Nanthini Nagarajah

# Sustainability transition in a developing country context: Drivers and barriers to renewable energy technologies in Sri Lanka

Dissertation for the degree *Philosophiae Doctor* (PhD) at the Western Norway University of Applied Sciences

Disputation: 20.11.2023

Year: 2023

Title: Sustainability transition in a developing country context: Drivers and barriers to renewable energy technologies in Sri Lanka

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Print: Molvik Grafisk / Western Norway University of Applied Sciences

ISBN 978-82-8461-031-3

In memory of a great leader
and a human being both unique and rare, who has influenced the lives of many through his warm and compassionate service. He knew no compromise, but to give the utmost to enrich the life of another – Terje Heggernes.

# Scientific milieu

The research leading to this doctoral dissertation was funded by the Royal Norwegian Embassy Colombo, Sri Lanka, through grant number LKA-3182/LKA-16/0001. This doctoral research project was carried out between 2019 and 2023 at the Faculty of Engineering and Science, Western Norway University of Applied Sciences (HVL) with Professor Arnt Fløysand as the main supervisor for the doctoral research. The doctoral research was part of the *Capacity Building and Establishment of Research Consortium* (CBERC) project managed by Professor Dhayalan Velauthapillai of HVL who also co-supervised this doctoral research.

In October 2020, I was accepted to carry out my PhD within HVL's Responsible Innovation and Regional Development (RESINNREG) programme. While attending the courses carried out by the RESINNREG programme, I also attended Summer School courses (Oslo, July 2019 and Os, August 2021). As part of this doctoral work, I participated in the European Forum for Studies on Policies for Research and Innovation (EUSPRI) Early Career Conference on *Rethinking innovation policy: Creating resilience in times of uncertainty* organised by the University of Manchester (Manchester, UK, May 2022) where an attached article (Paper #3) was presented for discussion and critical analysis. Furthermore, I attended conferences in Sri Lanka, and seminars and workshops physically and digitally in Norway during my doctoral training.

# Acknowledgements

The PhD journey has not been an easy one. It was filled with challenges and at times uncertainty. Yet, it was also a journey of learning, awakening and exploration, and the ending process has been rewarding. This journey was not accomplished alone, but made possible with the support of many, academically and personally, without whom this dissertation would not have been possible in this form, and for whom I am indebted and extend my sincere gratitude.

First and foremost, this PhD would not have been possible without the generous funding provided by the Royal Norwegian Embassy Colombo, Sri Lanka for which I am enormously grateful. The Faculty of Engineering and Science of Western Norway University of Applied Sciences (HVL) has provided me with space, necessary resources and access to engage, explore and work on my research without any shortfalls. I extend my sincere gratitude to them.

This dissertation is deliverable today and for that I am extremely grateful to my supervisor Arnt Fløysand. There is so much to thank him for. For introducing me to the world of academia, for providing me invaluable supervision, critical discussions, creative and constructive feedback, and for his extreme patience and guidance to see this PhD project through. I am ever so grateful for the time and energy he has invested to make this challenging academic journey of mine the most motivating, memorable and rewarding one. Thank you for showing what it means to become a scholar. I could never have hoped for a better supervisor.

My co-supervisor Dhayalan Velauthapillai, with his intellectual rigour and guidance, has shaped this dissertation in multiple ways. I am grateful to him for all the support and guidance in completing this research journey, for being generous with his time, and for the long discussions and reflection of ideas that contributed to the shaping of this dissertation. I thank Suyash Jolly and Lars Martel Antoine Coenen for their constructive feedback during my midterm evaluation, and for offering fresh perspectives which not just provided a better direction for the research but enriched the outcome of this dissertation. I appreciate the constructive comments and criticisms from the anonymous reviewers and the editors' support, which made my articles publishable. I would like to express my gratitude to the various PhD course

coordinators, both internal (HVL) and external, for introducing me to new learnings and perspectives which the dissertation greatly benefitted from. I would also like to extend my special thanks to Rune Njøs for the long academic discussions on improving my third paper and for providing me with office space in Songdal for a week. I thank Svein Gunnar Sjøtun for the many informal corridor conversations for motivating me throughout my academic journey and from which this dissertation has benefitted. A big thank you again to both Rune Njøs and Svein Gunnar Sjøtun for being very helpful in suggesting and sharing literature and answering my list of questions from day one as a PhD student. Special gratitude to Frida Olsen Engedahl, for helping with the translation of the abstract into Norwegian. I greatly appreciate the support provided by the staff at the HVL library for their immense support in obtaining articles and books, as well as for providing other support in writing academic papers and for responding to my numerous questions.

The valuable contribution to my qualitative research came from the interviewees and informants in Sri Lanka, Norway, India, UK, and Canada, without whose input the research would not have been shaped into what it is today. I extend my sincere appreciation to each one of them for their valuable time and for providing me with insights and resources for my research.

I am ever so grateful to my colleagues at the Mohn Centre for Innovation and Regional Development and the RESINNREG PhD programme from diverse backgrounds and research strands for all the motivation, support, and academic discussions, seminars, as well as non-academic conversations, and the digital and physical coffee breaks that created an inclusive, friendly environment and made work enjoyable and truly inspiring. I extend my special thanks to my colleagues from the Department of Computer Science, with whom I shared office space at Fabrikkgaten-5, for the PhD social meets and the positive working environment that made the PhD years memorable. I truly appreciate colleagues attached to ANCEHA (HVL) for the many social exchanges that helped me take my mind off academic struggles.

Life in Norway was made memorable and enjoyable despite the numerous challenges I faced, having come from a tropical country with a completely different social and cultural background. This was made possible in particular through my long-standing

friends from FORUT Norway, especially Pavalarani and Thangarasa, Runa and late Terje Heggernes, Oddveig and Anders Stenvig, Trond Gunnar Rasmussen and Arne Bangstad by their many long conversations, visits and invitations. Life in Bergen would have been nearly impossible if not for the generous support from the families of Mayurie and Rajaselvi, and for the wonderful friendships of Thamilselvan and Nesakumari, who have extended support in innumerable ways. Thank you all for accommodating me, always being there and supporting me in completing my PhD, and for making my stay in Bergen pleasant and enjoyable.

On a more personal note, a big thank you to my friends and family in Sri Lanka. I would especially like to thank my great friend Kalani Ranasinghe for not only helping me with the translation of documents, but for the long motivational calls at times when my academic road was bumpy. I thank all my friends near and far for keeping that positive spirit in me. I truly appreciate the invaluable support of my aunt and uncle (Pooranachandrans) who have been instrumental in me taking this big step and always instilled in me the confidence and strength during the most stressful times to help me stay focused despite my many academic struggles. I express profound gratitude to my sister (Nalini), brother-in-law (Rajendra) and nephews (Thivviyan and Tharunijan) for their unconditional support, encouragement and patience from the beginning until the end, without which this journey would have been miserable. I also wish to thank my cousin (Nageswaran) for his unstinted support throughout my PhD course as well as to my cousin-in-law (Chandra) for constantly checking on me and motivating me. Finally, I am grateful to my mother for placing her irrepressible belief and confidence in my work, for emotionally supporting me, and for her many sacrifices in this strenuous journey of mine.

Nanthini Nagarajah
Bergen, 16 May 2023

# Abstract

Developing countries are evidently moving slowly in utilising emergent and matured renewable energy technologies (RET) to address the global call to bring about effective global decarbonisation and net zero emissions of greenhouse gases to limit global temperature rise to 1.5 degrees. The global decarbonisation effort primarily refers to the fundamental restructuring of established energy systems with a technological shift, with a decline in fossil fuels and a rise in renewables. In this global effort, transition studies recognise the need for socio-technical transition emphasised through theories and concepts developed and applied for developed countries. The geography of sustainability transition (GeoST) literature emphasises the need to pay attention to the context in which the transition emerges. In doing so, it informs the challenges of defining and operationalising sustainability transition with existing theories and concepts, as each context is intertwined with unique characteristics. This necessitates the need for revisiting and further developing theories and concepts for such contexts.

This dissertation aims to understand and document the contextual conditions influencing sustainable energy transition processes linked to the implementation of RETs in Sri Lanka, a developing country. The dissertation achieved its objectives by way of applying the sustainability transition precepts of technology-centred technological innovation system theoretical framework and focusing its research on answering its research questions, namely: (i) What contextual conditions influence sustainable energy transition processes linked to the implementation of RETs in Sri Lanka? (ii) How does the study inform the GeoST literature in developing countries? and (iii) In what way can the study stimulate policy scaling up of RETs in Sri Lanka?

The dissertation employed a qualitative case study approach. The study gathered data from multiple sources related to the power sector in Sri Lanka. This included data utilised from 50 semi-structured interviews with stakeholders associated with the whole spectrum of responsibility related to sustainable energy transition in the power sector, document reviews, and participant observations. The data analysis resulted in three papers that collectively contributed to answering the research questions.

The three papers, in the main, identify and inform respectively of informal networks, narratives and relational materiality as exerting varying degrees of influence on the

country's progress towards sustainable energy transition. The qualitative research also informs that the operationalisation of sustainable energy transition needs to have a context-sensitive perspective, particularly in developing countries with complex socio-cultural features. Paper #1 explains how the country is uplifting knowledge and skills necessary for RETs. It reveals how informal networks are strengthening coupling mechanisms for knowledge exchange between the global and local levels. It underscores the positive role played by diaspora informal network in building local innovative capacity through global university-university cooperation. Paper #2 informs how the narratives in play influence the energy transition pathway of the country. The key stakeholder narratives in the Sri Lankan power sector highlight the formal and informal institutions and practices, as well as the varied stakeholder expectation of a sustainable and responsible energy pathway for the country and where the hegemonic narratives marginalise the alternative narratives. Paper #3 emphasises the relational perspective and the importance of contextualising technology. It discusses how absolute materiality is influenced by relational materiality in the technology-context interaction in transitions, and is based on the implementation of grid-tied solar, including floating solar PV in Sri Lanka. By understanding and addressing the negatively impacting factors identified in these papers, as well as stimulating the identified budding drivers, the dissertation offers a way forward for Sri Lanka in its efforts to achieve sustainable energy transition.

The dissertation argues that the elements of sustainability transitions, when used for analysis in geographical contexts, need to be exercised with adjustments, especially when used in a developing country context. It finds that GeoST literature needs to pay closer attention to the role of informal networks, narratives and relational materiality to assess how transitions play out in such settings. Thus, the dissertation adds to the theory, particularly to the GeoST literature, that for transition to be responsible, the technology and the process itself need to be context-sensitive.

# Sammendrag

Anvendelsen av nye og modne fornybare energiteknologier som svar på det globale behovet for effektiv avkarbonisering og null-utslipp av klimagasser for å begrense den globale temperaturøkningen til 1.5 grader, utvikler seg sakte i utviklingsland. Innsatsen for global avkarbonisering handler primært om den fundamentale omstruktureringen av etablerte energisystemer gjennom et teknologisk skifte, med redusering av fossilt brensel og økning i fornybar energi. I denne globale innsatsen anerkjenner transformasjonsstudier behovet for sosio-teknisk transformasjon gjennom teorier og begreper som er utviklet og anvendt i industriland. Transformasjonslitteraturen, 'The geography of sustainability transition' (GeoST), understreker behovet for å ta hensyn til konteksten transformasjonen finner sted i. På den måten utvikles økt kunnskap om utfordringene med å definere og operasjonalisere bærekraftig transformasjon med eksisterende teorier og begreper, ettersom hver kontekst er sammenvevd av unike karakteristikker. Dette nødvendiggjør behovet for å videreutvikle teorier og begreper for slike kontekster.

Denne avhandlingen har som mål å forstå og dokumentere de kontekstuelle forholdene som påvirker bærekraftige energitransformasjonsprosesser knyttet til implementeringen av fornybare energiteknologier i Sri Lanka, et utviklingsland. Avhandlingen oppnådde sine mål ved å anvende grunnprinsipper av bærekraftig transformasjon i det teoretiske rammeverket av teknologi-fokuserte teknologiske innovasjonssystemer og fokuserte forskningen på å svare på følgende forskningsspørsmål: i) Hvilke kontekstuelle forhold påvirker bærekraftige energitransformasjonsprosesser knyttet til implementeringen av RET i Sri Lanka?, ii) Hvordan gir studien økt forståelse for GeoST litteraturen i utviklingsland?, og iii) På hvilken måte kan studien stimulere oppskalering av policy for RET i Sri Lanka?

Avhandlingen anvendte et kvalitativt casestudiedesign. I studien ble det samlet inn data fra flere kilder i kraftsektoren i Sri Lanka. Dette inkluderte data fra 50 semi-strukturerte intervjuer med interessenter ansvarlige for bærekraftig energitransformasjon i kraftsektoren, dokumentanalyser, og deltakende observasjoner. Dataanalysen resulterte i tre artikler som sammen bidrar til å svare på forskningsspørsmålene.

De tre artiklene identifiserer og bidrar til økt kunnskap om henholdsvis uformelle nettverk, narrativer, og relasjonell materialitet som utøver ulik grad av innflytelse på landets fremgang mot bærekraftig energitransformasjon. Den kvalitative forskningen bidrar også til økt forståelse for at operasjonaliseringen av bærekraftig energitransformasjon må ta hensyn til konteksten, spesielt i utviklingsland med komplekse sosio-kulturelle trekk. Artikkel #1 forklarer hvordan landet løfter kunnskap og ferdigheter som er nødvendig for fornybare energiteknologier. Den avdekker hvordan uformelle nettverk styrker koblingsmekanismene for kunnskapsoverføring mellom globalt og lokalt nivå. Den understreker den positive rollen til diaspora uformelle nettverk i etableringen av lokal, innovativ kapasitet gjennom globalt universitet-universitet samarbeid. Artikkel #2 bidrar til økt kunnskap om hvordan narrativer påvirker energitransformasjonsutviklingen til landet. De viktigste interessent-narrativene i den srilankiske kraftsektoren trekker frem de formelle og uformelle institusjonene og praksisene, samt den varierte forventningen fra interessenter til en bærekraftig og ansvarlig energiutvikling for landet og hvor de hegemoniske narrativene marginaliserer de alternative narrativene. Artikkel #3 vektlegger det relasjonelle perspektivet og viktigheten av å kontekstualisere teknologi. Den diskuterer hvordan absolutt materialitet påvirkes av relasjonell materialitet i teknologi-kontekst-interaksjonen i transformasjoner, og er basert på implementeringen av grid-tied solceller, inkludert flytende solceller i Sri Lanka. Ved å forstå og adressere de negative påvirkningsfaktorene identifisert i disse artiklene, samt stimulere de identifiserte driverne, peker avhandlingen ut en vei videre for Sri Lanka i deres arbeid med å oppnå bærekraftig energitransformasjon.

Avhandlingen argumenterer for at elementene i bærekraftig transformasjon, i analyser av geografiske kontekster, må anvendes med justeringer, spesielt når de anvendes i utviklingsland. Et av funnene i avhandlingen er at GeoST litteraturen må ta mer hensyn til rollen av uformelle nettverk, narrativer og relasjonell materialitet i vurderingen av hvordan transformasjoner utspiller seg i slike settinger. Avhandlingens viktigste bidrag til teorien, spesielt GeoST litteraturen, er dermed at dersom transformasjoner skal være ansvarlige må teknologien og selve prosessen være kontekstsensitiv.

# Contents

# List of tables



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# List of papers

This dissertation is based on the following three papers:

#1. **Nagarajah, N**. & Fløysand, A. Mobilising Diaspora for Sustainability Transition in Global University Cooperation. Accepted for publication as a book chapter in *Universities and their places: Reflections on the work of Paul Benneworth* in March 2023

#2. **Nagarajah, N**. 2022. Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector. *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography*, 1-12. DOI: https://doi.org/10.1080/00291951.2022.2136108.

#3. **Nagarajah, N**. The geography of sustainability transition and materiality: The grid-tied solar photovoltaic technology in Sri Lanka. Resubmitted to *Regional Studies, Regional Science* in May 2023.

*Papers #1 and #3 are submitted proof versions as they are yet to be published. Paper # 2 is published online and can thus be reprinted freely.*

# 1. Introduction

## 1.1 Motivation and research objectives

The UN Conference of the Parties (COP26) on climate change held in Glasgow in November 2021, brought global leaders together calling for urgent global action to accelerate the global energy transition[1] towards net zero by reducing emissions and limiting global temperature rise to 1.5$^{o}$C (United Nations (UN), 2021a). This conference call demands increasingly effective global decarbonisation and net zero emissions of greenhouse gases. The global decarbonisation effort is primarily directed towards achieving a transformation of energy generation and consumption from carbon-intensive to a low or zero-carbon energy systems. In other words, bringing about a technological shift to achieve a decline in fossil fuels and a rise in renewables[2]. The reality of anthropogenic climate change and subsequent declarations of a climate emergency[3] calls for sustainable energy transitioning at a greater pace and scale than ever before, necessitating massive global investments in renewable energy generation, technology deployment, and international collaborations (International Energy Agency [IEA] et al., 2022). Emphasis is also given to make renewable energy technologies (RET)[4] and sustainable solutions the most affordable, accessible, and attractive options for countries (IEA et al., 2022). Consequently, sustainable energy transition is being embraced by many countries, predominantly in the power sector, triggering energy research, innovation, investments, policy reviews, and regional and international collaborative work and development. Many developed countries (interchangeably used in this dissertation with global North, Western and

[1] In this dissertation, I have used the term sustainability transition as an analytical-oriented concept and used the terms energy transition, sustainable transition, and sustainable energy transition to denote more empirical-oriented concepts.

