How can we meet the energy challenges of small and remote coastal communities affected by changing climate in Bangladesh and globally?

Keele University **Institute for Sustainable Futures** discussion paper 2 - 19th July 2019

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In Bangladesh, energy poverty in small and remote coastal communities inhibits development and exacerbates livelihood and migration pressures, social changes, and gender disparities. Climate change threatens low lying coastal areas, bringing sea level rise and increasing salinity. Cyclones and flash floods are having increasing impacts on coastal terrains, habitats, and associated livelihoods. Such challenges are faced by similar communities globally and represent significant barriers to addressing multiple UN Sustainable Development Goals (SDGs) - in particular across Small Island Developing States (SIDS).

Small-scale renewables potentially offer clean and secure energy solutions that also address the broader climate change mitigation context. Yet existing efforts to address energy challenges with small-scale renewables typically perform poorly. We argue that solutions need to be tailored to specific socioeconomic contexts and use durable established technologies in economically and socially viable local business models. Long term and catastrophe-resilient renewables solutions to energy challenges will help vulnerable communities adapt to climate change. Work towards solutions that address the UN SDGs is being carried forward through approaches that are internationally translatable, especially to SIDS.

The **"Building resilient energy generation for small and remote communities"** symposium held 4-5 April 2019 at the University of Liberal Arts Bangladesh (ULAB) was delivered by ULAB's Center for Sustainable Development and Keele University's Institute for Sustainable Futures.

This brought together universities, government bodies, NGOs, community groups, businesses, and other stakeholders with the **aim "to explore routes to provision of resilient, appropriate renewable energy in small and remote coastal communities in Bangladesh and in related Small Island Developing States (SIDS) contexts".**

The symposium identified the following key:

Needs - accessible technological solutions tailored to socioeconomic context; viable and affordable business models for mass deployment; advocacy and marketing

Challenges - community buy in and capacity building; durability and maintenance; gender differences; climate change and catastrophe resilience; economic viability; risk of benefits capture by elites

Opportunities - refrigeration to support livelihoods (fisheries and agricultural) and for medicines storage; diversifying livelihoods; co-construction of agendas; education; engaging global partnerships of expertise; supporting evidence-informed policies and programmes

We identified **three priority work areas to pursue:** partnership development resources to allow other work to happen; context research to inform technological solutions resilient to predicted climate change spatial impacts and fitted to socioeconomic needs and capacities; and, because impact is had by *actually delivering* solutions in communities, solution delivery developing viable renewable energy solutions supporting coastal livelihoods with freely and openly available plans and specifications. Funding bids have been submitted for each priority area:

- Partnership development: 'Ensuring Equity and Sustainability in Blue Economy Development' Science for Nature and People Partnership (SNAPP - The Nature Conservancy; Wildlife Conservation Society)
- Context research: 'Integrating regional sea level and climate projections with adaptation strategies for low-lying coastal communities' Global Partnerships Seedcorn Fund (NERC, UK)
- Solution delivery: 'Sustainable cooling technologies for coastal livelihoods: a gender-sensitive community-wide approach' Sustainable Energy and International Development: Beyond Technology (GCRF, UK)

Vision for next steps based on this discussion paper:

1. Invite discussions from partners and outside on the context and future working options presented
2. Act as a basis for ongoing collaboration and a project pipeline researching and delivering solutions

Contact us to join the conversation and explore connecting as a partner or co-applicant for funding

Rationale

This discussion paper: (1) analyses symposium deliberations and participant views to present an open access statement of identified needs, challenges and opportunities; (2) outlines agreed priorities and follow up actions taken. This offers a basis on which to explore next steps in partnership working and an open invite for interested parties to join our network and future funding bids.

This is explicitly not a peer-reviewed research paper focused on an analysis of published material. Rather, this is a structured and (as far as a value-laden thematic analysis allows) objective presentation of expert views drawing on subtle experiences and interpretations from practice.

Symposium programme and approach

The University of Liberal Arts Bangladesh (ULAB) has ongoing experience working with small and remote coastal communities in Bangladesh on sustainable development. Keele University and other participants joining ULAB at the *"Building resilient energy generation for small and remote communities"* symposium brought experience working with similar communities globally and developing renewable energy systems (at a range of scales and with associated smart technologies).

