	71,263	22,710,000	15,398	-

Table 1: Baseline location and population statistics for SUEUAA partner organisation cities (including authors own contributions and information from Brinkhoff 2016; Firth 2011; Philippine census 2015; Philippine Statistics agency 2016; UN 2016; US CIA 2017). Cities are ordered from west to east (Africa through Asia).

The partner cities also vary widely with respect to climate, and this means that in certain situations, that each city must employ different environmental resilience intervention strategies. For example, Duhok has a Mediterranean climate and abundant sunshine, but this cannot be efficiently captured for electricity generation by mass deployment of photovoltaics due to high volumes of windblown sand and dust. Sanandaj, with an arid to semi-arid climate, has significant water resource challenges. Johannesburg has a subtropical highland climate, so has comparatively consistent year-round fairly-mild temperatures, but due to its elevation has real challenges with 'violent' or 'extreme' UV indexes (WHO 2002), that can lead to serious harm from unprotected sun exposure, during

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the summer months. Located proximal to the equator and being at sea level, Dar es Salaam and Manila have tropical wet and dry climates.

Interventions

The remainder of this paper will focus on strategic interventions employed by SUEUAA partner cities, with the main focus on those directly involving SUEUAA partner institutions. Overall the main driver has been to tackle environmental resilience in a holistic way that incorporates sustainable resources for both energy and sustenance to stimulate the local green economy. This approach has already been strongly developed in Johannesburg (Figure 1) and is already comprehensively incorporated into educational strategies at the University of Johannesburg's Process, Energy & Environmental Technology Station (PEETS) and their local institutional partners. The primary mandate for PEETS is to contribute towards improving the competitiveness of industry and SMEs through the application of specialized knowledge, technology and facilitating the interaction between industry (especially SMEs) and academia to enable innovation and technology transfer.

There are close linkages between the production and usage of energy and water and consequently generation and disposal of waste. PEETS endeavours to promote cross-disciplinary knowledge transfer that supports the development of the green economy by building on relationship with research and development networks within the UJ and NSI community as it relates to sustainable development in the energy-water-waste nexus. Overall PEETS focus is on Process Optimization, specifically in the energy and environmental sectors. In the Energy Sector, focus is on energy efficiency and renewable energy solutions, waste to energy conversion, microgrids and energy storage. In the Environmental Sector, focus is on waste utilisation and optimization, air quality management, water management and purification and desalination.

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Figure 1: University of Johannesburg Process, Energy & Environmental Technology Station (PEETS) Focus areas.

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Figure 2: PEETS Focus to support: (A) greening and capacity building in public transport and industry; and (B) green agribusiness innovations.

Concentrating on initiatives to support the green economy and finding the linkages with research conducted at the University of Johannesburg, PEETS strength lies in industry support relating to air quality control, energy management and waste management (Figure 2A). The technology station will expand on internal capacity in FY2017/18 to support and develop a green economy services industry in this environment by partnering with neighbouring technology stations, the Sustainable Energy Technology and Research (SeTAR) Centre, the UJ Energy M&V Group and research groups at UJ to accelerate on the roll out of these initiatives.

The Biofuel Research Network at UJ enhances the reach and capacity of PEETS and this relationship will be strengthened in the next financial year to support a research and innovation eco-system through strategic partnerships with local government, international research agencies and commercial partners. Linking the scaled production of solid waste to fuel conversion to the transport industry to existing initiatives to green the City of Johannesburg's fleet vehicles will be a key driver and application area for this focus area. This focus will require PEETS to expand air quality and particle emissions control capacity to support this growing industry on the continent, combating climate change and growing the biofuels industry.

The e-Mobility application area also extends to the last mile in public transport, supporting the development of lightweight electric vehicles to support the movement of people, logistics systems and expands to off-grid containerized small-scale manufacturing, supporting SMEs to retrofit and service e-bikes, and smart city data collection through geolocating and sensing using lightweight, electrically assisted vehicles. This research and development focus will also support the growth and development of solar charging stations, energy storage and smart grid applications.

Food, water and energy security form the basis of a self-sufficient economy, but as a water-scarce country with little arable land and a dependence on oil imports, South Africa's economy is testing the limits of its resource constraints. When supporting sustainable development, the focus shifts to the food-water-energy nexus in the agriculture sector, the services and circular economy, and the role of SMEs in the green economy. South Africa has the potential to be at the forefront of green agribusiness innovation. Its entrepreneurial culture, its leading role in the solar energy market in Africa and the importance of agriculture for the region all foster the development of cutting-edge energy solutions for the energy-agriculture nexus.