[2] This dissertation is focused on renewable energy technologies. However, the decarbonisation of energy systems is also about other low-carbon technologies, fuel, energy storage, energy efficiency, and demand-side mitigations.

[3] Nearly 40 countries have declared a climate emergency, and these include countries such as UK, Norway, Australia, Bangladesh, Canada, Maldives, Philippines, Singapore to name a few.

[4] The focus of this dissertation is on RETs. However, the term clean energy technologies is used to describe the project-related terminology and the term non-conventional renewable energy is used to describe the energy mix as used in the Sri Lankan statistical reports.

industrialised countries) are supporting and enabling legal frameworks to promote and integrate RETs into their energy systems, ensuring such policies are aligned with international agreements including the 2015 Paris Agreement, 1997 Kyoto Protocol, or the 2020 European Green Deal (Cantarero, 2020). While global efforts are focused on moving towards a zero-carbon agenda, UN Sustainable Development Goals (SDG) 7 and 13 established in 2015 reminds us to accomplish such a transition with parallel commitment to "ensure access to affordable, reliable, sustainable and modern energy for all" and to "take urgent action to combat climate change and its impacts" by 2030 (UN, 2022b). To realise these global commitments, agreements, goals, and transition to more renewables, countries are required to create an enabling environment by establishing robust frameworks, policy instruments, and targets to bring about positive and long-term economic, social, and environmental benefits. However, the progress towards achieving UN climate goals has been uneven between and within countries (UN, 2022a). Access to reliable and affordable energy in a number of countries is still lacking with much of the expansion of energy systems secured through fossil fuels (Asian Development Bank [ADB], 2021), partly due to differing available resources and transitioning capabilities. Different countries have varied energy governance mechanisms, attributes, resource potentials and other specific challenges to be able to adopt sustainable solutions or practices. Developing countries[5] (interchangeably used in this dissertation with global South, Global South, low-and middle-income countries and resource poor settings) in Asia, despite witnessing rapid economic development, still find themselves in need of mobilising substantial efforts and resources to achieve universal energy access that is reliable and affordable across the region (ADB, 2021). They are largely energy import-dependent developing countries (Selvakkumaran & Limmeechokchai, 2012).

[5] In this dissertation, the terms 'developing countries', 'global South', 'Global South', 'resource poor settings', 'low-and middle-income countries' are used interchangeably referring to specific conditions and characteristics of the nations classified as low-and middle-income countries. Giving attention to the multiple facets and fragility across the international development spectrum by the World Bank including the presence of poverty, inequality and rapid economic growth (Dados & Connell, 2012; Fantom & Serajuddin, 2016; Ghosh et al., 2021).

Meanwhile, there is also an increasing demand for additional energy generation as a result of the rapid economic and other developments taking place in many parts of the globe. Developing countries are said to hold most of the untapped renewable energy potential in the world, yet they lack the domestic capacity and capital to ensure that transition by utilising these potentials is done sustainably and responsibly (Cantarero, 2020; Goldthau et al., 2020). Many of these countries, although contributing least to climate change historically and currently, are highly vulnerable to the impacts of climate change (Pörtner et al., 2022). Energy transition is expected to include energy efficiency, affordability, reliability and energy independence. In developing countries there is also an expectation that in addition transition gets realised in parallel with economic development, social inclusion and environmental sustainability (Cantarero, 2020). Against this backdrop and ensuring that no place is left behind in this global effort, this dissertation looks at the drivers and barriers of technological transition with a specific focus on the adoption of RETs in Sri Lanka. Choosing Sri Lanka, a country striving to move towards renewables and yet dominated by, and continuing to further invest in, fossil fuel-based energy development, for this dissertation is motivated both by the project that I am part of as well as by a personal interest in understanding sustainable energy (electricity sector) transition opportunities for the country.

Motivation for this project was driven by the *Capacity Building and Establishment of Research Consortium* (CBERC) project, of which I am part. The project is presented in-depth in the empirical section (Section 4.2.1). CBERC was established in Sri Lanka in 2017 as part of an existing academic and research partnership, namely *Higher Education and Research in Nanomaterials for Clean Energy Technologies* (HRNCET), between the Western Norway University of Applied Sciences (HVL) and the University of Jaffna (UoJ), Sri Lanka with financial assistance from the Royal Norwegian Embassy Colombo, Sri Lanka. The research consortium, which comprised of researchers and private sector industrialists from Sri Lanka and Norway, promotes RETs and facilitates linkages between research and business communities from both countries. One of the aims of CBERC is the advancement of and investments in innovation and RETs such as solar. The research consortium identified the need for an in-depth study into the energy governance in Sri Lanka as it encountered barriers at multiple levels to the processing and implementation of investments in RET projects. This need resulted in this PhD research position and study. As such, the objective of

this dissertation was pre-defined and outlined by the CBERC project. Personally, the motivation is to see my home country, with its rich natural environment and abundant renewable sources, moving towards more environment-friendly and engaged sustainable and responsible practices in energy generation and consumption. It is also the desire to better understand the opportunities for the country to tap into and expedite the processes towards steadily adding more renewables to its national energy mix while also building its local capacities. Thereby the objectives of the research are threefold:

- to develop and apply a context-sensitive perspective to sustainability transition in developing countries,
- to map the existing drivers and barriers within the electricity sector for sustainable energy transition in Sri Lanka,
- to inform of RET innovation and investments in Sri Lanka.

## 1.2 Theorisation and research questions

The theoretical perspective for this dissertation evolved through an iterative process that spanned the study period. The research's theoretical starting point was transition studies. New perspectives, insights, and concepts from other literature such as global innovation networks (GIN), innovation studies, responsible innovation (RI), discourse, and the geography of sustainability transitions (GeoST), were subsequently introduced in light of the empirical observations. The empirical analysis that resulted from this abductive approach offered a relational perspective on technology for this dissertation, and also allowed for the development of an analytical framework to investigate the contextual interplay between technology and context focusing on networks, discourse, and materiality.

As mentioned above, the dissertation situates itself theoretically within transition studies including socio-technical transitions (Bergek et al., 2008a; Geels, 2002; Geels et al., 2017; Markard et al., 2012; Rip & Kemp, 1998; Truffer, 2012), acknowledging that most established sectors (such as energy) need to change or fundamentally restructure to become sustainable (Farla et al., 2012; Markard, 2018). Expressed differently, the fundamental restructure is to ensure the decline of the existing unsustainable fossil-fuel-based systems and the emergence of systems with sustainable

alternatives (Markard, 2020). The centrality and emphasis are placed on innovation and technological solutions or artefacts for transition (Grin et al., 2010; Kern & Rogge, 2016; Lawhon & Murphy, 2011). Nevertheless, there is general agreement in the literature that technological fixes often provide only temporary or partial solutions due to negative externalities or other unintended consequences (Farla et al., 2012; Truffer & Coenen, 2012). As such, sustainable transition is not solely about technological transition but about socio-technical transitions i.e., in addition to the technological dimensions, transition needs to include the changes in markets, user practices, institutions, and policy and cultural discourses (Coenen et al., 2012; Geels et al., 2008; Markard et al., 2012). These judgements mentioned above make transition studies a broader field of engagement.

While the transition process is necessitated globally, the theories and concepts within transition studies were initially developed in and applied to developed Western European economies (Hansen & Coenen, 2015; Lawhon & Murphy, 2011). However, within this global process, transition processes and pathways vary across countries (Markard, 2018) due to significantly differing challenges and opportunities between countries. This necessitates revisiting and further developing theories and concepts (Hansen & Coenen, 2015) to make transition studies also context-sensitive by paying attention to the context and geographies in which transitions are emerging (Coenen et al., 2012). The analytical focus on developing countries in this dissertation requires a context-sensitive perspective to capture the place-based conditions in such settings that enable and constrain transitions. Thus, analytically the study is placed within GeoST in developing countries to pay attention to the importance of contextual factors of transitions in particular places. The GeoST literature has focused on understanding how and why the emergence of renewable energy systems are similar or different across countries (Köhler et al., 2019). Moreover it is concerned about how transition-related innovation, technology and knowledge "travel" across geographies beyond the places from where they originated (Köhler et al., 2019, p.14). While technology transfer evidently contributes to sustainable energy pathways in developing countries, the application of it is markedly probed by contextual conditions, which can either enable or constrain the development and diffusion of the transferred technology (Jolly et al., 2012; Köhler et al., 2019). This study demonstrates that in this process the technology-

context interaction in developing countries needs to be studied by paying heed to influencing contextual elements on the transition process.

Empirically the study is situated within the technology-centred technological innovation systems (TIS) literature, which conceptualises transition by looking at how new technologies contribute to a broader transition process (Truffer & Coenen, 2012). Technological innovation or technology development through the lens of TIS looks at the non-linear, systemic, interactive, and evolutionary character of the innovation process brought out through the core elements of innovation systems - actors, networks, and institutions, and their internal functions (Bergek et al., 2008a; Binz et al., 2016; Hekkert et al., 2007; Markard & Truffer, 2008). A TIS framework looks at how technology development for sustainability transition is shaped through interactions by social, economic, and political factors and also how these factors are in turn reconditioned by the technologies and technology systems (Rip & Kemp, 1998). While acknowledging that a technology-centred perspective to transition is seen as more appropriate to study transition in developing countries, it is also necessary to concede that the TIS configuration is under-developed for suitable application within developing country context (Bergek et al., 2015).

TIS highlights that technology, network of actors, and institutions are crucial elements for technology development in context[6] (Bergek et al., 2015). While the diffusion and utilisation of technology in the transition process is enabled through the interaction between these different elements (Bergek et al., 2008a; Markard, 2020), the "technologies-in-context" for transition also needs to be viewed relationally to the context (Rammert, 1997, p.176), and necessarily reconfigured in relation to the elements emerging through the contextual particularities (Gault, 2010; Ghosh et al., 2021). However, these elements are not supported by a home-grown coherent framework that incorporates the contextual particularities to better understand these elements in shaping TIS-context interaction in transitions (Bergek et al., 2015; Edsand,

[6] In this dissertation, I regard context as a particular setting moulded by specific political, economic, social, cultural, and environmental elements; hence, the context is embedded within these complexities.

2019; Hansen et al., 2018). Recent contributions stress the importance of approaching technology-context interaction by allowing absorption of contextual particularities in innovation studies and transition processes to facilitate the delivery of responsible transition (Haselip et al., 2011; Rahmani et al., 2022). Coping with this gap, this dissertation proffers an analytical framework with a context-sensitive perspective to these elements viewed through networks, discourse, and materiality to enable a responsible transition.

GeoST literature acknowledges the centrality of *network* element comprising multiple actors involved in reproducing, maintaining, and transforming the system elements during the transition process (Geels, 2002; Geels et al., 2004). Scholars have cast much light on the roles and contributions of formal actors, actor networks, or multi-actor interactions brought into effect by technology manufacturers, suppliers, vendors, research institutes, public authorities, non-governmental organisations (NGOs), and civil society (Markard, 2020). However, by keeping the focus on (a) dynamic interaction between these different kinds of actors at the system level, and on (b) understanding how strategies, resources, and capabilities of individuals, firms, and other organisations impact and influence transformative processes (Farla et al., 2012), the literature has paid inadequate attention to the role and contributions of informal networks in the transition process. The contribution of informal networks is primarily voluntary and inconspicuous (Martin et al, 2018) yet influential in transition especially so in developing countries.

The literature has addressed the influencing effect of *discourse* in technology development and diffusion (Komendantova & Neumueller, 2020; Mohan & Topp, 2018). Institutional variations across space, including rules, laws, regulations, as well as norms, and values, have partly resulted in spatial variations in transitional processes (Hansen & Coenen, 2015). Informal institutions and practices, that permeates every institution in the global South contexts, demand a deeper understanding of their nature and workings, as they consistently negotiate with formally enacted rules in a complex transition agenda (Ghosh et al., 2021). Comprehending the different stakeholder narratives to appreciate the formal and informal institutions and practices becomes inevitable in studying transitions in these contexts.

Despite the fact that transition is first and foremost about technology shift, very little attention has been paid to *materiality* in literature by viewing technology merely as an end product of transition. The GeoST literature, while concerned about how transition-related technology travels to other contexts (Köhler et al., 2019), pays less attention to contextualising technology, i.e., how materiality enables, shapes and hinders technology transition (De Hoop et al., 2016). Enabling responsible transition involves paying attention to the context-related materiality to technology (relational materiality) and implementing context-relevant changes to the technology.

Placing the above mentioned rationale empirically, the dissertation argues that the core elements of transition need adjustment to effectively accomplish energy transition in developing countries. The dissertation finds that GeoST literature needs to also pay closer attention to the role of informal networks, narratives, and relational materiality to assess how transitions play out in such settings. The dissertation presents evidence of the three central Sri Lankan context-related impacting conditions. These are informal networks presented by way of diaspora dynamics, discourses by way of narratives in play, and relational materiality by way of context adjusted technologies highlighting them as influential determinants in the transition process (or the lack thereof) in Sri Lanka. The research findings presented through three articles, allowed me to address the following research questions (RQ):

1. What contextual conditions influence sustainable energy transition processes linked to implementation of RETs in Sri Lanka?
2. How does this study inform the GeoST literature in developing countries?
3. In what way can the study stimulate policy scaling up of RETs in Sri Lanka?

## 1.3 Overview of the papers

Empirical evidence gathered by means of a qualitative study for this dissertation, which aimed to answer the RQs, has been published, accepted and resubmitted for publication through three peer-reviewed articles. This section briefly discusses the content of individual papers in relation to the RQs. This dissertation assesses the enabling and disabling conditions of technological transition in developing countries through three context-adjusted elements. Table 1 below summarises the empirical

focus as well as the key aspect of each RQ against the paper, again highlighting the three context-relevant elements brought out by each of them.

Paper #1 (*Mobilising Diaspora for Sustainability Transition in Global University Cooperation*) investigates how adopting a coupling mechanism in a GIN can be strengthened through informal networks. The paper empirically presents the Sri Lankan Tamil diaspora as an example of a global informal network that informs and contributes to the wider literature with its driver effect on the Sri Lankan energy transition, playing a crucial role in levelling-up this developing country by attempting to systematically, though gradually, address its *innovation poverty* and capacity deficiency. The paper demonstrates that the coupling mechanism can be strengthened through informal networks and adds disapora's contribution to GeoST literature.

Paper #2 (*Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector*) investigates how contextual understandings of RI are discursively constructed and how such understandings enable or constrain sustainable energy pathways in developing countries. The paper identifies three broadly categorised key stakeholder narratives, each with its own perceived understanding of sustainable and responsible transition, as a means of grasping these contextual perceptions. These contested key narratives greatly determine the country's energy pathway by way of swaying the negotiation between the formal and informal institutions and practices. In this paper, the narratives in play are viewed as barrier for effective application of transition policies, and the paper informs wider literature that understanding and absorbing prevalent narratives is a necessary bridge to link sustainability transition with RI.

Paper #3, (*The geography of sustainability transition and materiality: The grid-tied solar photovoltaic technology in Sri Lanka*) explores the role of materiality in the transition process. It highlights that the GeoST literature has granted less attention to materiality and emphasises the need to pay closer attention to the determinant role of materiality. In doing so, this paper brings the relational dimension to the fore as key to understanding how globally regarded footloose technology also needs to be contextualised in relation to its material and immaterial relations. The paper presents empirical evidence through the grid-tied solar PV implementation, including floating

solar PV (FPV) in Sri Lanka. While materiality, is seen as a barrier in the transition process unless the technology is contextualised, the case also highlights that the process itself is a driver towards innovation (from within) in bringing a context-relevant technology.