Plenary talks by speakers from universities, Bangladeshi government bodies, and other stakeholders addressed energy challenges in small and remote coastal communities in Bangladesh, translatable case studies elsewhere, the wider context, and more conceptual or technological expertise. Symposium participants[1] including speakers then self-selected into three follow on roundtable discussions focusing separately on technological, social or environmental aspects of the energy challenges of small and remote coastal communities affected by changing climate. Academic participants from ULAB and Keele University then reviewed the talks and roundtable discussions - agreeing priorities for action and identifying needs, challenges and opportunities.

Identified key follow on project possibilities were screened for potential development for available funding calls - one for each of the three priority areas of work (partnership development; context research; solution delivery). A follow up workshop one month later saw ULAB academics visit Keele University, with a further three roundtable discussions[2] building on progress (again focusing separately on technological, social or environmental aspects). Collaborators developed the core of the three funding bids then submitted[3].

Renewable energy mini-grids and context

Communities that cannot viably be connected to a national power grid are disadvantaged in energy security, access and costs. Lack of grid connection may be due to practical reasons (remoteness; transmission line losses) or economic reasons (cost of transmission line infrastructure relative to population size). Remote settlements, when they have access to electricity, usually have this supplied by diesel powered generators dependent on fuel deliveries that inefficiently provide expensive electricity with negative environmental impacts (pollution risk, carbon emissions).

Global energy decarbonisation has focused on replacing fossil fuels with mixed renewables. This has largely, however, been limited to national electricity grids. There has been limited deployment to date of mini-grid renewables systems. Those that have been developed are typically inefficient and, with limited training or capacity for maintenance, prone to short asset lifespan because of falling into disrepair and disuse. Mainland villages in coastal contexts such as in Bangladesh have similar vulnerabilities to those highlighted prominently for islands in global discourse. Small and remote coastal communities across the tropics and subtropics are amongst the most vulnerable to climate change impacts. Climate change is bringing rising sea levels and increased vulnerability to tropical storms[4] to these communities, with complex long term impacts such as increasing salinity of coastal lands and

[1] from ULAB, Keele University, government-affiliated bodies including the Sustainable and Renewable Energy Development Authority (SREDA), intergovernmental bodies including the Asian Development Bank, UK- and Bangladesh-based businesses, charitable bodies including the Kazi Shahid Foundation, community activists, various non-governmental organisations (NGOs), and miscellaneous other groups

[2] joined by technology partners in Keele University's Smart Energy Network Demonstrator project

[3] listed page 1; summaries in grey text boxes pages 7-8

[4] Cyclone Fani, which struck the Bay of Bengal in April 2019, was one of the strongest to hit the region in the past 20 years

responses by people including changing livelihoods. In Bangladesh, rice agriculture is increasingly impossible as fields are flooded with seawater but one of the emergent alternatives, shrimp farming, is highly vulnerable to disease outbreaks and of questionable long term viability.

Bangladeshi small and remote coastal communities have quite considerable levels of complexity with major challenges in poverty, climate change vulnerability and social characteristics. Developing energy solutions flexible and sensitive to the complexity of the Bangladeshi context inherently drives translatability as an integral characteristic. Approaches developed within the complex spectrum of Bangladeshi small and remote coastal communities should therefore be translatable globally, for example within the high profile context of Small Island Developing States (SIDS)[5]. Many settlements in SIDS have similar contexts to these Bangladeshi communities. With a combined population of approximately 65 million, SIDS have been prominent in intergovernmental cooperation for energy decarbonisation[6]. Their coastal exposure to sea level rise through climate change, and typical dependence on imported fossil fuels at prices set by bigger countries, makes them particularly vulnerable to external environmental and economic shocks. SIDS have led in taking forward emphasis on sustainable development focused on ocean and coastal resources, using Blue Economy[7] approaches.