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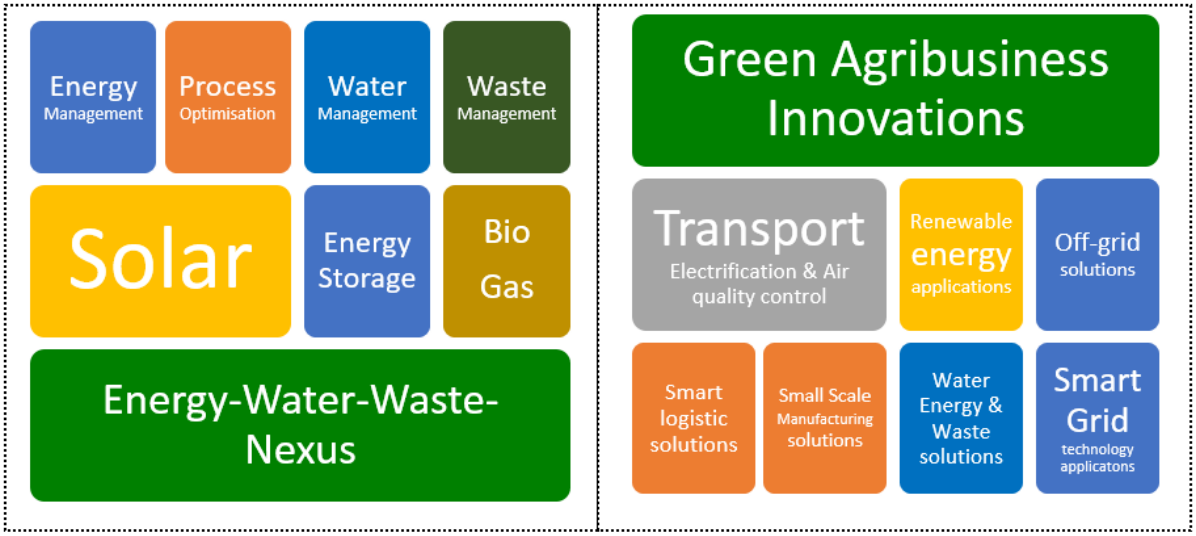

Figure 3: Building blocks to support SMEs growing the green economy.

Building on the established PEETS capacity of waste to energy conversion, the energy-water-waste-agriculture applications will link our focus areas to support SMEs in vulnerable communities. Continuing the support of rural and urban small-scale farmers throughout the value chain, PEETS will expand on renewable off-grid solutions to support production, food processing, water and waste management and logistics in this sector. The building blocks to support the green economy as it relates to the PEETS mandated is illustrated in Figure 2B highlighting the Technology development areas and the SME application areas to support the green economy (Figure 3).

PEETS focuses specifically on Solar and Bio energy/fuel. Biofuels are liquid or gaseous fuels derived from organic material or biomass. They are particularly important for the transport sector as a replacement for fossil fuel based fuels. Biofuels include bioethanol, biomethane, and biodiesel and bio hydrogen. Bioethanol produced from sugar and starch crops such as sugarcane and sugar beet, and biodiesel produced from vegetable oils such as canola, sunflower and soya. The government has excluded maize, South Africa's staple food, from use in biofuels production.

Similarly, the University of Dar es Salaam (UDeS), is diligently working on innovations in biofuel production. Over 90% of energy in Tanzania is sourced from wood fuel, which has large implications for deforestation, soil quality and surface water retention. Investigations in cooking stove innovation are paving the way to replace charcoal or oil based systems with seed oil. This has in part been driven by Government desire to decrease the use of charcoal in cooking. Currently, plant oils are largely imported from India and Malaysia. The UDeS team are researching appropriate plant-source feedstocks that are non-edible and drought resistant which can be grown in Tanzania to help fuel the local economy.

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In Tanzania, agriculture represents 50% of GDP, but it is typically small-scale and is heavily reliant on the climate, so even short-term perturbations can cause massive problems for productivity. The agriculture group of UDeS is working to combat macroeconomic issues, including government corruption, and unreliable power resources. A common theme form both PEETS and UDeS, is the promotion and creation of food gardens in derelict buildings. This take agriculture in to the inner city to increase, local production, ease transport logistics, improve livelihoods and change conceptions of farming, which is commonly seen as a low-level job. Effort are afoot to develop more interesting farming methods and technology to entice youth workers.

For the densely populated Manila which forms an Urban Heat Island (UHI), the main environmental risks are from fires and floods. The city is built on a river delta and many areas are situated below sea level. Many people live in and on former water ways that have been consumed as the city has grown. In the 1970's and flooding cleared within 1 to 2 hours, but now the city grinds to a halt during torrential downpours. The Philippines National University (PNU) and local public and private partners are engaged with local communities in an attempt to bring down communication barriers. Due to the vast volume of people, a key challenge in Manilla is connecting and harmonising with the public and penetrating local government. Attempts at interventions are also being made with concerns to electrification of public transport, and capture and utilisation of Manila's waste heat.