## 1.4 The structure of the dissertation

The structure of the dissertation is as follows. Section 2 presents the theoretical framework of the research. In this section, the key precepts of transition studies are first presented, in which this dissertation is theoretically situated. This is followed by discussion on the GeoST in developing countries and where the analytical basis of the dissertation is placed, including discussions on the fundamentals of TIS and the need for adjustments of TIS elements when empirically applied in geographical contexts. Section 3 discusses the methodology and methods used to answer the RQs of the dissertation. Section 4 presents the empirical context of the different cases, as well as additional information to sustain the empirical facts that broaden the understanding of the separate cases. This section focuses on the Sri Lankan context and its power sector, both of which are relevant to all three papers. It also describes the emergence and establishment of HVL-UoJ collaboration, not only because of its relevance to Paper #1 and #3, but also importantly because this PhD position came into being as part of this collaborative project. Lastly, the Sri Lankan diaspora is presented in this section to understand the essence of and relevance to Paper #1. Section 5 presents a more detailed discussion in relation to theoretical, empirical and analytical basis for each paper, and the findings that contributed towards answering the RQs as well as their contribution to literature. Section 6 concludes by answering the RQs of the dissertation and apprising the limitation of the research. Full version of the papers, the interview guide and information sheet follow the conclusion section of the dissertation.

| Paper | Empirical focus | RQ1: Contextual conditions | RQ2: Informs GeoST | RQ3: Impact on RETs in Sri Lanka |
|---|---|---|---|---|
| **#1:**<br>**Nagarajah, N**. & Fløysand, A. Mobilising Diaspora for Sustainability Transition in Global University Cooperation. Accepted as a book chapter for *Universities and their places: Reflections on the work of Paul Benneworth (March 2023)* | Global university-university cooperation (GUC) between HVL-UoJ | Sri Lankan Tamil diaspora | Informal networks | Driver |
| **#2:**<br>**Nagarajah, N**. 2022. Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector. *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography*, 1-12 | The power sector in Sri Lanka | Narratives in play: Policymaker-centric, professional-centric and investor-centric | Narratives in play | Barrier |
| **#3:**<br>**Nagarajah, N**. The geography of sustainability transition and materiality: The grid-tied solar photovoltaic technology in Sri Lanka. Resubmitted to *Regional Studies, Regional Science (May 2023)* | Grid-tied solar PV implementation in Sri Lanka including FPV | Natural material requirement (land and water) for technology development | Relational materiality | Driver and barrier |

***Table 1:*** *The papers in which the dissertation is founded, their empirical focus and their engagement with the RQs*

# 2. Theoretical framework

## 2.1 Transition studies

The foundation for this dissertation is based on the principles and fundamentals of transition studies (Bergek et al., 2008a; Coenen et al., 2012; Geels, 2002; Rip & Kemp, 1998). Transition studies is a broad field that is based on system thinking and underscores the interrelatedness of social, technical, institutional, and political factors, as well as issues related to path-dependency, system lock-in, and conflicts among varied actors (Markard, 2018). It highlights the reality that most established sectors such as energy need a fundamental change in order to become sustainable in the long run (Markard, 2018; Markard et al., 2012). Energy transition scholars state that conceptualising the technological transition from carbon-intense energy system to low-carbon energy system is not just about the technological shift from fossil fuel-based technology to renewables. They recognise that energy transition is a wider, inclusive process that needs to take into account and absorb the effects of social factors and changes, cultural meaning and symbolic values attached to the technology, emerging changes in user practices, regulations, industrial networks, infrastructure, discourses, and institutions (Geels, 2002; Geels et al., 2008). To simplify, Grin et al. (2010, p.12) explain that the socio-technical perspective of transition is "based on a contextual understanding of technology", indicating that transition is not just about a technology shift, such as the material and infrastructure of transition, but also involves interconnection and interdependence between heterogenous elements, such as actors, physical artifacts, organisations, institutions, natural resources, scientific elements, and legislative artifacts. Rip and Kemp (1998, p.330) describe this as a "configuration that works".

### 2.1.1 Conceptualising transitions

Transition studies comprise multiple theoretical frameworks, each focusing on different aspects and stages of transformation to analyse sustainability transitions. The popular guiding framework has been the multilevel perspective (MLP) approach to socio-technical transitions (Geels, 2002; Rip & Kemp, 1998) followed by the TIS (Bergek et al., 2008a; Hekkert et al., 2007). While MLP investigates broader transition process at an abstract level, TIS focuses on the prospects and dynamics of a particular

technology that has the potential to contribute to far-reaching changes (Markard & Truffer, 2008). Though a detailed discussion on MLP approach is beyond the scope of this dissertation, the dissertation delves into the conceptualisation of how a transition towards sustainability unfolds, and where MLP has been acknowledged to be successful. The MLP (Geels, 2002; Rip & Kemp, 1998) was developed to understand how the transition towards sustainability, whether successful or attempted, occurs through the interaction between three conceptual levels, namely landscape level, socio-technical regime level, and niche level.

Landscape (macro-level) represents the wider external setting of the economic, physical and political environment beyond the direct control of the actors (niche and regime) within the system. These external influencing catalysts affect the sociotechnical development and determine deep structural trends that are difficult to alter (Geels, 2002, 2004, 2005). Changes at the landscape level can occur gradually (over decades) or through short-term shocks (Geels & Schot, 2007; Grin et al., 2010; Sorrell, 2018). These changes can exert pressure and influence the regime (meso-level) and niche (micro-level) functions. Factors influencing the landscape are heterogeneous and include "oil prices, economic growth, wars, emigration, broad political coalition, cultural and normative values, environmental problems" (Geels, 2002, p.1260) and corruption (Hansen et al., 2018; Lachman, 2012).

The socio-technical regime, which is the central of the three conceptual levels, is described as the established infrastructure and institutions that influence the technological trajectories and their stability (Geels, 2005). A regime is defined as consisting of "scientific knowledges, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructures that make up the totality of a technology" (Kemp et al., 2001, p.272). There are three interlinked dimensions to the regime which are (i) networks of actors and social groups, (ii) regulative, normative and cognitive rules that guide the activities, and (iii) material and technical elements (Geels, 2004). Innovation that takes place at the regime level needs to be incremental and needs to reinforce the existing technological trajectory. That way, the regime, incorporating incrementally brought out innovation, becomes stabilised and path-dependent. This is due to the lock-in caused by the economies of scale, sunk investments on equipment,

infrastructure and competencies, vested interests, institutional commitments, shared beliefs and discourses, and the entrenched norms and practices of different actors within the system (Unruh, 2000). Additionally, consumer lifestyles and preferences may have become accustomed to the existing technical system (Geels, 2011). The stabilised and path-dependent regime resists change and makes it hard for an alternative system to compete.

The alternatives emerge in a niche, which constantly challenges the socio-technical regime. The niche materialises within spaces where experiments take place and radical innovations emerge within a protected environment (Geels, 2005). The niche provides a learning space and also functions as "incubation rooms", protecting novelties from the structural pressures of the incumbent regime (Geels & Schot, 2007, p.400). It also improves novelties' performance by articulating policies, establishing networks, offering a socio-cultural environment, and letting the novelty mature and stabilise the configuration (Sorrell, 2018). These protected environments can be research and development (R&D) laboratories or demonstration projects (DP) (Geels, 2011). The niche then has the potential to breakthrough and hence to challenge and replace the incumbent regime (Sorrell, 2018). However, under an existing strong and stable socio-technical regime, radical innovations will have a hard time diffusing beyond niche level, and radical innovation will only achieve breakthrough when the socio-technical regimes become weak and/or unstable (Markard & Truffer, 2008).

Although MLP has been successful in this conceptualisation of transitions, it has received criticism for its difficulty in empirically operationalising these conceptual levels (Berkhout et al., 2004; Geels, 2011). Additionally, it has been criticised for neglecting the role of places and spatial scales in the transition process (Coenen et al., 2012; Smith et al., 2010). A comprehensive understanding of the influence of such place-based conditions in transition becomes imperative when studying transitions in different geographies such as developing countries (Binz et al., 2020; Köhler et al., 2019). This requisite necessitates positioning such transition studies within the GeoST literature. Therefore, the analytical focus of this dissertation, which is based on a developing country, places it within the GeoST literature.

## 2.2 Geography of sustainability transitions in developing countries

Despite transition being a global process, transition studies and innovation studies scholars have traditionally focused effort on academic debates and research in the realisation of sustainable futures in the global North (Ghosh et al., 2021; Köhler et al., 2019). Nevertheless, there has been a growing body of work focusing on transitions and innovations in the global South in recent times (Cantarero, 2020; Edsand, 2017a; Hansen et al., 2018). This growing body of work suggests that the way sustainability transitions unfold and are governed in developing countries are likely to differ from developed countries (Lundvall et al., 2009; Wieczorek, 2018). Furthermore, scholars also highlight the complexity in applying existing sustainability transition theories and concepts within developing countries, indicating the limited explanatory power due to fundamental contextual differences in social, political, economic, and ecological elements (Furlong, 2014; Ghosh et al., 2021; Hansen et al., 2018; Köhler et al., 2019; Lachman, 2012; Ramos-Mejía et al., 2018). The GeoST, in a recent addition to the theorising of transition, emphasises the need to place greater sensitivity on scale and place-based factors in shaping transitions (Binz et al., 2020). The context or places are constituted by the relations between actors, materials, institutions, cultures, histories, and structures (Binz et al., 2020; Pierce et al., 2011). These contextual particularities, unique to specific geographies, influence and determine the energy transition process greatly (Wieczorek, 2018) and have to be approached differently. For instance, innovation is widely acknowledged as the key attribute towards sustainability transition. However, this Western notion of innovation may not be understood from the same system perspective in developing countries (Berkhout et al., 2011; Hansen et al., 2018). In developing countries, the term innovation is generally associated with less formalised low-technology innovation or improvisation through the utilisation of local assets and indigenous knowledge systems, which are situated outside of R&D laboratories, or viewed as “imitative innovation” where the transferred technology is tailored for adaptation to local needs (Barnard & Chaminade, 2017, p.4; *see* also Hansen et al., 2018; Jeffrey & Young, 2014; Lema et al., 2021; Prabhu & Jain, 2015). This adaptation may only be enabled by being cognisant of the ground realities of the recipient country.

The GeoST has primarily focused on understanding how and why transition are different or similar across geographies. This is emphasised by examining how placed-based factors enable or constrain the transition process towards sustainability, and how transition-related innovations, knowledge and technology related to transitions travel across places (Hansen & Coenen, 2015; Köhler et al., 2019). However, the GeoST literature has insufficient concepts related to the interaction between technology and contexts (Bergek et al., 2015) necessary to understand and engage in responsible transition. In this circumstance, empirical application of adjusted TIS is likely to help better capture these contextual interactions to technology and understand technology development and diffusion in developing countries.

## 2.3 Technological innovation system (TIS)

TIS, a technology-centred framework that focuses on technology-specific factors, has been largely applied for RETs, but with limited application in developing countries (Bergek et al., 2015; Gosens & Lu, 2013; Markard et al., 2012). This technology-centred framework focuses on (a) understanding how the innovation system around a particular technology, be it mature or emergent, functions, and (b) the diffusion of new and radical innovation (Bergek et al., 2015; Bergek et al., 2008a; Hekkert et al., 2007; Markard & Truffer, 2008). In transition studies, the TIS framework is often used for understanding the complex nature of the emergence and growth of new industries by way of analysing the obstacles to the processes, and subsequently translating them into intervention and policy strategies (Bergek et al., 2015). Although viewed through a system perspective that suggests collective and collaborative action, the TIS is primarily an analytical construct used to better conceptualise and understand system dynamics and performance (Bergek et al., 2008a). TIS is also about the technology's interaction with the prevalent system in which the technology is embedded (Hekkert et al., 2007). Markard and Truffer (2008, p.611) define TIS as "a set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilisation of variants of a new technology and/or a new product".

Thus, TIS is shaped by actors, networks, and institutions (Markard & Truffer, 2008). Actors refer to individuals and different kinds of organisations such as firms,

technology manufacturers, suppliers, vendors, universities, research institutes, associations, public authorities and NGOs (Hellsmark & Jacobsson, 2009; Markard, 2020). Networks refers to both formal and informal networks which are associated with inter-organisational networks for knowledge exchange (e.g., user-supplier and university-industry) as well as formal alliances and advocacy coalitions (Bergek et al., 2008a; Markard, 2020). While formal networks are easily recognised, informal networks will need to be identified through experts or other actors, or through collaboration projects such as joint university-industry projects (Bergek et al., 2008a). Institutions are, and represent, the formal and informal "sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals and groups" (Edquist & Johnson, 1997, p.46). Whereas the formal institutions refer to laws, regulations and rights, informal institutions refer to the societal code of conduct, traditions, taboos and customs (North, 1991). In general, and for effectiveness, the institutions need to be aligned with the functional needs of the new technology (Bergek et al., 2008b; Hellsmark & Jacobsson, 2009). It is to be acknowledged that these components of a TIS are not exclusively dedicated to a particular technology, but these components contribute to the innovation process and progress, either by obstructing or promoting the technology (Bergek et al., 2008a).

A TIS goes through two main stages of development: a formative stage and a growth stage (Negro et al., 2007). In the formative stage, various components are needed for development, diffusion, and utilisation of the TIS to emerge, including the formation of networks, institutional alignment, and knowledge accumulation (Bergek et al., 2008b; Negro et al., 2007). The system faces a high level of uncertainty at this stage, which may be due to the fluidity of the emerging technology or weak or absent technological and institutional structures necessary to support it (Suurs et al., 2010). In the formative stage, the networks may also be underdeveloped, and/or informal, and the TIS-specific institutions may be non-existent (Bergek et al., 2008a). Hellsmark and Jacobsson (2009, p.5599) highlight that formative stage is characterised "by a build-up of an embryonic structure" involving the accumulation of knowledge and artefacts, entry of firms and other organisations, formation of networks, and institutional alignment. Describing the formative stage Bergek et al. (2008a, p.419) states that "constituent elements of the new TIS begin to be put into place, involving

entry of some firms and other organisations, the beginning of an institutional alignment and formation of networks. A rudimentary structure is formed [in the formative stage]"

Once the essential TIS structural components (actors, networks, institutions) are in place, and positive and negative feedback loops are established between these different components, TIS progresses from formative stage to growth stage (Bergek at al., 2008b; Edsand, 2017a). A stable positive feedback process can make the system "increasingly self-sustained" and consequently allow the TIS to become a mature and a stable structure able to withstand external pressure (Bergek et al., 2008b, p.577). It eventually becomes rigid and path-dependent (Markard, 2020). This stage is described by Bergek et al. (2008a, p.420) as "system expansion and large-scale technology diffusion through the formation of bridging markets and subsequently mass markets" Scholars further highlight the need to move beyond merely analysing the components of a system and to focus on the emergent properties and the interplay between actors, networks, and institutions which have a direct or immediate impact on the development, diffusion, and use of the new technology (i.e., to move from a structural focus to process focus) (Bergek et al., 2008a; Hekkert et al., 2007). To analyse these interplays or TIS performance, scholars have suggested a set of key processes to be used as indicators, which they term TIS functions (Bergek et al., 2008a; Bergek at al., 2008b; Hekkert et al., 2007; Jacobsson & Bergek, 2011). Jacobsson and Johnson (2000) define TIS system function as "a contribution of a component or a set of components to a system's performance" (cited in Negro et al., 2007, p.927).

The structure and functions of TIS are intertwined and mutually influential. The TIS performance analysis tool consists of seven key system functions[7] that enable the characterisation of the innovation system by separately analysing its strengths, and weaknesses of the underlying processes (Bergek et al., 2015). These functions assess the innovation system to derive policy recommendations for supporting the

[7] The functions of TIS framework pay less attention to the external surrounding contexts as they do not affect the TIS-internal processes (Bergek et al., 2015). This dissertation focuses on the influences of contextual factors on technology-context interaction that greatly impacts technology development in a developing country.

development of a technology. The seven TIS functions include (i) entrepreneurial activities, (ii) knowledge development, (iii) knowledge diffusion, (iv) guidance of search, (v) market formation, (vi) resource mobilisation, and (vii) creation of legitimacy (Hekkert et al., 2007).

While the TIS framework offers effective inbuilt mechanisms to identify the blocking and promoting factors for sustainable transition, it has been criticised for being too inward looking and not paying enough attention to the contextual factors or TIS's external environment (Markard & Truffer, 2008; Smith & Raven, 2012). As the system functions do not pay attention to the external dynamics of the surrounding context (Bergek et al., 2015), a boundary is formed between the innovation system and its environment for the purpose of analysing geographical factors, technological fields, product areas, and activities (Coenen & López, 2010). This situation allows the framework to only consider endogenous blocking mechanisms within the TIS boundary while ignoring those outside it. However as every innovation system is placed within a context, attention to the influence of the external environment becomes vital in the growth of the TIS (Asheim & Coenen, 2005; Coenen & López, 2010). Put differently, Gault (2010, p.104) points that "innovation is constrained or advanced by the cultural, geographical, and legislative and regulatory environment in which it happens".

Another limitation of the TIS framework is its lack of attention to the spatial dimension of the wider research agenda on the geography of transition (Coenen et al., 2012; Markard et al., 2015). Although the TISs are said to consist of geographical dimensions (Bergek et al., 2008a), the TIS analysis is largely focused on a selected technology in a selected country, and foreign or global influences are often neglected in the analysis, which may be significant for policy interventions (Binz et al., 2014; Markard et al., 2015). This becomes especially significant for developing countries, where transitions are spurred from transnational reliance and technology transfers. The TIS framework has been developed for and mainly applied in developed countries (Edsand, 2017b). As such, TIS development will differ significantly in developing countries due to their differing structural, institutional and place-based conditions. Coenen et al. (2012) state that TIS's neglect on interdependencies on spatial contexts leads to oversimplified conclusions. The transfer and application of an unchanged framework to a different

context from which it was originally developed will undoubtedly affect its effective application (Blum et al., 2015; Markard et al., 2015).

Edsand (2019) informs that TIS analysis of RETs in developing countries is still in its formative stage due to the influences of exogenous contextual factors, which limit its progress to a growth stage. However, application of TIS in developing country contexts are also emerging (Edsand, 2017a, 2019; Esmailzadeh et al., 2020; Kebede & Mitsufuji, 2017; Tigabu, 2017; Tigabu et al., 2015). These dynamic analyses have received much attention and focus on the functions and processes of the innovation system. For instance, the studies argue for a modified set of indicators for developing countries (Esmailzadeh et al., 2020; Kebede & Mitsufuji, 2017), or the inclusion of wider contextual factors by way of an extended TIS function approach to be applicable to developing countries that focuses on the diffusion of new technologies (Edsand, 2017a, 2019). However, ambiguity remains regarding how the TIS needs to be re-configured in a manner that engages with RET development in developing countries. This needs to take into account their local-global linkage and contemporary contextual realities in a way that would enable a responsible transition.