With reference to the comprehensive and widely used framework of the UN Sustainable Development Goals (SDGs)[8], energy challenges in these communities might at first glance be most focused on *Affordable and Clean Energy* (SDG 7). Yet from this short review of context, meeting energy challenges in small and remote coastal communities can readily be seen as also directly relevant to *No Poverty* (SDG 1), *Decent Work and Economic Growth* (SDG 8), *Reduced Inequalities* (SDG 10), *Sustainable Cities and Communities* (SDG 11), *Climate Action* (SDG 13), *Life Below Water* (SDG 14), and *Life on Land* (SDG 15). In the symposium analysis we identify clear links to the remaining nine SDGs too[9].

Partner universities' relevance

ULAB has a growing reputation for working with communities to deliver impact and has strong connections with the Bangladeshi government, offering a communication channel to influence policy. The Center for Sustainable Development at ULAB is working explicitly on integrating research (coastal ecosystems and climate change adaptation, climate change and migration) with key organisations from the private and public sectors to deliver real world impact. Keele University aims to be an international leader in campus sustainability, with strategic work and major funding going into various programmes to embed state of the art approaches to energy, waste, and related areas across the 612 acre (250 hectare) campus - which has homes, businesses, other buildings, renewable infrastructure, and utilities equivalent to a town of approximately 12,000 people. As part of that, Keele University is actively developing approaches to integrating energy technologies, decarbonised electricity, and power balancing systems to maximise efficiencies - with the campus transitioning to a Smart Energy Network Demonstrator (SEND; the largest test system of the kind in Europe). This offers a resource of diverse expertise and testing facilities, as well as experiences that can be translated into derived solutions appropriate to the small and remote coastal community context.

Drawing on this background, what can we do to address the energy challenges of small and remote communities, unable to viably connect to national grids, as they face uncertain social, economic and environmental impacts from climate change?

[5] typically island or coastal states with a small land mass

[6] from the 1994 Barbados Program of Action and 2004 Mauritius Strategy of Implementation to the 2014 and current SIDS Accelerated Modalities of Action (SAMOA) Pathway

[7] the term 'Blue Economy' is used with varying meanings within different academic and policy circles but, ultimately, promotes an integrated approach to managing sustainable development within coastal and ocean spaces; see Silver et al., 2015, *J. Environ. Dev.* 24(2):135-160

[8] United Nations (2015) *2030 Agenda for Sustainable Development*. New York: United Nations

[9] *Zero Hunger* (SDG 2), *Good Health and Well-Being* (SDG 3), *Quality Education* (SDG 4), *Gender Equality* (SDG 5), *Clean Water and Sanitation* (SDG 6), *Industry, Innovation and Infrastructure* (SDG 9), *Responsible Consumption and Production* (SDG 12), *Peace, Justice and Strong Institutions* (SDG 16), *Partnerships for the Goals* (SDG 17)

Symposium analysis

Needs, challenges and opportunities

Three main themes (with multiple sub-themes) emerged from a formal thematic analysis[10] of symposium talks and roundtable discussions: 'governance, partnerships and knowledge transfer'; 'technological aspects'; and 'social, economic and environmental aspects'[11].

Governance, partnerships and knowledge transfer

Business model resilience was by consensus vital to the success of any long term renewables solution for mass deployment. The problem is not technology but the economics, up front costs and maintenance, and getting community buy in. Funding for collaboration development was identified as critical to being able to then access any other work areas. Functioning partnerships, drawing on wider expertise and best practice globally, will also increase rates of funding and optimise effectiveness versus working alone.

Research needs centre on context data for developing appropriate solutions - such as solar and wind data for renewables viability or assessing the potential impacts of electrification on a wide scope of socioeconomic issues such as migration, differences in impact and opportunity by gender, and livelihoods change. We need detailed future scenario modelling of the spatial impacts on hydrology, soils and other environmental parameters in the areas we are looking to develop energy solutions for. What contribution can a renewables future make to climate mitigation versus retaining dependence on fossil fuels?[12] There is a need to assess the social capital (sense of belonging, participation, citizen power, values, outlook on life) and human capital (skills, abilities, education, creativity, workforce) - and what risks and opportunities there are with different future energy access scenarios. There is existing policy for increasing renewables but wider policy change is needed to join up approaches, address costs which limit viability, and revise import taxes on vital technologies (or preferably enable development of local technology innovation and manufacture). We should be engaging policymakers and working with them on evidence- and practice-informed policies facilitating programmes for solution delivery.