The major challenges for Sanandaj are development of renewables and earthquake resilience. Seismic activity is very common in the area and the city was recently impacted by a magnitude 7.3 earthquake. Though this was a terrible event, it has resulted in a rise of community openness and positivity towards helping across all aspects of society. Investigations on building materials and structures are underway, and this is feeding directly in the education programme. There are ca. 70,000 students in the Kurdistan area across 10 universities, but currently 40% of graduates are unemployed across all levels. It is hoped that tying education to real challenges, such as earthquake resistant construction could help address this issue. There are also issues with damning of rivers in the Kurdish area. 50 to 70 damns have been built since the revolution to divert drinking water to central Iran. This has led to massive environmental damage of rivers so investigations are underway to investigate resource ownership, assess the damage and develop appropriate interventions.

In Duhok the environment is threatened by several factors, namely neglect, sandstorms, drought, and legacy pollution from local hydrocarbon exploration which it has proliferated since 1995. University of Duhok (UoD) has been engaging actors on many levels. This includes the Kurdistan Regional Government (KRG) and many of its 14 ministries.

With respect to water resources, Duhok has several internal and external issues which UoD are assessing (Figure 4). The main external factor is reduced flow of surface water from neighbouring countries, either through drought, or increasingly because of water projects in those countries. There are several internal factors which include; lack of

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domestic water usage regulations, lack of modern Leak Detection techniques for water mains and water networks, and lack of awareness within the public and the absence of effective educational and awareness campaigns to build the knowledge base of the public for responsible water usage. For external factors, UoD is in dialogue with the KRG to encourage Governmental Political Initiatives and open dialogues with the neighbouring countries for a fair and equitable use of shared water resources and to get the support of the International community for equal water distribution in the basin.

Urban areas suffer from unhealthy air quality and impacts to land due to practices that both the government and the public are adopting such as: unregulated use of fossil fuel power generators (due to the insufficient output of electricity generated by the government), lack of car emission regulations and modern car inspection techniques, trash (due to inadequate trash collection) and tire burning (in social and ethnic celebrations), and lack of green belts and parks in and around urban areas.

Figure 4: Environmental monitoring activities around Duhok. Top left: water quality for drinking water samples from Duhok city for analysis. Top right: wastewater monitoring and sampling for analysis. Bottom left: monitoring of air pollution. Bottom right: solid waste monitoring for management and treatment.

UoD environmental projects have mainly been concentrated at the college of agriculture. These have included studies on the effects of heavy metals on the growth of economical plants and the soil chemical treatment to reduce the effect of these metals. Further environmental research from the college of science includes assessment of the

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population of algal flora in two different aquatic ecosystems inhabited by a rare species of salamander (Raoof et al. 2016).

UoD, in collaboration with the Duhok Directorate of the Environment, are planning to establish two Eco-garden projects: one at Zawa Mountain and one at Zawita Forest. Duhok city is surrounded by several mountain ranges. One of the best and most accessible sites to view the city is from Zawa Mountain (Figure 5), one of the city's defining features and, despite its lack of development, a top tourist attraction. Over the last decade, Zawa hilltops and slopes have experienced consistent deforestation resulting in a grassland rocky landscape with low density of shrub cover and now largely devoid of trees. Therefore, a large-scale reforestation of trees and shrubs can both increase the potential recreational opportunities for Duhok city and at the same time ecologically conserves the mountain. It will generate income and create employment opportunities for local people and camps residents (IDPs and refugee) during the establishing phases.

Figure 5: View pf Duhok City with Zawa Mountain in the background.

The Zawita Forest Eco-Garden is located on the northern face of the Zawita Mountain. It forms a small natural forest about 25 km^2 within limestone foothills ca. 16 km form the city centre. The Eco-Garden will provide a valuable means for moving towards sustainable forest areas that provide many non-woody forest products, and assure multipurpose forest functions such as recreation and conservation of habitats that host endangered species of plants and wildlife. For two decades, Zawita Forest was severely exploited- e.g., shifting agriculture, burning of trees, heavy grazing, urbanization, and mass recreational activities during spring. These activities have resulted in the erosion of large areas of the natural forest. The major driving forces behind such disturbances are the low socio-economic

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status of local community and low public awareness and understanding of the forests ecosystem. The establishment of an Eco-Garden in Zawita Forest could help to assess the role of such types of gardens in generating jobs and raising the local awareness towards the importance of environment preservation and forests ecosystem functions.

Summary

Serious higher education efforts are underway, in a range of contexts and urban environments, to help the environmental resilience of cities and urban settings. Many of these efforts are still in their early stages due to the developing status of universities in some cities and the capacity of those universities to perform activities beyond teaching. Focused education of students to meet environmental challenges is underway, and more is being encouraged in STEM areas to help industrial and business efficiency. SME's working in these areas have been a major target of University collaboration. In terms of direct intervention via focused research, many innovative solutions are being put forward and investigated. The main mantra of developing these solutions is that they are scalable and sustainable, so they are being carefully linked to business models to ensure their long-term success.

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