Dealing with contextual realities and challenges necessitates new ways of doing research and bringing out innovation in order to allow proper embedding of technological advances in society at large in a responsible manner. The RI (Stilgoe et al., 2013) discourse highlights the need (a) to anticipate and to foresee the potential risks and public concerns, (b) to ensure reflexivity by innovator's role in and responsibility for society, (c) to ensure inclusiveness for legitimisation and public acceptance, and (d) for responsiveness to stakeholder concerns to ensure that contextual particularities are absorbed (De Hoop et al., 2016). These RI identified attributes to research and innovation do influence the technology trajectory when introducing and absorbing a RET into a context. This dissertation shows that TIS elements need to be adjusted when analysing energy transitions in developing countries. In light of the above observations and to ensure that transition is accomplished in a responsible way, this dissertation provides an analytical framework interlinking networks, discourse, and materiality to assess how transitions play out in such settings (Figure 1). While these elements influence the RET development in a

developing country, these elements are interdependent and hence the transition pathway eventually is determined by the interplay between them.

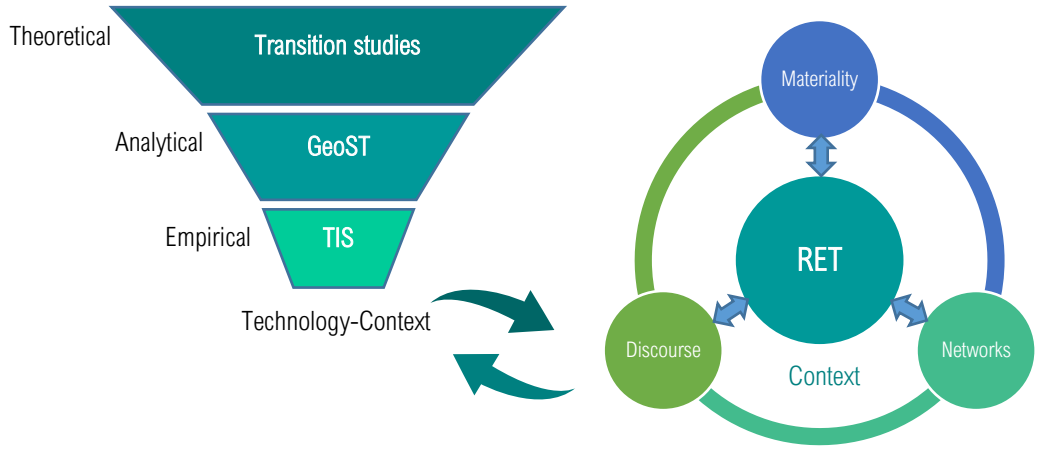



**Figure 1:** TIS-adjusted analytical framework to RET in a developing country

### 2.3.1 Networks

Networks play a key role in knowledge transfer between countries with unequal knowledge bases, especially from developed countries to developing countries. While actors are characterised by their capabilities, type, and scale and numbers, networks are found within and "between sectors, and constituting of local-global relations" (Asheim et al., 2019, p.71). Literature on innovation systems looks at different territorial system networks for building, exchanging, and recombining knowledge for industry development in developed countries, in the form of regional innovation system (Asheim et al., 2019; Asheim et al., 2011), and national innovation system (Lundvall, 1985, 1992). The access to, and availability of, global innovation system (GIS) (Binz & Truffer, 2017) emphasises the increasing importance of international linkages to the innovation process. Scholars suggest that, regarding novelty, "local and regional networking are associated with incremental innovation while global linkages tend to lead to more radical innovations" due to the fact that local and regional networking provides similar knowledge, and global networks provide access to new knowledge (Grillitsch & Chaminade, 2018, p. 2280). The GIS literature also informs us that the performance of a system in relation to developing and diffusing innovation depends not only on the subsystems, but importantly also on establishing structural couplings regionally, nationally, or globally through various actors, actor networks,

and institutions (Binz & Truffer, 2017). Thus, it is crucial for countries with poor or inadequate knowledge bases to establish coupling mechanisms with global knowledge networks to facilitate, exchange and recombine resources that are not locally available or scarce. This innovation collaboration and the collaborative linkages involve a two-way exchange of knowledge between independent organisations located in different countries and which have the capacity to transfer and receive complex knowledge (Ebersberger & Herstad, 2011; Herstad & Ebersberger, 2015; Martin et al., 2018). Developing countries can benefit from networking in international scientific meetings, collaborative projects, and links between universities that can transfer knowledge to domestic firms and universities (Cirera & Maloney, 2017). The innovative process greatly benefits from GIN, which is considered crucial, particularly for contexts with limited or lack of local knowledge resources (Grillitsch & Chaminade, 2018). GIN refers to the globally organised network of collaborative interactions between different organisations (firms or non-firms) engaged in knowledge production that is related to and leading to innovations (Chaminade, 2009). To tap into GIN, countries, in particular developing countries, need to garner transnational cooperation and need to build exogenous linkages with a variety of globally distributed knowledge networks and actors. Such linkages will allow and facilitate users to acquire new knowledge, to upgrade their knowledge-base, and to apply the acquired knowledge in their regions in order to advance their own domestic capabilities and knowledge sharing (Asheim & Vang, 2006). Establishing these coupling mechanisms through GIN and other networks can be either internal or external (networks of organisations in different countries performing different functions), and the linkages between actors within networks can be either formal or informal (Chaminade, 2009). While the role of formal networks for transnational linkages (Berkhout et al., 2010; Kim, 2019; Marquardt, 2015; Wieczorek et al., 2015) is easier to identify, it is harder and challenging to analyse the interaction taking place within informal networks (Chaminade, 2009). Martin et al. (2018) classify the informal networks that provide access to global knowledge sources as (i) labour mobility, (ii) temporal professional gathering, (iii) online platforms and virtual communities, and (iv) personally embedded networks.

Knowledge transfer through skilled labour mobility is effected by cross border movements of scientists, who contribute to the transfer and growth of academic knowledge both at the local and global level (Asheim et al., 2019; Trippl, 2013). This

international knowledge flow through skilled labour mobility tends to be multidirectional in nature, sharing the benefits of skilled migration between sending and receiving countries or regions (Trippl, 2013). It is assumed that the country that sends skilled labour will benefit from the return of the said labour after acquiring highly qualified knowledge. However, the sending countries will still likely benefit from the unreturned skill labour (Ackers, 2005; Gill, 2005; Trippl, 2013). This is because of persisting emotional and professional linkages that the skilled labour maintains with their home country. One such example is that of the diaspora network of skilled people who have dispersed globally but who continue to maintain and transfer knowledge via informal networks to their home countries (Gill, 2005). The diaspora is a category of people uprooted from the same country where they were born and living in one or more foreign countries (Safran, 1991).

The focus on networks in TIS literature is on establishing linkages and interactions for the advancement of knowledge, skills, and innovation. In this respect, Larner (2015) informs that the diasporic academics have begun to play more explicit institutional roles in the creation of global knowledge networks through informal networks that work above and beyond individual institutional affiliation. In this dissertation, I add diaspora as a potentially effective, context knowledge-holding informal network among the portals of global knowledge transfer, knowledge recombining, and innovation process.

### 2.3.2 Discourse

A comprehensive understanding of the prevalent regime is central to innovation and transition studies to achieve the shift from the dominant regime to another (Geels et al., 2004; Rip & Kemp, 1998; Rotmans & Loorbach, 2010). Regimes are constructed by long-term coalition of actors such as politicians, businesses, or citizens, who (i) share a set of formal and informal rules that guide their decisions and actions, and who (ii) have a collective knowledge and a vision towards the future (Hermans et al., 2010). Accordingly, narratives that emerge from these key stakeholders become an important dimension of a country's energy transition mission. Being cognisant of narratives is therefore essential to make sense of the stability and changing energy system and related practices (Buschmann & Oels, 2019; Isoaho & Karhunmaa, 2019). Cognisance of narratives is also necessary for framing energy policy and solutions to problems

(Scrase & Ockwell, 2010) and consequently policy development. Policies are developed around dominant narratives as they become interlocked within a particular set of processes, technologies, system boundaries, intervention mechanisms, and socio-economic arrangements (Leach et al., 2010; Mohan & Topp, 2018). They marginalise alternative narratives and mechanisms. Geels (2014) suggests that identifying problems, advancing solutions to the problems, and providing rationale for actions at speed are part of discursive strategies by (powerful) actors to advance their interests and resist fundamental regime change. Research on environment and development issues has demonstrated that dominating narratives later get implemented as polices and laws which are not comprehended fully at the local level (Adger et al., 2001; Benjaminsen & Overå, 2011; Poudel, 2018).

Energy transition towards sustainability is a contested subject. The decision-making process in transitioning towards sustainable solutions and implementing policies at different levels of governance is greatly influenced by diverse stakeholder groups who hold different perspectives, aims and views (Komendantova, 2021). In developing countries, infrastructure, institutions, and policies are less established or weak, and the reliance on informal arrangements, institutions and practices is substantial (Kraemer-Mbula & Wamae, 2010; Wieczorek, 2018). Narratives of different stakeholders, informal practices, informal institutions, formal institutions, and how they communicate with each other hence become discourse-related determinant factors in this contested subject.

The specific contextual aspects or social phenomena are mediated through discourses, leading to different meanings rather than leading to a single or fixed meaning (Rear, 2013). These meanings are brought about by different perspectives of different groups consisting of social actors or organisations (Fairclough, 2013). These emerge through talks and discussions on specific contemporary aspects based on the cultural and political context, leading to an intended meaning (Jørgensen & Phillips, 2002; Poudel & Aase, 2015). Discourse may thus turn into or may be seen as an attempt to fix a web of meanings within a particular domain (Laclau & Mouffe, 2014), such as of energy transition. These occurring aspects can "be small or large and the understanding of it may be shared by a small or large group of people on a local, national, international or global scale" (Adger et al., 2001, p.683). Dryzek (1997, p.8) views discourse as,

> a shared way of apprehending the world. Embedded in language it enables subscribers to interpret bits of information and put them together into coherent stories or accounts. Each discourse rests on assumptions, judgements and contentions that provide the basic term for analysis, debates, agreements and disagreements.

While discourse offers a shared meaning of a phenomenon, narratives constitute stories on particular issues within the discourses (Haarstad & Fløysand, 2007). What different stakeholders and institutions generate and reflect in these general discourses about the phenomena is reflected through the narratives, which together build these discourses. The narrative is increasingly seen being used and preferred in energy and climate research and policy (Moezzi et al., 2017; Mohan & Topp, 2018). They play a significant role in the emergence and (de)legitimisation of new industries (Nilsen & Njøs, 2022). In such processes, the hegemonic narratives gain traction with their underlying power relations (Fløysand & Jakobsen, 2017).

Narratives are discursive practices generally used by people to construct meanings and realities from fragmented observations (McComas & Shanahan, 1999). These encapsulate ideas that ultimately influence behaviour, shape culture and become embedded in institutions (Schreurs, 2020). Narratives are created and employed by individuals, groups, or nations to interpret and understand the social, cultural, economic and political realities around them (Patterson & Monroe, 1998). They influence the perceptions of "what we see and think about, how we see things, and how we behave" (Schreurs, 2020, p.113). Narratives provide an interpretation or evaluative commentary on a topic, illustrating what is significant to people about various practices, ideas and actions (Feldman et al., 2004). Narratives go on to relate a story with a temporal sequence of events, presenting a problem, its causes and consequences, and offering arguments for possible solutions (McBeth et al., 2005; Mohan & Topp, 2018). Narrative become a tool to simplify complex and uncertain issues and communicate to influence and enable actors to make decisions and suggest solutions (Roe, 1994). Thus narratives have a clear focus and purpose for policy change, as they can be strategically designed to influence policy preferences with a stance on policy issues (Leach et al., 2010; Mohan & Topp, 2018). Leach et al. (2010, p. 371) highlights,

> Narratives are created and promoted by particular actors, networks and institutions. They often start with a particular framing of a system and its dynamics, and suggest particular ways in which these should develop or transform to bring about a particular set of outcomes. Narratives therefore suggest and justify particular kinds of action, strategy and intervention. Some narratives, in turn, come to be supported by institutional and political processes - governance - so as to define and shape pathways: particular directions in which interacting social, technological and environmental systems co-evolve over time. Other narratives, meanwhile, may not become manifest in actual pathways of intervention and change, remaining marginalised.

Njøs et al. (2020) points out that works inspired by the TIS have not given sufficient attention and focus to narratives. Narratives play a key role in the responsible (innovation) energy transition process. They shed light on potential risks and stakeholder concerns, and their absorption within the transition operation is likely to aid the sustainable transition process through RI practices embodying inclusiveness, legitimisation, and public acceptance (De Hoop et al., 2016). In this dissertation, I incorporate narratives in play (Fløysand & Jakobsen, 2017) to reflect the influence of context-relevant institutions and practices and their influence on RET development.

### 2.3.3 Materiality

Energy transition in developing countries is tied to technology transfer, as discussed earlier. Energy transition primarily involves the transfer of and fundamental shift from one technology to another - the material shift. The material shift presents the tangible dimension of transition. The GeoST literature (Truffer & Coenen, 2012) is populated with diverse approaches and expansions to transition and sustainability by going beyond a technological fix perspective (Köhler et al., 2019). Such advances in energy transitions are particularly so in relation to the "distribution of different energy-related activities across a particular space" and "the geographical connections and interactions between that space and other space" (Bridge et al., 2013, p.333). These diverse approaches, interactions and activities reflect the intangible dimension of transition. This expansion in literature resulted from scholars signalling that sustainability transition is not only about having confidence in "technological fixes for solving environmental problems" (Truffer & Coenen, 2012, p.4), but also about the need to "go

beyond a mere diffusion of specific technological fixes" and to pay attention to the broader perspectives of socio-technical transitions by encompassing institutional structures, lifestyles, and infrastructures (Truffer, 2012, p.182). Hansen and Coenen (2015, p.95) further state that "sustainability transitions are geographical processes - they are not pervasive, but happen in particular places, i.e., actual geographical locations with a materiality to them". Yet, materiality has not been granted the same attention as the intangibles within the GeoST literature, in both theoretical and analytical terms.

TIS implies innovation (i.e., new technology) as an output of the system (Edquist, 2006; Markard & Truffer, 2008). Different contexts in GeoST offer different potentials and challenges that certainly influence the progress of innovation and technology (Jakobsen et al., 2019) and the configuration of technology. Consequently, different types or configurations of materiality becomes suited or relevant for different contexts. This lack of contextualisation of technology is prevalent, for instance, in the seminal work on multi-scaler conceptualisation of innovation systems by Binz and Truffer (2017). In their illustration for a footloose GIS, they highlight mature solar PV as an example of standardised valuation. The authors describe "standardized valuation" where "end-users have relatively undifferentiated preferences" (Binz & Truffer, 2017, p.1289). Here the solar PV technology is understood as footloose and hence applicable globally, missing the analytical dimension of contextualising technology. Contextualising technology becomes crucial, especially to understand transitions in developing countries, where technologies for energy transitions are not developed or designed locally, conforming to local contexts, but established technologies are imported for diffusion and utilisation.

The literature on GeoST presents the role of materiality by representing technology for transition as merely an end-product of the process. To put it differently, while emphasising the role of context in transition (Coenen et al., 2012), GeoST has not been advocating to contextualise technology, even though successful sustainability transition will necessarily mean contextualisation of technology too. In portraying the importance of local natural resource endowments for sustainability transitions, Bridge et al. (2013) and Hansen and Coenen (2015) state that social attachments to natural materiality/landscape can impede transformations necessary for sustainability

transition, such as in the case of locating wind turbines. Similarly, the growing evidence coming from empirical research on the need for contextualising technologies, or at least highlighting the negative implications on social space and lives as a result viewing technology, such as solar PV, as footloose (Sanseverino et al., 2021; Silva & Sareen, 2021; Stock, 2022; Taye et al., 2020) apprise the significant role of materiality in context and the need to not disregard it analytically.

The concept of materiality in the GeoST is both an absolute characteristic (e.g., solar technology) and a relative one. Relative materiality describes the relational characteristic of the technology with natural materiality (i.e., land) and with different but related stakeholders. Though absolute is fixed and unchanging and relational can be highly dynamic (Bridge et al., 2013), the absolute can change due to the influence of the relational on the absolute. The interaction between the human and the non-human environment can and will modify the innovation process consequent upon the relations that humans and non-humans have with each other, wherein the role of materiality becomes equally important in enabling, shaping, and blocking innovation process (De Hoop et al., 2016). The extant literature gives only limited attention to the way absolute materiality influences different actors and the environment, and vice versa. Similarly, how transitions are constrained by this energy transition-related materiality is less acknowledged analytically in the literature. Analytically, materiality in relation to technology cannot be approached as absolute materiality, but needs to be viewed through a relational perspective, and due emphasis given to its role in energy transition. In this dissertation, I present the impacts of relational materiality on sustainability transition, thereby illustrating their role in GeoST.

# 3. Methodology

The three scientific papers that contribute to this article-based dissertation describe the methodology in concise form, conforming to the requirements and limitations of the individual publishers. This section, therefore, records a broader account of the methodology, including information not presented in the three papers. First the section presents the research setting and the research design. This is followed by details related to methods used for data collection, ethical considerations, and reflexivity. The final sub-section presents details of the fieldwork followed by a brief discussion on reliability and validity of the research.

## 3.1 Research setting

The research setting pursued for this dissertation is determined by, and reflects, the RQs as set out in the introduction section (Section 1.2). To identify and comprehend the nature and extent of the influence of contextual conditions and factors on sustainable energy transition, it is necessary to appreciate ground level realities and involve different stakeholders to obtain prevalent perspectives, narratives, and practices related to empirical realities within the Sri Lankan electricity sector. The research setting of this dissertation, therefore, largely rests on the narratives of the stakeholders of diverse categories linked to the electricity sector and/or its endeavours to achieve sustainable energy transition. Narratives-rooted data cannot be quantified but need to be interpreted and analysed qualitatively. Consequently, this empirical study sits broadly within the qualitative research setting.