Co-construction of agendas is required for effectively mainstreamed business models that are both economically and socially viable[13]. Universities with expertise across disciplines and in social sciences are well placed to link communities, governments, businesses and other stakeholders together. Active engagement and appropriate frameworks are required for understanding what communities need, basing solutions on that, and maintaining engagement at different stages. Networks of respected persons, for example teachers, could act as community champions for dissemination and meaningful two-way dialogue. Engaging with NGOs was highlighted as important because they have existing pilot projects addressing different aspects of electricity or energy access, fisheries, and other livelihoods in small and remote Bangladeshi communities. There is opportunity to draw on existing NGO expertise and networks in advocacy and service provision, in particular for engaging government and priority communities.

Knowledge transfer should draw on approaches used globally, whether in similar developing world contexts or in the developed world, to adopt appropriate best practice. That might be experience of waste to fuel in the UK, or linking up with pioneering projects in SIDS. Knowledge and skills transfer should be part of any partnerships with government and NGOs, including giving people from communities and local businesses experience of, and training in, technologies and project management.

Education and engagement is needed for uptake and appropriate solutions. Different forms of education are available but we need to ask what we want to achieve to decide objectives and to approach those optimally. Wide availability requires development of free open access education resources. Vocational training to open up livelihood opportunities is needed for people to

[10] transcripts of the talks and minutes taken, along with flip charts and notes of the roundtable discussions, were thematically analysed using a general inductive approach (*sensu* Thomas, 2006, *Am. J. Eval*. 27(2):237-246)

[11] content addressed three broad areas: 'needs and context'; 'challenges identified'; and 'opportunities' where ULAB and Keele University partners could act

[12] *Climate Action* (SDG 13): Take urgent action to combat climate change and its impacts

[13] *Partnerships for the Goals* (SDG 17): Strengthen the means of implementation and revitalize the global partnership for sustainable development

fully benefit from improved energy access. Improved access to education more widely may also come from electrification, for example making information and communications technology or lighting for nighttime study possible[14].

Trust and transparency of motives, plans, and whether outsiders are genuinely going to respond to people's values is an issue for communities and practitioners because of past experience. Community experiences are often of past schemes that did not deliver. Champions and trusted authentic authorities are needed within communities if outsider engagement is to be effective. Interestingly, community voices stressed that local government has relatively high trust, whereas regional or national government, and NGOs, are less trusted. Project 'successes' should be taken with scepticism because there is considerable pressure that limits honest reporting (meeting funding requirements, maintaining track record). We argue that the involvement of universities can potentially mitigate trust issues by bringing broader perspectives and transparent critical evaluations independent of government or short term project funding. Varying levels of corruption and risks of elite capture are identified as threats for misaligning project aims with whole community needs and for the chance of success[15].

Technological aspects

Technological appropriateness was the most prominent sub-theme. It was repeatedly emphasised that reliability, value, ease of deployment, and reduced risk centre on using proven basic technologies. Technologies should be economically anchored in the host area (whether manufactured, maintained or in routine use). There is a trade-off of affordability versus performance but technology should be matched to community needs and economics, not aiming at state of the art. Small-scale renewables address energy penetration (related to remoteness and lack of grid availability) rather than price, unless subsidised. Mini-grids are more appropriate as business models, and for power balancing, than household systems. Renewable mini-grids are also only viable long term investments at present if no national grid connection is envisaged - otherwise when a grid connection is achieved the renewables become redundant. Longer term context change is needed to develop networks of mini-grids, with peer to peer trading as being developed in the UK, that will remain viable alongside future potential national grid connections.

Uncertainties over lifespan and performance of technologies, and poor experience of battery life, are key areas to address. Resilience needs to be central to solution design criteria. Technological resilience means local capacity to restore technologies and recover from catastrophe, easy maintenance, and contingencies planning through risk management. Technological capacity building is needed for local expertise and infrastructure; and must train local businesses, workers and users in renewables practices (vocational training as part of education and engagement)[16].

Social, economic and environmental aspects

Social appropriateness was recognised as central to achieving viable long term solutions and actually addressing the real needs of communities, including responsiveness to the varying sustainable development requirements of different communities[17]. That means energy solutions driven by setting and need first, rather than what is technologically possible as state of the art. Rural, semi-rural and urban needs are different; the needs of small and remote communities depend on the level of remoteness and local context of livelihoods. It was emphasised that the required technology components already exist and solutions can be found if appropriately combined - but the challenge to successful implementation and longevity is in changing people's behaviours and meeting both needs and capacities to engage.

Social equity is at risk with richer sections of the community better positioned for access to the benefits of technology (and what should be fairly shared government or outside subsidy and aid). We need to explicitly consider fairly shared

[14] *Quality Education* (SDG 4): Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

[15] *Peace, Justice and Strong Institutions* (SDG 16): Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

[16] *Industry, Innovation and Infrastructure* (SDG 9): Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

[17] *Sustainable Cities and Communities* (SDG 11): Make cities and human settlements inclusive, safe, resilient and sustainable

benefits, energy prices, and access[18] - ensuring the very poor especially benefit[19]. Impacts of changed behaviours can also affect the commons and the whole community whilst benefits are felt by only a few. Solar electric pumps, for example, have so far benefited rich farmers (water supply) but, by increasing water use and lowering water tables, have harmed water access for poor farmers and risk the sustainability of agriculture and food[20]. Energy affects households but men and women play different roles. Climate change impacts have varyingly increased and decreased aspects of gender differences - men, for example, are more likely to be seasonal migrants and women take on certain work roles in communities as a result. Any solutions approach should synergise livelihoods enhancement through electricity availability with consideration of differences by gender[21].

Other social benefits and aligned avenues, wide ranging, can dovetail with energy provision - "electrification makes other things possible". In particular, community voices emphasised that possibly the top social priority would be "access to proper medicine" - meaning refrigeration allowing storage of (and hence access to) vaccines and medication, with public health benefits, as would be made possible by electrification[22].

Livelihoods resilience identified fishers and the opportunity to offer refrigeration for storage and reduced spoilage, allowing better access to markets and greater retained value. Similar benefits apply to milk, with an example cited of how existing solar-powered chillers have improved livelihoods by allowing a second (afternoon) milking and storage before distribution. There is a need with changing climate and shifting geographies of livelihoods to accommodate changing livelihoods[23] - electricity opens access to new ways of earning a living. Movable batteries that can be charged centrally then used in homes or other locations can maximise penetration of electricity access across communities.

Economic appropriateness discussions stressed that renewables are only economically viable when no grid connection is available and that any solutions have costs - who is going to pay? Returning to the centrality of viable business models, any energy must be affordable and accessible to users, which is context-dependent, and subsidies or investment needed must be both universally available and viable long term[24].

Environmental protection emphasised consideration of installation and end-of-life impacts of technologies (especially acid batteries and other hazardous wastes). A circular economy approach to designing solutions was argued for repeatedly[25]. Uncertainty was a concern across discussions of what environmental impacts changing livelihoods might have both on land[26] and in coastal waters[27] (for example, increased fishing affecting fish stocks). What risks to the environment may be posed by electrification aided development, for example mangrove clearance for aquaculture or water resource depletion[28] due to access to electric pumping?

Work areas and priority projects

The needs and context, challenges identified, and opportunities that emerged from the symposium talks and roundtable discussions were analysed by the ULAB and Keele University team. Brainstorming and evaluation of potential projects, programmes, strategies and funding sources identified broadly five interlinked work areas. Wide future potential was identified but three work areas emerged to pursue in the near term as a priority - on the basis of their being needed to make proposed efforts possible, context informed, and impactful.