This dissertation is inspired by action research, addressing a real-world situation through abductive reasoning. Action research is a participatory process that deals with a real-world problem or situation, and the process involves improving or changing the existing situation while also generating knowledge through those actions and using such knowledge for further improvements or change (Burns, 2009; Greenwood, 2007; Vasstrøm et al., 2008; Yorks, 2009). It combines theory and action leading to a cyclical and iterative exercise of co-generative knowledge creation by way of action, research, reflection, and action again (Coghlan & Brydon-Miller, 2014; Greenwood, 2007; Lune & Berg, 2017). Action research thus consists of a dual goal of resolving a specific problem which is of value to the people the researcher(s) is collaborating with, and

simultaneously contributing to theoretical knowledge of value to a research community (Mathiassen et al., 2012; O'Brien, 1998). An important part of action research relates to that of abductive reasoning, which is neither inductive or deductive but a pragmatic perspective, whereby the researcher seeks to choose the best explanation among many alternatives to the observed new insight of the phenomena (Timmermans & Tavory, 2012). The research process starts with a real-world observation, then searches for suitable theories that could best explain the empirical observation, which ultimately could also refine theory (Kovács & Spens, 2005). Thus, abductive reasoning aids in constructing a new theory through an iterative process moving back and forth between data and theory (Timmermans & Tavory, 2012).

The CBERC project identified the need for this particular research with the focus on not only building and strengthening the industrial partnerships and engagement between the Norwegian and Sri Lankan private enterprises and academia by adopting approaches to accelerate the process towards achieving more RETs, but also to overcome the existing bottlenecks in such engagement. I became part of the CBERC project to carry out this research and fulfil the identified objectives. In doing so, I became a beneficiary-implementer-researcher within the CBERC project, and an insider researcher by being part of the situation I am investigating (McNiff & Whitehead, 2011). In short, I am a beneficiary, as I am recruited by the CBERC project, I am a researcher because I carry out the research identified by the project. I am an implementer, though minimally, because of my engagement with CBERC's other project activities. My research has a specific goal and directionality through the CBERC project. It aimed to improve, as well as to inform the project of, RET innovation and investments in Sri Lanka.

## 3.2 Research design

Research objectives influence the research design. To achieve the objectives of my research, this dissertation takes a qualitative case study approach (Yin, 2009). According to Yin (2014, 'no pagination') a case study is "an empirical inquiry that investigates a contemporary phenomenon (the "case") in its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident". Case studies enable the use of data from multiple sources to obtain different

perspectives and insights to gather a vivid picture of the case, making it a pragmatic and flexible methodology that can fit a range of different aims (Laurier, 2010). It facilitates elucidation through a deep yet nuanced understanding of reality and the acquisition of context-dependent knowledge, as human behaviours and contextual relations cannot be meaningfully understood by mere application of context-independent theories (Flyvbjerg, 2011). Moreover, case studies of deviant cases can add to theory development (George & Bennett, 2005). The strategic selection of a case can lead to its generalisability and inform theory of new concepts and explanations unravelled by intense narratives (Flyvbjerg, 2011). In light of these attributes, a case study methodology was employed to study the complex nature of the Sri Lankan electricity sector, its empirical setting, and their influence on RETs, with the aim to determine suitable options, approaches, and thereby a way forward for achieving sustainable energy pathway for Sri Lanka and at the same time, make a contribution to the literature.

A case is seen as a specific entity bounded within space and time (Laurier, 2010). The selection of "a case is not 'natural'" but is an analytical construct to organise knowledge about reality in a manageable way (Lund, 2014, p.224, emphasis in original). In some instances, the case requires a researcher to find a solution to a problem. In my research position, I would say that the case found me rather than the other way around (Poudel, 2018; Stratford & Bradshaw, 2016).

Theoretically, research enquiries can be classified as concrete or abstract based on their nature (Lund, 2014). Concrete cases are those that are immediately accessible to the researcher, such as micro situations that can be directly observed. Abstract cases, however, are those that may be experienced but are not visible and have to be established through concepts (Lund, 2014). In this dissertation, I have approached the cases both as concrete and abstract. Papers #1,#2 and #3 are concrete case enquiries related respectively to the global university-university cooperation (GUC) project between Norway and Sri Lanka, the Sri Lankan electricity sector, and the grid-tied solar implementation including FPV. However, the interpretation of these concrete cases by way of concepts and theories leads the enquiries into the ambit of abstract case enquiry. For instance, in Paper #1, the diaspora's engagement in the GUC project, though presented as a concrete case, is linked to the concepts of coupling and informal

network from GIN literature, thus also making it an abstract case. In Paper #2, the prevalent barriers within Sri Lankan electricity sector for sustainability transition are presented as a concrete case enquiry. However, the discussion on different stakeholder narratives unravelling their understanding of sustainable energy transition and RI makes the case an abstract enquiry. Finally, Paper #3 is a concrete case enquiry related to grid-tied solar implementation including the FPV DP in Sri Lanka. However, it is presented and is linked to the spatial concepts of materiality and relational materiality, thus making the enquiry an abstract one too.

## 3.3 Methods

This section presents the methods employed for data collection for my case study research. The methods employed were flexible and sensitive to the context (Hox & Boeije, 2005). They included data from secondary sources, semi-structured interviews, and participant observations. This section also includes the ethical considerations and reflexivity practiced during the research.

### 3.3.1 Secondary sources

Using extensive secondary sources proved useful for this research as they provided historical insights into the Sri Lankan electricity sector, the current status of the sector, and its future goals and objectives. The secondary sources not only provided contemporary data relevant to the RQs (Hox & Boeije, 2005), but were also utilised to cross-check information obtained through interviews and participant observations. A variety of secondary sources were utilised for data collection in this dissertation. These included research reports, government institution reports and documents, scientific articles, parliamentary Acts, policies, regulatory reports, newspaper articles, letters, minutes, summaries of workshops/conferences, feasibility studies, reports from research institutes and websites. Grey literature such as annual and evaluation reports, general reports, and feasibility studies by the UN, ADB, World Bank, IEA, International Renewable Energy Agency (IRENA), Food and Agriculture Organisation, World Economic Forum, Warsila, Centre for Energy Finance, RMA Energy Consultants (RMAEC) and NGOs, also proved useful and offered informative data. In addition, PowerPoint presentations from conferences and government institutions,

video materials such as public speeches and energy expert interviews on television accessed through YouTube were also used as secondary materials.

### 3.3.2 Semi-structured interviews

Qualitative interviewing is a flexible and powerful tool for capturing the voices of people, and the way they make sense of their experiences (Rabionet, 2011). They are well-recognised as a common and powerful way to understand stakeholders (Fontana & Frey, 2000). Since the empirical focus of this study was to understand the challenges and opportunities of the electricity sector in Sri Lanka, structured interviews, which typically involve a fixed set of pre-established questions centred around a limited set of response categories (Fontana & Frey, 2000), were deemed unsuitable for this study. Unstructured interviews, which can be too flexible running the risk of losing the focus of the research and preventing the collection of focussed and relevant data for answering the RQs, were also not appropriate (Rabionet, 2011). Therefore, semi-structured interviews were chosen to allow for a focused discussion on specific topics related to the Sri Lankan electricity sector, and to provide a clear and in-depth understanding of the motivations, perceptions and experiences of the different key stakeholders. The interviews were run through the use of an interview guide (annexed) formulated in September 2019, while being mindful of, and within the confines of the RQs and project objectives. However, the interview process unfolded in a conversational manner, and offered me the scope to explore areas which I felt were important by asking spontaneous follow-up questions based on the interviewee's responses (Longhurst, 2003). This approach also provided the interviewee with the opportunity to elaborate on points of interest, and enabled me to ask questions outside the pre-defined sequenced questions to gain clarity and focus (Brinkmann, 2014). The pre-defined questions focused mainly on the energy governance, energy policies, key decision-making processes, views on past and current developments, as well as drivers and barriers in the Sri Lankan electricity sector. The questions were also tailored to the role and background of the stakeholder category.

The fieldwork commenced only after obtaining the necessary approval from the *Norsk Sentre for Forskningsdata* (Norwegian Centre for Research Data [NSD]). The NSD approval was received on 14 October 2019, and the first fieldwork interview

commenced on 24 November 2019 in Sri Lanka. The data production and protection of the research complied to NSD's ethical considerations, as outlined below.

#### *3.3.2.1 Ethical considerations and reflexivity*

Qualitative research describes a phenomenon from the participants' perspectives using interviews and observations. The researchers' intention is to listen to the participants and/or observe them in their natural setting (Orb et al., 2001). This makes fieldwork an interaction between a researcher and key stakeholders over a period of time (Briggs, 1986). This process can create a dilemma, as the aim of the research is to come up with generalisations for the good of others, versus the rights of the participants to maintain privacy (Orb et al., 2001), raising concerns over the ethics of research and researchers. Research ethics involve ensuring that no harm is done, obtaining consent, protecting privacy and confidentiality of data, in addition to honesty, integrity and responsible reporting of data (Lune & Berg, 2017). To adhere to this essential accountability process, the interview guide I developed to help with data collection formed part of the application material submitted for ethical clearance and approval by the NSD. When the NSD granted ethical clearance, it also approved the interview guide, along with the standard project information and consent form to be used during interviews. To adhere to NSD guidelines and mitigate ethical dilemmas in my research, I practiced the *informed consent*, and *anonymity and confidentiality* expectations, as detailed below. Following this, I have also presented my positionality and reflexivity in detail.

##### *Informed consent*

Researchers are obliged to provide participants with clear and sufficient information about the research and the implications of their participation. The National Committee for Research Ethics in the Social Sciences and the Humanities (NESH) (2022, p.19) states "the information should make clear to participants why they are asked to participate, what type of data is being collected, how it will be used, who will make use of the data, and for which purpose". In keeping with this prerequisite, my research provided participants with an information sheet (annexed). Before providing the information sheet to participants, they were briefed digitally and verbally about the objective of the research and why they were contacted by me. Only after such initial explanation were they asked for their willingness to participate in an interview. Once

the participants expressed their willingness to contribute to an interview, they were provided with the NSD approved and printed information sheet detailing the following: the purpose of the project, who is responsible for the research project, why they were being asked to participate, what participation means for them, how the research will store and use their personal data and safeguard personal privacy, what will happen to the personal data after the project period, participant rights, and contact details of the researching institute to exercise their rights. The printed information sheet also made clear that participation was voluntary and they could withdraw from the study. The detailed information sheet was in English, and all the participants were given sufficient time to read through the document before commencing the interview. Some participants requested additional details or clarifications, which were provided without hesitation, and in their local languages if they raised it in their mother tongue. In addition to the information sheet, participants were given a *participant consent form,* where signed written consent was obtained from participants to participate in the interview, to include their name in the interview annexure of the dissertation, and for the data to be stored for the project period. Face-to-face interviewees signed a hardcopy of the consent form. The participants who gave interviews digitally using the Zoom either signed and sent a digital copy via email or provided their consent as a reply to the sent email. Additionally, during the interviews, the participants' consent was once again obtained prior to commencing voice recording. In places where participants preferred not to be recorded, notes were written down.

### *Anonymity and confidentiality*

Anonymisation refers to the protection of research participant's identity and integrity (NESH, 2022). In my data collection, the participant consent form provided to research participants also checked if they consented to include their names, designation and institutions to appear in the interviewee list to acknowledge and recognise them as contributors to the research dissertation. Additionally, it assured participants that their names would not be disclosed anywhere else in the dissertation or in any written and published articles. While some participants agreed, some were sceptical. There were numerous concerns that needed to be taken into account when conducting qualitative research fieldwork in countries like Sri Lanka, which experience fluctuating political situations and have a record of political victimisation (Malthaner, 2014). Mollet (2011) suggests that social science researchers must be vigilant to the

cultural sensitivity, security concerns, and the consequences of administrative and political practices when conducting fieldwork in developing countries, and should carefully consider the application of ethical practices, which cannot be applied in the same way as in developed countries. To ensure best integrity practices, and to maintain the anonymity of participants and confidentiality of information, I gave anonymised codes to the interviewee list before starting my data analysis to avoid keeping any identifying records and lists (Ngozwana, 2018). Additionally, the interviewee lists were categorised anonymously into three sectors (Section 3.4) rather than as an annexure of a *list of interviewees* to the dissertation. This ensured the credibility as a researcher and the participants' trust in the research. Furthermore, I transferred the recordings to a hard drive immediately after the interviews and deleted voice records from the recorder to further ensure confidentiality.

### *Reflexivity*

Research is a constant and dynamic interaction between the researcher and the researched. In such a process, it becomes essential that the (over)involvement of the researcher does not become a threat to the credibility of the study (Chilisa & Preece, 2005). In other words, it is essential to avoid the researcher's biased claims. Reflexivity is a way of ensuring that the researcher does not influence the research process through their own personal background, beliefs, perceptions, and experiences in shaping the interpretation of the study (Ortlipp, 2008). Reflexivity, therefore, requires commenting on the researcher's past experiences and how these shape their interpretations (Creswell & Creswell, 2018). Being reflexive means aiming to make visible to the reader the research process and the research outcomes by (the researcher) consciously acknowledging the choices, decisions, and experiences during the process (Ortlipp, 2008). Against this backdrop, as a researcher, I would like to explain my positionality and reflexivity.

First, I am a Sri Lankan citizen, making me native to the context that I am researching. Within the Sri Lankan context, I am a Tamil by ethnicity, a female, born and having roots in the North (Jaffna), while growing up and educated in the Central Province (Kandy), which put me in a privileged position to experience the blend of the different Sri Lankan cultures and become trilingual. I am also a victim of communal riots, including the *Black July of 1983* (Section 4.2.1). My career started as an academic, then

administrator, and shifted to a humanitarian worker, and finally, to a development practitioner. My long engagement with a Norwegian development agency as a humanitarian worker and development practitioner in the North of Sri Lanka during the height of the war, led me to experience the devastation of war on communities, irrespective of their ethnic backgrounds. This also led me to get involved and get engaged in reconciliation mechanisms such as transitional justice initiatives, to ensure sustainable peace. This professional background made me to take up a Master of Development Practice through which my interests in the areas of energy and environment grew and got strengthened.

Secondly, my fieldwork in Sri Lanka, which lasted nearly four months, was as a PhD researcher attached to a university in Norway. Norway has had a long-lasting relationship (Section 4.2) with Sri Lanka in the development of different sectors. However, it is Norway's role as a facilitator in the Sri Lankan peace process what stands out in the minds of many and is viewed both positively and negatively. Any biased views the people I interviewed (with the exception of a couple of them) had about these attributes of my background quickly became irrelevant. I perceived this to be due, mainly, to the fact that everyone I interviewed was in favour of seeing Sri Lanka shift to renewables, although how to get there was a puzzle they had to solve, and as such they welcomed this research initiative, particularly by a native Sri Lankan. Additionally, being trilingual helped both me and the interviewees to engage more and overcome the challenges, and led to more productive conversations.

Thirdly, I had acknowledged my role in the CBERC project. I was recruited by the project to carry out the research identified through a needs assessment performed as part of the project. This is how my engagement with the project began in 2019. While I have become part of the project, my engagement with other activities of the project has been minimal. Additionally, I acknowledge the manner in which Norwegian interviewees were selected during Phase-II. Interviews were carried out with a delegation that had visited Sri Lanka through the CBERC project in 2018. Only a couple of members of the delegation maintained their involvement with the project after the visit. The participants for the delegation were invited by the project through different networks which were not directly linked to the project. The people I interacted with during this phase were, therefore, completely new to me. I also attempted to use

snowball sampling to find more participants for interviews. This led to the addition of one more interviewee. However, my attempt to connect with more interviewees who were already engaged or interested in engaging in RET projects in Sri Lanka did not result in finding more interviewees.

### 3.3.3 Participant observation

Participant observation at conferences and site visits to power-plant sites also provided relevant, rich, and first-hand data. While the conference participation and attendance were planned, the site visits came as a result of interviewees' suggestions. Participation requires no technical knowledge, but being part of it adds new perspectives to the analysis, which becomes a useful tool to gather further real-time and rich data (Laurier, 2010). The participant-observation provided me with a better and explanatory understanding of the setting. At the same time, I have been mindful of the fact that data from such methods is tied to me as the researcher, and can be challenging when presenting it as pointed out by Laurier (2010). Table 2 summarises an overview of the different participant-observations at discussions, conferences, seminars, and site visits in different settings and their relevance and observations made for the research. Three of these observations were critical for the study and are briefly presented.

My participation at an international conference on *Advanced Materials for Clean Energy and Health Applications* (AMCEHA) and the *Norwegian-Sri Lanka workshop on clean energy technologies* jointly organised by HVL and UoJ from 6-8th February 2019, presented me with an added understanding of the prevailing issues and concerns related to the electricity sector, in particular to renewable energy generation. I was afforded the opportunity to participate in these conference as I had just become part of this project holding PhD research position and was hence invited to participate. Although the research themes of these conferences covered topics and subjects very different to my research area, the workshop on clean energy technologies (CET) was relevant with presentations and discussions. It was at this conference that I identified two potential interviewees who gave an overview presentation of the Sri Lankan electricity sector and the solar industry during a dedicated session. Following an informal discussion, one of the participants directed me to a few more key stakeholders as potential interviewees. This informal discussion on 7th February 2019 was my initial entry point for data collection.