[18] *Reduced Inequalities* (SDG 10): Reduce inequality within and among countries

[19] *No Poverty* (SDG 1): End poverty in all its forms everywhere

[20] *Zero Hunger* (SDG 2): End hunger, achieve food security and improved nutrition and promote sustainable agriculture

[21] *Gender Equality* (SDG 5): Achieve gender equality and empower all women and girls

[22] *Good Health and Well-Being* (SDG 3): Ensure healthy lives and promote well-being for all at all ages

[23] *Decent Work and Economic Growth* (SDG 8): Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

[24] *Affordable and Clean Energy* (SDG 7): Ensure access to affordable, reliable, sustainable and modern energy for all

[25] *Responsible Consumption and Production* (SDG 12): Ensure sustainable consumption and production patterns

[26] *Life on Land* (SDG 15): Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

[27] *Life Below Water* (SDG 14): Conserve and sustainably use the oceans, seas and marine resources for sustainable development

[28] *Clean Water and Sanitation* (SDG 6): Ensure availability and sustainable management of water and sanitation for all

To be able to pursue other work areas, our first focus needs to be identifying and securing partnership development resources to allow that (funding and institutional support). Importantly, the emphasis on appropriateness of solutions and means of working (for climate change, technology, social context, and economics) highlighted the uncertainties and lack of data on which to assess that appropriateness. That made context research the second agreed priority - to inform solutions tailored to technological, social, and economic circumstances. Solutions also need to be resilient to predicted climate change spatial impacts across the range of future projections. Impact, however, is had by *actually delivering* work improving energy access and security for these small and remote coastal communities - that is the reason for everything we are looking at. It was felt strongly therefore that beginning informed solution delivery soon needed to be a priority.

Pursuing the three near term priority work areas

1. Partnership development to continue partnership working. Scoping identified a funding call[29] through which we could develop partnership working (and apply that for impact with a pilot study developing a prototype integrated approach to renewables systems for an island community in the Noakhali region of Bangladesh):-

Funding bid: **'Ensuring Equity and Sustainability in Blue Economy Development'** (ESBED)

This project will establish a global partnership of academics and practitioners, with 3 international workshops, to develop a prototype integrated approach to renewables systems in small and remote coastal communities over 18 months using a pilot study of a model island community in Bangladesh.

Further partnership areas to develop include:

- Actively engage and reach out to potential collaborators working in similar contexts, regionally and globally; scope funding avenues
- Exchange visits between partners for context insights, seeing trial and demonstrator systems, and working together on analysis and proposals
- Co-supervision of aligned PhD research

2. Context research to evaluate the present socioeconomic and environmental situation[30], and model likely long term changes with climate for resilient energy security. We developed a potential project[31] to integrate modelling addressing the data gap of future impacts (of sea level rise on hydrology, agriculture and aquaculture) and research on associated socioeconomic needs in low-lying coastal communities, and to co-create appropriate solutions for energy security:-

Funding bid: **'Integrating regional sea level and climate projections with adaptation strategies for low-lying coastal communities'** (INTEGRITY)

This project will integrate state-of-the-art modelling with application. The aim is to improve the quality of projections, quantify and assess the predicted impacts of sea level rise on hydrology, agriculture and aquaculture, and apply that to the co-creation of mitigation and adaptation strategies for low-lying coastal communities.

Further specific research to explore includes:

- Create a database of communities with which to potentially work (with their energy needs and environmental and socioeconomic context)
- Develop criteria and frameworks for appropriate renewable energy systems; explore how communities can be persuaded that solutions are suitable so they will engage
- Environmental economist led cost-benefit analysis of renewables versus non-renewables (and mini-grid versus national grid) for developing viable business models
- Scope electric shock risk and mitigation for people and livestock, particularly in the context of flooding with sea level rise and climate change (with infrastructure considerations such as raised or water-proofed assets)
- Assess the likely impact of new electricity access on livelihoods, education, social roles
- Review the potential for recycling of technology components at end-of-life, reusing technology from other contexts (e.g. lithium batteries from electric vehicles), and of wider e-waste issues

[29] Science for Nature and People Partnership (SNAPP) "climate, oceans and equity" call for *Science to Solutions* teams addressing the intersection of climate, oceans and equity for pragmatic solutions that are feasible to implement quickly and across the globe

[30] geographical distribution of communities, remoteness, proximity to national grid connections, livelihoods and economic characteristics, cultural parameters, climate parameters for solar and wind energy performance, etc.