My invitation to the above conferences also included participation in pre-conference discussion on 05 February 2019 in the same venue. During this discussion, I remained as an audient member and tried to familiarise myself with conference themes and aims. While the objectives and agenda of the conference were planned and discussed, the discussants identified an urgent need to strengthen science, technology, engineering, mathematics, and medicine (STEMM) education and to uplift student motivation and engagement in the Northern Province of Sri Lanka. Moreover, the discussion also suggested a way forward through mentoring and supporting initiatives to motivate and strengthen the ongoing project activities by way of using the best and most successful educational tools, practices and experiences from the participants' host countries. The participants in this discussion were mainly the Sri Lankan Tamil diaspora from different countries who were also contributors in the conference.

The Royal Norwegian Embassy in Colombo, Sri Lanka organised an international conference, which combined a seminar and panel discussion on 21st January 2020 on the topic of *A new decade: Investing in clean energy in Sri Lanka: Drivers and barriers*. My participation in this conference, where I also presented my research, was very productive and relevant to my research progress, as it helped me to understand some of the contextual factors influencing the electricity sector and to also recruit interviewees. The conference attendees included public and private sector representatives from Norway and Sri Lanka, members from financial institutions, academics from Norway and Sri Lanka, energy experts and environmental activists and representatives from NGOs. The panel discussion, which included different key stakeholders and their diverse views on RETs for Sri Lanka, made me realise the interplay and contestation of the different narratives existing within the Sri Lankan electricity sector.

Another engagement was at the launch of the first FPV DP held on 24th January 2020 at the UoJ (Kilinochchi). I also attended the pre-launch conference with presentations and speeches by collaborators and key stakeholders. These direct attendances, as well as informal conversations and involvement, broadened my understanding of the reasons that led to the implementation of the DP, the interests and visions of different stakeholders in implementing and trying out new technologies in the Sri Lankan context, and their perceptions and expectation from the FPV DP for Sri Lanka.

| Participation | Date and location | Type, observation and relevance |
|---|---|---|
| Discussion forum on STEMM education: challenges and opportunities | February 5, 2019. Jaffna, Sri Lanka | Pre-conference discussion. Engagement and involvement of Sri Lankan Tamil diaspora in the project activities and in uplifting the STEMM education. Networking and informal conversations. |
| Advanced materials for clean energy and health applications (AMCEHA) and Norwegian-Sri Lanka workshop on clean energy technologies | February 6 – 8, 2019. Jaffna and Kilinochchi, Sri Lanka | International conference. Relevant for networking and informal conversations. Capturing an overview of the electricity sector. Connecting to potential interviewees. |
| Talk on HVDC transmission | December 18, 2019. Kilinochchi, Sri Lanka | Seminar. Relevant for networking and informal conversations. Connecting to potential interviewees. |
| A new decade: Investing in clean energy in Sri Lanka – drivers and barriers | January 21, 2020. Colombo Sri Lanka | Seminar and panel discussion. Presented my research proposal. Relevant to get a deeper understanding of the sector and influencing factors to clean energy investment. Emanating ideas on way forward. Networking and informal conversations. Connecting to potential interviewees. |
| Launching of the FPV DP | January 24, 2020. Kilinochchi, Sri Lanka | Conference and site visit. Relevant to obtain an understanding of the expectations and prevalent uncertainties of a new technology. Connecting to potential interviewees. |
| Off-grid wind solar hybrid system | January 25, 2020. Eluvaithivu island, Jaffna, Sri Lanka | Site visit. Relevant for observing the future potential solution for distant islands with renewables. Informal conversation. |
| Lakvijaya power plant station | February 12, 2020. Narakkaliya, Noraichcholai, Sri Lanka | Site visit and interview. Relevant for observation of the coal power plant operation and the large dependant labour force. Informal conversation on the process, cost, and challenges of operating the large capacity power plant. |

***Table 2:*** *Overview of the participant observation practiced at conferences and site visits*

## 3.4 Fieldwork

The section is divided into three sub-sections, namely pre-fieldwork, fieldwork, and post-fieldwork. The pre-fieldwork section is about the design stage and the operationalisation of data gathering strategy. The fieldwork section is about data collection, experiences, and challenges. The post-fieldwork section deals with the analysis and use of data. However, there are considerable overlaps between the three sub-sections.

### 3.4.1 Pre-fieldwork

To gain knowledge about the Sri Lankan electricity sector, I conducted desk-based research during pre-fieldwork and fieldwork stages by reading reports, various webpages, and newspaper articles related to the electricity sector in Sri Lanka. I also listened to interviews and discussions related to energy on the local television channels. This started in February 2019 while I was in Sri Lanka, which was also the period I attended the first conferences in Sri Lanka (Table 2). These initial readings, listening, and observations helped to identify potential names of interviewees in the Sri Lankan electricity sector.

After arriving in Norway in April 2019, I prepared a database with a list of potential interviewees. The two sources for potential interviewees were my own search and participation in the conferences. In late August 2019, I started sending emails to three potential interviewees, mentioning the objective of my research and enquiring about their willingness to participate. All three expressed their willingness. The rest of the potential key interviewees were contacted during the fieldwork either via emails or phone calls. The key interviewees were then recruited based on a purposive sampling method, also known as the judgement sampling method, which Tongco (2007) states is a method of selecting the interviewees deliberately based on the amount of information they possess, allowing the researcher to find people who can and are willing to provide information on what needs to be known based on their knowledge and experience. Nevertheless, to expand the interviewee list, I also used the snowball sampling technique (Biernacki & Waldorf, 1981). This was done by seeking potential interviewees' assistance to connect to informed people considered suitable interviewees for the intended purpose of my research, while also being mindful of the

risk of relying solely on the snowball technique, which could result in the researcher meeting only like-minded participants or the first potential interviewee having a substantial influence on the selection process (Parker et al., 2019). To mitigate this, I used multiple other portals to identify potential interviewees, such as personal contacts that I had made prior to starting my research, and directly accessing institutions related to the Sri Lankan electricity sector during my fieldwork in Sri Lanka.

Through these processes, I had a list of 24 potential interviewees when I started my fieldwork in Sri Lanka. The list included representatives from solar companies, independent experts and consultants, investors and project developers, academics and scientists from universities and research institutions, representatives from the utility (electricity), and government institutions. Every possible effort was made to ensure a balanced representation of different perspectives by choosing interviewees from the stakeholder spectrum, ranging from policymakers to implementers to researchers. I categorised them into four groups: public sector, private sector, academics and energy experts, and environmental activists.[8] However, of these 24 identified interviewees, only 10 agreed to offer interviews.

It was my intention to recruit around 50 interviewees in Sri Lanka to capture the diverse perceptions, RET related experiences, the barriers that the stakeholders experienced, and governance related matters. With this number in mind, I planned for two rounds of fieldwork in Sri Lanka. The first phase of data collection was stopped when similar information was repeatedly emerging from the range of stakeholders (Fusch & Ness, 2015). The number of interviews ended with 30 (Table 3).

In Norway, the pre-fieldwork commenced in 2020 with interviewee selection made possible through the CBERC project, which I was part of. This was during the Covid-

[8] The second planned data collection in Sri Lanka had to be postponed due initially to the Covid-19 pandemic related lockdown, but later cancelled due to the economic and political crisis the country underwent. This also reduced the stakeholder category from four to three as the 'environmental activists' category was removed. This is due to the fact that a scheduled interview with an environmental activist had to be cancelled and others could not be contacted during Phase-I fieldwork in Sri Lanka. This had to be postponed to the next round of fieldwork in Sri Lanka which did not take place.

19 pandemic related lockdown, and research work had to be confined to work from home due to travel restrictions, social distancing, and precautions. One of the main objectives of the CBERC project was to understand the challenges, opportunities, and pathways for more investments in RETs, especially solar technology from Norwegian investors. Therefore, the interview category in Norway was narrowed down to private sector and academic groups that have had or were still having engagements and experiences with the Sri Lankan electricity sector in relation to RETs, either academically or through industrial relations. The main route to identifying contributors was through a brochure that listed participants who were part of a delegation that went to Sri Lanka in May 2018 at the invitation of the CBERC project. It consisted of 26 academics and industrialists including participants from Norway, UK, and India. Ten of the listed participants responded positively to give an interview. In addition, the snowball technique was used, through which one more interviewee was added.

The third pre-field activity emerged as a result of a PhD course on *Doing Responsible Innovation,* where PhD students were put in groups of 3 to 4 and assigned a project to analyse. The FPV DP in Sri Lanka under the CBERC project was selected as one of the projects for analysis, and I was part of this group. The recruitment of interviewees was based on their specific engagement with the FPV DP in Sri Lanka or involvement with similar renewable energy project in Sri Lanka. In total, 8 interviews were scheduled, and in some interviews, more than one interviewee participated. As the course period was stipulated, the interviews were carried out within a limited time period, and all the eight interviews during this phase were completed in three days, between 25-05-2021 to 28-05-2021. In the final phase, a face-to-face interview was conducted in September 2022 with an academic in Norway. The breakdown of interviews by phase and sector is summarised in Table 3.

| Phase | Sector | Interviews |
|---|---|---|
| Face-to-face interview in Sri Lanka: November 2019 to February 2020 | | |
| Phase-I | Academic cum energy experts | 10 |
| | Public sector | 14 |
| | Private sector | 6 |
| Virtual interview from Norway: August 2020 to March 2021 | | |
| Phase-II | Academic | 2 |
| | Private sector | 9 |
| Virtual interview from Norway: May 2021 | | |
| Phase-III | Academic | 5 |
| | Private sector | 3 |
| Face to face interview in Norway: September 2022 | | |
| Phase-IV | Academic | 1 |
| **Total** | | **50** |

***Table 3:*** *Summary of the interviews conducted from 2019 to 2022*

### 3.4.2 Fieldwork

The fieldwork in Sri Lanka lasted four months, from November 2019 to February 2020. I had the opportunity to participate/attend in three conferences/seminar, as well as the opportunity to visit different sites such as the coal power plant site, launching of the FPV DP and visiting an off-grid hybrid solution using wind and solar PV on an island (Table 2). The fieldwork in Sri Lanka consisted of three categories: interviews, conferences, and site visits, but were not planned in any particular sequence.

During my fieldwork in Sri Lanka, I was based in Kandy (Figure 2), located in the Central part of Sri Lanka. This location enabled me to travel to the North and Western parts of the country, where most of the interviews took place, using public transport. Using Kandy as my base offered me flexibility in terms of scheduling dates and times convenient for the interviewees' calendar and data collection locations in Sri Lanka. Before conducting the interviews, I introduced myself and my research to all interviewees by outlining the purpose and content of the study. I obtained consent and a signed hard copy of informed consent (Section 3.3.2.1) from interviewees as proof for participating in the interview, to audio record the interview, and to use the data from the conversation for research purposes in an anonymised form. The interviewees were also briefed on the data collection procedure and the use of data.

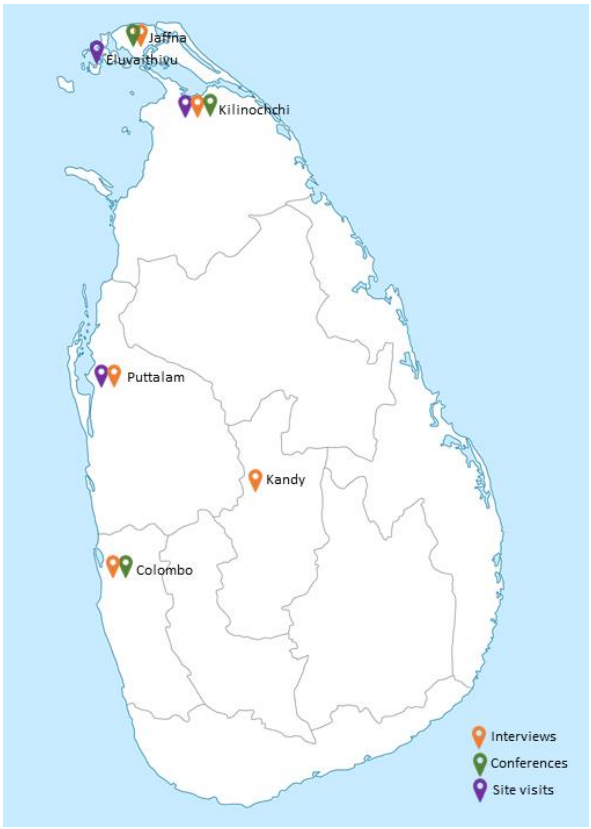



**Figure 2:** Summary of my fieldwork in Sri Lanka

During the semi-structured interviews, the interviewees were given ample opportunities to share their experiences and views. The interviews were voice recorded with the interviewees' consent. The voice recording of the interviews helped me to concentrate and to be attentive to the interactions and responses of the interviewees, directing all activities towards the main goal of the research interview instead of taking notes and failing to capture the details (Bucher et al., 1956). However, detailed notes were taken when interviews were not, or could not be, recorded. This occurred with three interviewees during the fieldwork in Sri Lanka, either because of their preference not to record, and/or because of unplanned spontaneous or informal discussions turning into interviews. In two cases, obtaining personalised face-to-face interviews was not possible either due to interviewees' logistical issues or preferences. In these instances, email interviews were carried out. During the fieldwork in Sri Lanka, I also used the recordings to listen and reflect together with the field notes to not only understand the sector but also to reformulate questions for planned upcoming interviews. The interview times varied from 15 minutes to 120 minutes.

Having time lapses between interviews became beneficial as it provided me with time to listen and reflect on the recorded interviews. This allowed me to gain insights and

clarify or address the questions from different perspectives in subsequent interviews. In Sri Lanka, the interviews were mostly conducted in English. However, some interviewees switched to their mother tongue, either Tamil or Sinhala, and in some instances, they preferred to communicate only in their mother tongue. Being trilingual helped me to communicate in their preferred language and to translate and transcribe the recordings during the post-fieldwork period. There were also instances where interviewees requested to switch off the voice recorder so that they could share views which they did not want to be recorded. In a few other instances, interviewees shared interesting views after the interview was over and I was ready to leave. Although these helped me to better understand opinions and perspectives related to the sector, I did not use them anywhere in my research writings as they were opinions and regarded by the interviewees as *unofficial* claims. A few public sector officials and energy experts also shared documents, PowerPoint presentations and website links for me to obtain additional information.

During my fieldwork in Sri Lanka, I also carried out three site visits on the recommendation of public sector interviewees. They suggested visiting the coal power plant site and the off-grid hybrid power plant site to help me understand first-hand the challenges and opportunities. The visit to the FPV DP launch was aimed at gathering data, networking, and to attend the conference. I maintained a field diary to write down notes and details from informal conversations and observations during site visits. This was necessary as the site visits were conducted in a working environment and impromptu conversations with different people on the site. These conversations took place while walking around the site area, but due to the background noise from working plants and wind, voice recording was not feasible. These were more of an informal conversation with, and preferred by, the people present at work at that time. Loubere (2017) identifies this challenge, stating that audio recording is necessary for the transcription of interactions with interviewees, however, at times, the environment is not conducive to producing a recording of sufficient quality. Furthermore, it would have been difficult and ethically inappropriate to request consent from impromptu participants who came and went while we were conversing (Loubere, 2017). Therefore, I noted down details of the conversation in my field diary at the site. Although occasionally important information was presented or expressed even when voice-recordable, these informal conversations were used only to accumulate additional

information for me to understand the sector, and were not used or quoted anywhere in the study.

I left Sri Lanka in the beginning of March 2020 with the hope of returning for another round of field visits for interviews and site visits after analysing the collected data. However, this turned out to be impossible due to Covid-19 lockdown and travel restrictions. An initiative to carry these out through digital interviews using the Zoom with Sri Lankan stakeholders was abandoned, not only because they did not respond to emails, but also due to their poor internet connectivity and frequent power cuts.

The Phase-II interviews with academic and private sector were conducted via digital video interviews using the Zoom, as face-to-face interviews were not possible during Covid-19 lockdown and restrictions. Ten interviews were carried out this way from Norway, while one was done as an email interview as preferred by the interviewee. The interviewees, though largely Norwegians, also included one from India and one from the UK. All interviews were voice-recorded with consent. Recent works have highlighted that virtual interviews can be good alternatives for capturing people's narratives and perspectives when other options are not possible or available (Thunberg & Arnell, 2021).

The Phase-III interviews were also conducted as digital interviews via the Zoom at a PhD course group work with four interviewers. However, this format faced challenges when attempting to conduct virtual interviews with Sri Lankan stakeholders due to the then prevailing power cuts in Sri Lanka and poor internet connectivity leading to disrupted interviews and insufficient clarity. In such situations, the interviewer/s had to repeat their questions a few times, or the interviewee had to repeat their responses a few times. Due to the poor internet connectivity, a few interviewees preferred to keep their video cameras switched-off to improve the audio connectivity. To mitigate this, one interviewee later sent the responses in the form of voice messages through the WhatsApp App.