[31] for the UK Natural Environment Research Council (NERC) "Global Partnerships Seedcorn Fund 2019" call

- Research on potential and context for battery electric boats powered by renewables
- Benefits of electrification versus wood use for fires and cooking e.g. air quality, reduced deforestation (maintaining ecosystem services)
- Strategic Environmental Assessment for programmes and Environmental Impact Assessment for projects to minimise risks, communicated appropriately to assuage community doubts and concerns (including risk analysis of agricultural intensification possibilities associated with electrification)
- Reviewing how approaches can maximise multiple benefits across all 17 SDGs and how evaluations might objectively be made across the 169 specific targets[32]

3. Solution delivery to have meaningful impact by *actually delivering* energy solutions. Reviewing priorities and opportunities from the themes of the symposium, we identified potential for maximising impact in a proposal to develop a viable renewables approach supporting coastal livelihoods including fisheries that is grounded in the socioeconomic context and recognising gender differences in vulnerabilities and livelihoods. Making this then available for others to deliver, readily and independently, via openly available technical designs, operations manuals, and other resources will greatly increase possible impact.

This project[33] would include technology development using a test installation at Keele University with access to the campus Smart Energy Network Demonstrator (SEND) and associated UK-based commercial expertise:-

Funding bid: **'Sustainable cooling technologies for coastal livelihoods: a gender-sensitive community-wide approach'** (SCENA)

This project will work with users and use existing low cost and durable technologies to develop an adaptable renewable energy module with cold storage supporting fisheries. We aim to increase livelihoods resilience and diversity, with attention to addressing gender inequalities. The model will be an open access resource for others to deliver independently.

Further delivery projects to explore include:

- Trial collaborative infrastructure provision e.g. community facilities for battery exchange, charging, and maintenance for electric rickshaws (and models for how these could be organised, managed, and funded)
- Develop and test programmes to improve energy efficiency using pilot study villages
- Sharing energy within mini-grid communities (via direct connections and via separate batteries) and within networks of mini-grids (peer to peer trading and demand balancing)
- Trial biogas and biomass generated electricity projects including scaling up existing community based biogas from household to village systems

Further work areas for the longer term

4. Knowledge transfer. Covering: education (skills for technology deliverers, renewables and wider sustainability literacy for target communities); awareness raising; engaging policymakers and practitioners with solutions; and translating technologies from different contexts into forms appropriate to small and remote communities (such as from developed world practice).

From discussions aligned to emergent priorities outlined in this paper, we identify as a discrete project priority the establishment of a demonstrator of modular mini-grid technologies in Dhaka. This should combine solar, wind, and biogas renewables with pumped storage hydroelectricity[34] and battery options, alongside integration and power balancing systems. In Bangladesh's capital, a demonstrator at ULAB's campus, for example, can act as a central physical resource for engaging policymakers, businesses, NGOs, community representatives and other stakeholders with the options for what can be put in place technologically. This is similar to the role that Keele University's Smart Energy Network Demonstrator will play in the UK and Europe for large-scale smart energy technologies. A parallel demonstrator in an actual small and remote coastal community could alongside show solutions in context, and one geographically more accessible to communities in the region than a demonstrator in Dhaka.

[32] for example, using the United Nations' 2017 *'Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development'*

[33] for the Global Challenges Research Fund (GCRF; UK Research & Innovation) "Sustainable Energy and International Development: Beyond Technology" call

[34] surplus electricity pumps water to elevated tanks (storing energy as gravitational potential) from which it is released during high demand to drive turbines and generate electricity

Further knowledge transfer priorities include:

- Capacity building and education schemes within small and remote communities; “train the trainer” schemes; wide-ranging sustainability literacy and education opportunities
- Professional development for renewables maintenance within communities
- Equipping schools in small and remote communities with basic solar systems to both provide power and act as a community engagement and education resource (rainwater purification could be added too)
- Education for and engagement of teachers; curriculum and wider skills development
- Synthesise different technologies and case studies across the collaborator network to draw out best practice, evaluate how technologies can be translated to different contexts, and identify opportunities for knowledge transfer
- Advocacy with the Bangladeshi (and other) governments on the economic impact of limited energy access and security on household opportunities (and how mini-grid renewables can help) to build the policy and financial support needed for change in rural areas

5. Developing new technologies and systems. A key theme from this analysis has been that component technologies already exist - where technology development is needed is in how individual technologies are integrated into resilient, easily installed, locally manageable, affordable, and maintainable systems. By consensus, the priority within technological development should be to develop a range of viable systems as technical designs, operations manuals, and other resources freely and openly available for others to deliver, readily and independently. These should be scalable and modular so flexible for future growth and for suitability across communities of different sizes and contexts. Interoperability is also key - technological assets must be able to communicate with each other and with a central management system for efficient use and load control.