### 3.4.3 Post-fieldwork

The data analysis process was continuous throughout the research period and involved interactive and reflective processes, between, for example reading field notes,

transcriptions, listening to interview recordings, and reference to secondary sources. Qualitative data analysis involves "researchers attempt to get a deeper understanding of what they have studied and to continually refine their interpretations" (Basit, 2003, p.143). After returning to Norway in March 2020 following my Phase-I fieldwork in Sri Lanka, I began manually transcribing recorded interviews verbatim. Verbatim transcribing involves reproducing verbal data word for word, with the written words replicating the audio-recorded interview but failing to capture the interviewee's nonverbal communication (Halcomb & Davidson, 2006; Poland, 1995). I used dots, brackets and highlights to indicate pauses, sighs, and interruptions that happened during interviews (for example, when the interviewee received phone calls or other people came in to meet them briefly). Listening to the audio recordings repeatedly brought back recollections of the interviews and highlighted the interviewee's emphasis on their views through the choice of their words and the tone of their voice. MacLean et al. (2004) suggest that the accuracy of transcription is dependent on how the transcriber hears as well as perceives the interview content. Interviews which were in local languages (i.e., Tamil or Sinhala) were translated into English by me during the transcribing process. Where interviews were not recorded, field notes were read again and repeatedly, if necessary, to identify key issues mentioned by those interviewees. The in-depth interviews provided rich and new data, including alternative interpretations of the many challenges faced by the electricity sector in Sri Lanka, some of which were not found in the secondary sources. These in-depth insights were utilised in my data analysis, with an emphasis on significant insights identified by many interviewees, not by just one. The observations made during site visits and the perceptions which arose during informal conversations were also noted down along with the field notes. As my mother tongue is Tamil, I translated an official letter written in Sinhala from a Divisional Secretary[9] with the help of a Sinhalese contact to ensure the accuracy of the translation. I also collected newspaper articles from Sri Lanka mostly in English and Tamil, and took notes while highlighting relevant sections of the article. Phase-I transcription, while providing rich data, also brought in new queries which required clarifications during the follow-up fieldwork phase in Sri Lanka (planned for December 2020 but had to be postponed and subsequently cancelled due to Covid travel restrictions). In addition, I also made contact with a retired public

[9] Responsible for the civil administration of the division in Sri Lanka

servant from the Sri Lanka electricity sector who provided me with several secondary sources and also links to various Facebook groups related to and involved with renewable energy in Sri Lanka. I viewed the discussions of these groups to understand their opinions and presented facts. These viewings brought to my attention existing viewpoints, stances, and contextual issues, enhancing my understanding during data analysis.

I transcribed Phase-II interviews soon after completing each virtual video interview conducted using the Zoom. Transcribing soon after the interview helps to enhance the memory of the interview event with details before it fades away (Sunstein & Chiseri-Strater, 2011). This helped me to make necessary alterations, reframe questions, and adjust the sequence and flow of questions for subsequent interviews with remaining stakeholders. Transcribing for Phase-III and IV was similar to Phase-II as I started transcribing soon after the interviews. However, in these phases, the transcribing was handwritten rather than computer typed as in the previous phases.

Data analysis commenced in the transcribing phase. When I completed transcribing the first two phases of the interviews, I had a good understanding of where the data was orienting and noted many interesting common features (codes) emerging from the interview data. These codes were related to the RQs, and I listed them on a Word document by using quotes from the interviews. Codes are regarded as the building blocks for themes, providing a framework for organising and reporting the researcher's analytic observations (Clarke et al., 2015). These recurring patterns, commonalities and meanings emerging from interviews were summarised into categories or themes. These themes were again referenced in multiple secondary sources related to the Sri Lankan context, including making linkages to scholarly articles and reflections from participant observations. The use and combination of different types of data sources, including some partial/incomplete accounts given by interviewees, helped provide a more accurate overview. Thematic analysis is described as a method used for identifying, analysing, and interpreting patterns of meaning (themes) “within and *across* data in relation to participants’ lived experience, views and perspectives, and behaviour and practices” (Clarke et al., 2015, p.297, emphasis in original). Thematic analysis encompasses the important themes in the description of the phenomena under investigation and highlights the most salient constellations of the meanings

present in the dataset (Joffe, 2012), thus assisting to better interpret data. These themes of empirical evidence were used in the different articles to highlight the fundamental impacting issues in the Sri Lankan electricity sector.

The strength of thematic analysis is its flexibility, meaning it can be used both as inductive and deductive methodologies (Alhojailan, 2012). Through my interview guide, my data analysis took an abductive approach, as the data interpretation was taken through a highly iterative process between summarised themes and theoretical concepts in refining the links. The themes that emerged from the data analysis of Phases-I and II were informal networks and narratives in play, which became central subject matter for Papers #1 and #2, informing the Sri Lankan-context related dimensions of network and discourse, respectively. The analysis of Phase-III and IV unveiled the broad theme of materiality, which formed the subject matter for Paper #3. By identifying and pointing to the driver activities of the diaspora, which had thus far remained inconspicuous, this study has further spurred the CBERC project while making the research an action research. Some themes which emerged but were not processed further in this research, such as *gender in energy leadership*, were not absorbed into the dissertation, as this required further exploration and fieldwork in Sri Lanka.

## 3.5 Reliability and validity

Reliability and validity are measures used for evaluating the quality of research, and these are addressed in the different papers. They are regarded as challenging to apply in qualitative research (Golafshani, 2003). Reliability refers to research being replicable, where the data collection and analysis by multiple researchers yield similar findings under the same conditions (Franklin & Ballan, 2011). Validity, on the other hand, is about the appropriateness (e.g., the accuracy and truthfulness) of the research findings (Creswell & Creswell, 2018; Golafshani, 2003). However, the reliability and validity of a study are "contingent of time-space and they are context-dependent" (Poudel, 2018, p.57). In this dissertation, reliability and validity are addressed through different research processes. The methods used, the data collected and analysed throughout the dissertation, are in line with the RQs presented in Section 1.2. The explicit and detailed description in Section 3.4 broken down into pre-fieldwork, fieldwork, and post-fieldwork phases, through which the case studies were built,

ensures increased reliability and transparency of the research process (Yin, 2009). Reliability is further ensured in the dissertation through "theoretical transparency" by explicitly explaining the theoretical stance from which the interpretations were derived (Silverman, 2011, p.360). Secondly, as presented, the dissertation is based on multiple types of qualitative data sources, which increases the validity of the case study (Yin, 2009). For instance, the notes and observations from participant-observations from sites and conferences were later used to cross-check the findings from the interview data and document reviews wherever necessary and possible. The claims and information processed through interviews for interpretations were not from a single interviewee but were claims and information shared by more than one interviewee and were also re-analysed with similar facts in the document data. In Paper #3, to determine the accuracy of findings, a few follow-up interviews with participants were carried out to cross-check the findings, which Creswell and Miller (2000, p.127), describe as "member checking" and is regarded as an essential practice to ensure validity. The use of identifiable quotes, which were desired to be used for interpretation in the different papers, were transcribed and used verbatim to ensure that respondents' expressed meanings are not altered. The dissertation also presents rich, detailed descriptions of the case and context to add validity to the findings and make them more realistic and richer (Creswell & Creswell, 2018). Reflexivity, involving self-scrutiny by the researcher throughout the entire research process, dealt with under Section 3.3.2.1, again contributes to good quality research.

# 4. Empirical context

This section describes the empirical background on which the cases for this dissertation were built. The Sri Lankan context, including the country's general energy landscape, electricity sector, policies, and key stakeholders is described first in this empirical section. This is followed by an overview of the Norway-Sri Lanka relationship related to higher education, research and industrial collaboration between both countries on CETs. Finally, the background on the emergence of the Sri Lankan Tamil diaspora and their support for educational upliftment for local capacity building is presented.

## 4.1 Sri Lankan context

Sri Lanka is an island nation with a population of 22.1 million[10] and a land area of 65,610 square kilometres. With a population density of 353 persons per square kilometre (Central Bank of Sri Lanka [CBSL], 2021), the country is regarded as a relatively low carbon emitter, with the largest $CO_2$ emissions coming from the transport sector followed by the electricity sector (Ceylon Electricity Board [CEB], 2021). However, the CBSL reports an 85% increase in $CO_2$ emissions from the electricity sector within seven years from 2010 to 2017 as a result of increased use of fuel oil and coal for electricity generation (CBSL, 2020). In 2010, Sri Lanka's per capita emissions were approximately 1.02 tonnes/per person, and its global cumulative contribution in 2019 was 0.03% (Ministry of Environment [MoE], 2021). However, Sri Lanka has consistently been placed among the top ten countries at risk of extreme weather conditions (MoE, 2021), as demonstrated by the 2018 climate risk index, which ranked Sri Lanka sixth among countries most affected by climate change (Eckstein et al., 2019). The ND-GAIN[11] index, which scores a country's vulnerability to climate change and other global challenges in conjunction with its readiness to improve resilience, ranks Sri Lanka at 103 out of 181 countries, with Norway ranking first (World Bank & ADB, 2021). This ranking highlights Sri Lanka's high vulnerability to the impacts of climate change, including rising sea and land temperatures, changing precipitation patterns, and increased frequency of natural catastrophes such as

[10] Mid-year population as of 2021

[11] Notre Dame Global Adaptative Initiative

extreme droughts, floods, landslides, cyclones, and coastal erosion, resulting in severe damage and loss of lives and properties (UN, 2021b; World Bank, 2021). Sri Lanka also experienced tsunami in 2004. Moreover, in line with regional averages, the impacts of climate change on Sri Lankan livelihoods are expected to be the most severe in South Asia due to the high degree of vulnerability of households in areas marked as hotspots (UN, 2021b).

As a signatory to the Paris Agreement and committed to the SDGs within the framework of the 2030 Agenda for Sustainable Development, Sri Lanka aims to achieve carbon neutrality in electricity generation by 2050 and generate 70% of its electricity from renewable energy sources by 2030 (MoE, 2021). The country has taken initiatives to implement sustainable energy programmes, recognising its responsibility to uphold Paris Agreement commitments of containing global warming (UN, 2021b). This is explicitly outlined in the country's Long-Term Generation Expansion Plan (LTGEP) 2022-2041, a crucial document presenting the electricity generation plan for the next twenty years, which states (CEB, 2021, 'no pagination')

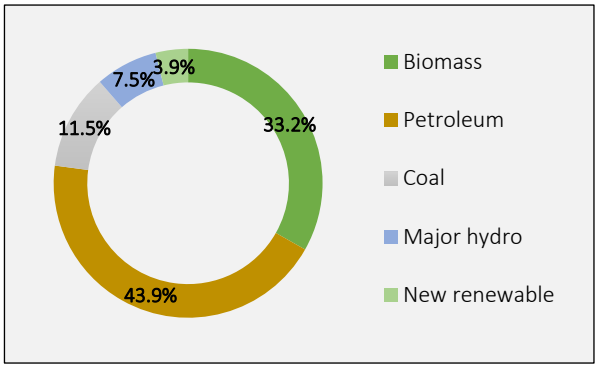
> It was clear from various policy indications given by the government that the intention of the government is to develop a low carbon electricity supply system and gradually take the sector towards indigenous renewable sources and ultimately towards energy independency.

Sri Lanka is seeking technical, financial and capacity building support from the global community to achieve this trajectory through implementing low carbon sourced electricity generation (UN, 2021b).

### 4.1.1 Sri Lanka's energy landscape

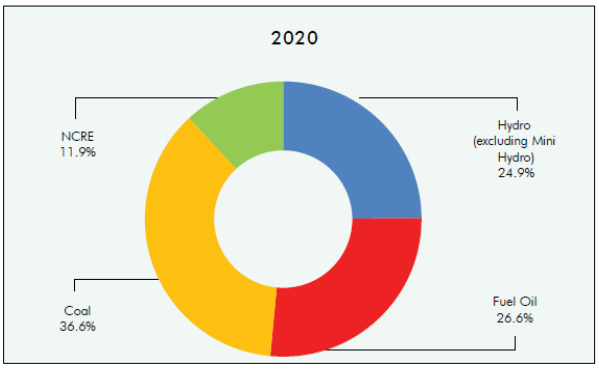
In Sri Lanka, energy is consumed in three forms: electricity, petroleum products, and biomass (fuelwood). However, electricity and petroleum products are the major commercial forms of energy (Silva & Silva, 2016). Sri Lanka's energy sector has evolved over the years from a predominantly indigenous primary energy supply base to a predominantly imported primary energy supply sector. Before the mid-nineties, the primary energy sources were biomass, hydro and imported petroleum. Currently, the

mix also includes coal and renewables (Presidential Expert Committee [PEC], 2019) (Figure 3).




**Source:** Energy Balance, Sri Lanka Sustainable Energy Authority (SLSEA, 2019)

**Figure 3:** Primary energy supply-2019




**Source:** Annual Report 2020 Central Bank of Sri Lanka (CBSL, 2020, p.80)

**Figure 4:** Electricity generation mix-2020

In consequence to the country not having its own fossil fuels on or off shore, it depends entirely on imported coal and oil (Figure 4),[12] putting a strain on the country's foreign exchange reserves and making it vulnerable to price fluctuations and escalations (Senanayake, 2009). The geo-climatic setting of Sri Lanka is conducive to harnessing renewable energy sources such as biomass, hydro, solar, and wind, which remain as indigenous energy sources for the country. In 2017, 11.3% of energy used was from electricity, which is relatively low when compared to other developing countries, but moderate in comparison to other countries in the region (Selvakkumaran & Limmeechokchai, 2012; L. Weerasinghe, personal communication, May 06, 2020). This dissertation focuses on the electricity sector in Sri Lanka.

### 4.1.2 Sri Lankan electricity sector

Looking back on the country's electricity generation, the largest share of generation came from major hydropower plants until 1996 when it shifted from a predominantly hydropower system to a mixed hydrothermal power system (ADB, 2015). The history of Sri Lanka's electricity generation dates back to the British colonial period during which mini-hydro power evolved to fulfil the energy requirement for motive power and in-house lighting of the large-scale tea factories. Hydro was then the only indigenous energy source the country had. Records show Gilbert Gilkes and Co. Ltd, recognised as the oldest manufacturer of hydraulic turbines and pumps in England, were the then-

[12] The non-conventional renewable energy (NCRE) includes solar, wind, biomass, and mini hydro.

largest turbine suppliers to Sri Lanka, with the first turbine arriving in 1887 (RMAEC, 2014; Silva & Silva, 2016). Since then, the mini-hydro power plants arriving in Sri Lanka had steady growth (RMAEC, 2014). After gaining independence in 1948, the first major grid-connected hydropower plant, the Laxapana in the Central Province, was commissioned in 1950 with an installed capacity of 25 MW (CEB, 2018). Capacity additions leading to an expansion of electrification were made in phase two of the project in 1954 with financial assistance from the World Bank (Meier & Munasinghe, 1994). Today, there are 17 major hydro power stations (CEB, 2021).

With the liberalisation of the Sri Lankan economy in 1977, the demand for electricity soared in tandem with rapid economic growth. While the country needed a reliable and consistent supply of electricity to meet growing demands, adverse monsoon seasons, regular and severe droughts, as well as societal demand for the same reservoir water source for multiple other usages such as irrigation, often resulted in reservoirs drying up, leading to inconsistent energy generation from the hydroelectric plants, rolling blackouts, and resultant heavy economic losses. These historic severe droughts, which caused major reservoirs to dry up and prevented optimum generation from the hydroelectric plant, led Sri Lanka to experience load shedding in 1974, 1979, 1983, 1987, 1992, 1996, 2001, 2002, and 2019 (PEC, 2019). In the years 1997, 1998, 1999, 2000, 2003, 2016, 2017, load shedding was avoided through expensive solutions such as hiring small diesel power plants, and the resultant expenses passed on to electricity consumers (PEC, 2019). This challenge necessitated the state-owned utility, the CEB, to find solutions in the mid-1990s through capacity additions. When it became clear that further expansion and capacity addition through major hydro-projects would be challenging, the CEB chose to add capacity with thermal power plants and use them as backups during the dry periods for baseload generation, as well as to improve the stability of the electricity supply. Until 1995, Sri Lanka produced 95% of its electricity requirements from hydro, and from 2000 onwards, the share of thermal generation rose above 50% (PEC, 2019). However, with the major hydro resources already being harnessed almost to their full potential, momentum gained to tap other renewable energy sources such as solar and wind (Wijekoon et al., 2019).

The principal planning objective of the state-owned Sri Lankan electricity sector, CEB, has always been to deliver the required electricity supply at the “least cost” (Meier &

Munasinghe, 1994, p.3). However, the LTGEP aims to strike a balance between its key objectives of sustainability, security, and reliability of electricity supply on the one hand, and the economic aspects of supply and affordability on the other (CEB, 2021). To achieve this balance, Sri Lanka is looking beyond publicly-funded projects and is focusing on increasing the share of commercial financing, and encourage greater private-sector participation through local and global engagement (World Bank, 2019).

Historically, public financing has been the primary source of funding for power plants owned by the CEB, whereas larger projects generating more than 10 MW were sourced by independent power producers on a build-own-operate-transfer scheme (World Bank, 2019). In 1996, private sector investors, supported by a feed-in-tariff, entered the market as small power producers (up to 10 MW) to generate renewable energy and sell it to the sole buyer, the CEB (ADB, 2015). By 2019, such private sector schemes had delivered 400 MW of electricity power by mini-hydro, 128 MW by wind, 51 MW by ground-mounted solar, 17 MW by biomass, and 120 MW by rooftop solar (World Bank, 2019). In 2011, the Sri Lanka Sustainable Energy Authority (SLSEA) installed the then largest grid-connected solar PV plant with a capacity to generate 1.237 MW, supported by a grant funding from Japan and Korea (RMAEC, 2014; ADB, 2013). However, Sri Lanka has not been able to develop further large utility-scale NCRE projects (World Bank, 2019). The barriers to energy transition using wind and solar PV are said to include (i) technical and regulatory barriers related to grid integration, (ii) institutional barriers whereby there is a lack of clearly allocated institutional responsibility (i.e., many different actors involved in the implementation of policies or realisation of the projects, with often institutional disagreement among these stakeholders), (iii) financial barriers for the commissioning of the technology and infrastructure, and (iv) insufficient stakeholder knowledge and information (i.e., inexperienced stakeholders and unawareness among decision makers of the economic, social, and environmental benefits of RETs) (ADB, 2013). Moreover, international investors perceive that the investing environment is highly inefficient with governance challenges, such as the lack of efficiency and transparency in the procurement process (i.e., non-adherence of globally expected procurement procedures and practices) (World Bank, 2019).