Further technology development priorities include:

- Research into battery storage versus pumped storage hydroelectricity, and other options[35]
- Technologies and systems for community battery exchange, charging and maintenance
- Explore how to translate mini-grid management at Keele University’s Smart Energy Network Demonstrator to rural mini-grid contexts

Symposium & discussions evaluation

The “Building resilient energy generation for small and remote communities” symposium aimed “to explore routes to provision of resilient, appropriate renewable energy in small and remote coastal communities in Bangladesh and in related Small Island Developing States (SIDS) contexts".

Our objectives were specifically to: initiate collaborations; prioritise future research and action; develop funding proposals; identify energy needs and opportunities; and present an accessible formal analysis of discussions and an assessment of how we can meet the energy challenges of small and remote coastal communities affected by changing climate in Bangladesh and globally. Meeting these objectives, the ULAB-Keele collaboration began with the symposium and has submitted joint funding proposals based on the priority future research and actions agreed; and this discussion paper establishes an open access baseline of needs.

Summary

How can we meet the energy challenges of small and remote coastal communities affected by changing climate in Bangladesh and globally?

Data and evidence-informed evaluations need to underpin work proposed. We need to know: what communities want and need in terms of energy access, livelihoods, resources, education, and other socioeconomic areas; the detailed resolution environmental backdrop; and how environmental and socioeconomic contexts are likely to change over the next 50 or more years with climate change and sea level rise under various scenarios.

In our experiences, progress to date on delivering solutions by universities and NGOs has typically involved resource intensive (outside expertise, focus on specialised technology, heavily dependent on specific international grant funding), expensive and complex one-off projects that are unfeasible to replicate on a mass basis. Delivering solutions to the vast majority of communities in need, however, depends on solutions that can be taken up with minimal outside resources and expertise.

[35] e.g. hydrolysis and hydrogen storage

Solutions proposed to meet the energy challenges of small and remote coastal communities should:

1. Have a socially and economically viable and resilient long term business model
2. Use established and easily sourced technologies that are long lasting, rugged, and require minimal maintenance
3. Be updatable and flexible to change
4. Be simple to operate and safe for users
5. Be interoperable with other systems using software based control, allowing scope to develop wider scale networks of mini-grids
6. Be resilient to shocks and able to rapidly and easily recover from catastrophe (e.g. cyclones and floods) using local skills and resources
7. Integrate energy with other systems (land, water, food, waste, buildings etc.) to maximise co-benefits
8. Bring together both supply of energy and energy efficiency to address energy sufficiency
9. Embrace circular economy principles: efficient reuse and recycling of technologies and materials for minimal complete loss and waste
10. Have openly available and adaptable ready to use technical designs, operations manuals, and other resources: these must be easy to implement quickly across the variable global breadth of small and remote coastal communities (with minimal specialist and outside international expertise)
11. Explicitly address the specific contexts of small and remote coastal communities and of the individual community and its setting
12. Consider how projects and programmes can effectively synergise benefits across all the UN SDGs, exploring how multiple gains can be achieved through effective coordination

We have begun working on such solutions with this symposium and discussion paper synthesising an assessment of needs, challenges, opportunities, and what criteria solutions should meet. Ongoing discussions are widening our collaborative networks. We have, for example, drawn together expertise in different disciplines around the world from further universities, businesses, NGOs, and other organisations for the three funding bids developed from this symposium.

We invite discussions on the context and future working options presented, which we intend to act as a basis for ongoing collaboration and a pipeline of projects researching and delivering solutions.

Contact us to join the conversation and explore being a partner or co-applicant for funding.

Views interpreted here are the responsibility of the corresponding author only and do not necessarily reflect those of any organisation or individual contributing

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Contact for further discussions

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