Unlike many other countries in the region, as of 2016, 99.3% of the Sri Lankan population had access to electricity from the national grid, with per capita electricity consumption of 686.7 kWh[13] (CBSL, 2021). However, with energy demand growing at an average rate of 5.7% (CEB, 2021), and with the committed policy decision to increase renewable energy generation to 70% by 2030, the energy sector of Sri Lanka requires significant capacity additions (Wijesinghe, 2022), estimated to be 3,500 MW (CEB, 2021). The energy sector's projected plan is to achieve an addition of 2,874 MW through solar by this target date (CEB, 2021). By 2021, the country had 434 MW of installed solar PV (IRENA, 2022). In 2022, Sri Lanka's renewable energy generation amounted to 426.43 MW from mini-hydro, 148.45 MW from wind, 13.08 MW from agricultural and waste-to-energy biomass, 37.01 MW from dendro[14] power biomass, 93.36 MW from ground-mounted solar, and 480 MW from roof-top solar (Adittiya, 2022).

### 4.1.3 Policies and key electricity sector stakeholders

The first National Energy Policy and Strategy (NEPS)[15] for Sri Lanka was published in 2008 with the objective of diversifying the energy mix for the delivery of reliable and affordable energy, and supply of services made available to a larger share of the population (Wickramasinghe, 2009). This NEPS, supported by a US$ 1,346 million loan, paved the way for the commissioning of the first coal power plant generating 900 MW in 2011, under a Chinese infrastructure development project (Wignaraja et al., 2020), making coal the third source contributing to 3% to the primary energy mix in that year (RMAEC, 2014). It is the NEPS[16] of 2019 that added domestic renewable energy resources as well as natural gas to the energy mix, thus committing to addressing the energy trilemma of energy security, energy equity, and environmental sustainability. The NEPS (2019) policy guideline for the electricity sector calls for a strategic mix of electricity generation through the diversification of resources, thereby achieving higher shares of renewable energy over time (World Energy Council, 2020).

[13] Kilowatt hour

[14] Dendro: derived from the Greek word Dendron – *tree* (RMAEC, 2014)

[15] National Energy Policies and Strategies, Government of Sri Lanka, Gazette Extraordinary No. 1553/10, June 10, 2008

[16] National Energy Policies and Strategies, Government of Sri Lanka, Gazette Extraordinary No. 2135/61, August 09, 2019.

The LTGEP, is another vital document in the electricity sector which outlines the plan for electricity generation and ensure energy security through least cost options for the next 20 years. The plan is renewed every two years (CEB, 2021), and serves as a road map for decision-makers to align their directives with the national policy objective, providing guidance to facilitate informed decision-making in the electricity sector.

Currently, the Sri Lankan energy sector is largely managed by a state-owned corporation, along with private sector participation for electricity generation (ADB, 2015). The Ministry of Power is responsible for formulating, implementing, monitoring and evaluating policies, programmes, and projects. The state-owned utility, the CEB, established in 1969[17] is the sole authority for transmission and distribution of electricity for the country. For designated urban areas along the western coastal belt of Sri Lanka, which includes Capital Colombo, the CEB supplies electricity through the state-owned Lanka Electricity Company (LECO), which was established in 1983 by the electricity sector (ADB & United Nations Development Programme [UNDP], 2017). CEB also accounts for 66% of electricity generation. The remaining 34% is generated by the private sector and sold to the CEB (ADB & UNDP, 2017). The country's regulatory authority for public utilities is vested in the Public Utilities Commission of Sri Lanka (PUCSL),[18] established in 2002. Therefore, the PUCSL regulates the generation, transmission, distribution, supply, and use of electricity and is answerable to the Parliament[19] (ADB, 2015; United States Agency for International Development & Integrated Research and Action for Development, 2018). In 2007, Sri Lanka further established the SLSEA,[20] remitting it with the responsibility to (a) assist in developing the national policy on energy, (b) implement policy for renewable energy, (c) regulate functions of renewable energy, energy efficiency, energy planning, and conservation, and (d) promote and develop renewable energy projects through private investments and R&D of indigenous energy resources (ADB, 2015; ADB & UNDP, 2017; RMAEC, 2014).

[17] Ceylon Electricity Board Act No.17 of 1969

[18] Public Utilities Commission of Sri Lanka Act No. 35 of 2002

[19] Government of Sri Lanka

[20] Sustainable Energy Authority Act No. 35 of 2007

## 4.2 Norway-Sri Lanka relations and collaborative projects for knowledge building and innovation

In 1952 Norway and Sri Lanka established bilateral ties through diplomatic relations and these ties were further strengthened through Norway's development support and assistance which began in 1965. The bilateral relations have mainly been centred around (a) strengthening political cooperation on issues of mutual interests, (b) sustainable development with a focus on economic development, including technical and private sector cooperation, and (c) contribution to lasting peace, justice, good governance, reconciliation, and human rights (Royal Norwegian Embassy Colombo, 2020). Notably, Norway played a significant role as a facilitator in the Sri Lankan peace process from 2002 to 2006. Norwegian Agency for Development Cooperation (NORAD) provides reference to Norway's multiple roles in Sri Lanka – as diplomatic broker, arbiter of the ceasefire, and humanitarian and development funder (Sørbø et al., 2011). Through these different collaborative efforts, Norway has helped Sri Lanka in its endeavours to expand development. Another recent outcome of this cooperation is the establishment of academic, research, and industrial partnerships, such as the initiation of the HRNCET and the CBERC projects between Norway and Sri Lanka. These academic, research and industrial partnerships, including HRNCET and CBERC projects, are central to understanding this PhD study as well as the selection of research cases that form the basis for this study.

### 4.2.1 Academic and research collaborations

In the early years following 2010, a few leading solar companies in Norway faced bankruptcy as a result of difficulties competing with China, which was at the time the market leader in the manufacturing of crystalline silicon solar cell technology. Western consumers and businesses were also importing solar PV from China, adding to the competitive pressure. This situation prompted researchers in many countries to shift their focus towards other productive new type of non-silicon based solar cell technologies. A Norwegian scientist of Sri Lankan origin, motivated by this, turned his research interest in electromagnetic waves and nano-optics towards the possible use of nanomaterials on solar energy technologies. This was at a time when both Norway and India were active in high-quality research on solar cell technology. This motivation to explore new types of solar cell technologies paved the way to establish collaborative

research with research institutions in India, where research on novel alternatives, such as on organic, dye-sensitised, and quantum solar cell technologies, were being studied. The researchers not only focused on exploring newer technologies but also aimed to produce technologies that are more affordable and cheaper (even if they turn out to be low-efficiency technologies) and could be produced anywhere, including in poorer developing countries, compared to silicon solar cells which required heavy investments and large infrastructure facilities.

To promote joint research initiatives and to motivate and educate students to innovate new, efficient, and cost-effective technologies, a memorandum of understanding (MoU) was signed in January 2011 between HVL (formerly known as Bergen University College) and Coimbatore Institute of Technology (CIT), a research institute in India. These initiatives were carried out by the researchers' own research resources and with the support of the Faculty of Engineering and Science at HVL. Financial assistance from the Bergen Research Foundation (Trond Mohn stiftelse) was received in the following years to establish research infrastructure facilities (laboratory) to take forward the research initiatives at HVL, which at that time had lacked adequate facilities for high quality nanomaterial research. Similarly, financial support from Indian funding agencies was received to suitably upgrade the laboratory in CIT in 2015 for the joint research activities. In 2015, HVL received funding from the Indo-Norwegian Cooperation Programme supported by the Norwegian Centre for International Cooperation in Education in order to enhance the collaboration between HVL and CIT through student and staff mobility, joint supervision and dissemination (Direktoratet for internasjonalisering og kvalitetsutvikling i høgare utdanning , 2018). This academic collaboration resulted in high-quality research in the field of thin films and nano structures for solar cells. This educational initiative also exposed staff and students to work in multicultural research environment.

The multi-centred research partnership led to the need to organise frequent international conferences and Indo-Norwegian workshops to present research findings, as well as to share, discuss and learn about nanomaterials for clean energy applications. Such conferences and workshops, that were partly funded by the Norwegian Research Council from 2013 onwards, attracted further new partnerships, networks, contacts, and research interests, generating an expansion in collaborative

research on novel materials for CETs. The universities involved in this wider research network included those in Norway, India, South Korea, Singapore, Japan, United Kingdom, and the USA, and were formalised as Advanced Nanomaterials for Clean Energy Applications (ANCEA). The initial HVL-CIT research partnership broadened its activities into higher education on nanomaterials for CET and jointly submitted research proposals to attract further funding from different funding organisations. Consequently, this successful expanded joint research collaboration was awarded the 2017-2020 project funding from UTFORSK.

As a further step forward, the research and educational partnerships between universities on CET expanded to involve Sri Lankan universities with an initial exploratory effort in 2016 supported by a seed fund from the Norwegian Partnership Programme for Global Academic Cooperation (NORPART). The following year, HVL and the UoJ, Sri Lanka through a joint application succeeded in signing up a MoU for an academic and research partnership between themselves to implement the HRNCET project with NOK[21] 4.7 million in financial assistance from NORPART for a period of four years (2017 – 2021). This collaboration, while increasingly focusing on improving the quality of higher education and research on CET at HVL and UoJ, has since been extended to involve the Universities in Agder, Bergen in Norway, the University of Peradeniya, and the National Institute of Fundamental Studies in Sri Lanka.

The HRNCET programme has been equipping staff and students from Norway and Sri Lanka with the necessary skills to work on clean energy applications that use nanomaterials for new generation solar cells, green hydrogen production, and energy storage technologies. Students carry out synthesis, modelling, and simulation studies on advanced nanomaterials to identify novel materials for these purposes, receiving joint supervision from Norway and Sri Lanka. Additionally, the programme also includes staff and student mobility programmes, involving short and long research stays between the two countries. These stays provide exposure and experience on the variations in research methodology. Furthermore, HRNCET has extended the academic and research partnership between Norway and Sri Lanka to CIT. It has also

[21] Norwegian Krone

expanded collaborative research between these three countries to make more efficient use of the different resources between Norway, India, and Sri Lanka.

Another milestone in the Norway-Sri Lanka collaboration was the establishment of a research consortium in 2017. Supported by the Royal Norwegian Embassy Colombo in Sri Lanka with a grant of NOK 6.2 million, the CBERC came into being as a result of the HRNCET collaborative partners identifying the importance and advantages of interlinking industrialists with Sri Lankan and Norwegian researchers through such a project. The CBERC project is aimed at two primary groups: academics and students at the UoJ working on CETs, and Sri Lankan and Norwegian private sectors working on CETs. The consortium gave strength to the ongoing HRNCET academic and research collaboration and expanded it by involving private sector industrialists to mentor and engage in research, enabling students to understand the need and role of the industry. It also created opportunities for industrialists to invest in CETs such as solar in Sri Lanka. CBERC promotes CETs, builds linkages between research and business communities to encourage capacity building, and helps advancement of and investments in innovation, related to CETs in Sri Lanka. The stakeholders in Norway and Sri Lanka contribute to this consortium through technical assistance, offering work placements for students, involvement in research projects, mentoring and external supervision for research work, promoting exchange visits, and disseminating knowledge through conferences and discussions, as well as financially investing in CETs and establishing partnerships and joint ventures (UoJ & HVL, 2022).

Another facet of capacity building supported by the CBERC was the launching of a clean energy research laboratory in Sri Lanka in 2018, complemented with advanced technology equipment to help improve the quality of research, especially for synthesis work and to motivate more students into the field. The CBERC also initiated outreach activities on CETs through school-level awareness programmes, exhibitions, competitions, and demonstrations. In addition, HVL and UoJ jointly developed an accredited master's curriculum on CETs (first and only one in Sri Lanka, as of 2023) in 2020, allowing students to get involved in CET initiatives in Sri Lanka, again supported by the CBERC.

In May 2018, facilitated by CBERC, a delegation from Norway, including 16 private sector representatives, travelled to Sri Lanka to explore opportunities and to study the energy landscape. The academics and researchers in the delegation were from HVL and from universities in Bergen, and Agder. The delegation met with bilateral and multilateral agencies, the Sri Lankan electricity sector stakeholders, and research institutions and universities. This visit by industrialists, academics and researchers paved way for the establishment, in 2020, of Sri Lanka's first FPV DP with a capacity of 46 kW (stationed in a waterbody at the UoJ premises) and a reference plant of 5 kW on land (UoJ & HVL, 2022). The Norwegian energy group Equinor AS and Innovation Norway, a state agency that promotes innovation and development of industries, provided the financial support to Current Solar AS Norway for the development and the implementation of the DP. The design is based on Norwegian maritime know-how from offshore and aquaculture industries and combines use of composite beams for mounting. While the panels, composite beams and the electronic materials arrived from Norway, the floating pipes are locally made. The total component cost of the plant is approximately Sri Lankan Rupees 10 million, which includes 157 solar panels along with other equipment (A. Atputharajah, personal communication, April 11, 2023). Data from the DP are transferred online to the Institute for Energy Technology in Norway, where a number of studies are carried out to assess performance, reliability, and operational characteristics of the FPV technology, with the aim to identify innovation opportunities, reduce risks, and to develop improved solutions on FPV (Kjeldstad et al., 2022). This PhD research is another major component of the CBERC project in its efforts to facilitate and take forward RET in Sri Lanka as presented in Section 1.1. Thus, in Sri Lanka the collaboration with Norway also includes industrial collaboration in addition to academic and research partnerships.

In parallel with the expansion of HRNCET in Sri Lanka, as outlined above, the research activities of the ANCEA network have also expanded and progressed into the health sector since 2018, utilising nanomaterials techniques to create materials necessary for scaffolds to place and grow stem cells. This research extension into the health sector led the research group to be renamed *Advanced Nanomaterials for Clean Energy and Health Applications* (ANCEHA). With this expansion, the first international conference on AMCEHA and a *Norwegian-Sri Lankan workshop on CETs* were jointly organised by HVL and UoJ in 2019 in the Northern Province in Sri Lanka. The

conference attracted a total of 400 attendees, of which 120 were international participants (UoJ & HVL, 2022). The participants comprised of experts, scientists, scholars, academics, students, and industrial representatives from various countries, including Norway, India, Canada, Australia, Bangladesh, UK, Sudan, Sweden, Finland, Egypt, China, Japan and USA (UoJ & HVL, 2022). Norwegian support for academic and research activities in India and Sri Lanka was further boosted in 2021 by way of new fundings received through UTFORSK and NORPART, earmarking further expansion in collaborative work with Alahappa University in India and Eastern University in Sri Lanka. High quality research carried out by the ANCEHA research group has resulted in 296 joint research articles in reputable international journals, in addition to presentations in various international conferences. For this dissertation, ANCEHA's engagement with Sri Lanka becomes relevant.

In this collaborative equation, there exists another inconspicuous player that has been supplementing ANCEHA project activities in Sri Lanka in the field of education, research, and industrial collaborations. As presented in Paper #1, the Sri Lankan Tamil diaspora has facilitated HRNCET and CBERC projects by way of providing material, finance, and cognitive support in building physical as well as knowledge resources to further embed and sustain the projects in Sri Lanka.

### *The Sri Lankan Tamil diaspora and their educational engagement with their homeland*

Sri Lanka is a multi-cultural, multi-ethnic, and a multi-religious country with an ethnic composition consisting of 74.9% Sinhalese, 11.2% Sri Lankan Tamils, 4.1% Indian Tamils, 9.3% Moors and 0.5% others consisting of Burghers and Malays (Department of Census and Statistics, 2012). Migration has played a key role in Sri Lankan history. According to Reeves (2013), the total number of Sri Lankan emigrants is estimated to be three million, of which two million are temporary migrants living on short-term job contracts with the explicit intention of returning, while the remaining one million are permanently settled Sri Lankan emigrants in the Americas, Europe and Australasia (Jayawardena, 2020). The ratio of permanently settled transnational community to the Sri Lanka population is reported to be 1:20 (Jayawardena, 2020). Records also highlight that one in every four Sri Lankan Tamils now lives as diaspora (Cheran, 2003). While there have been several waves of emigration from Sri Lanka since its

independence in 1948 from the British, the migration which occurred in the 1980s was a watershed in the Sri Lankan migration pattern. This group of migrants was categorised as *forced migrants* as they were forced to leave their home country due to an internal armed conflict, rather than because of economic need or a wish to forge a new life abroad (Jayawardena, 2020; Wayland, 2004). While it is beyond the scope of this dissertation to look deeper into the internal armed conflict in Sri Lanka leading to a forced migration, understanding the educational aspiration of the Sri Lankan Tamil diaspora and their desire to pay back their home country in the field of education becomes relevant.

The ethnic conflict was between the majority Sinhalese, densely populated in the central, southern, and western parts of Sri Lanka, and the minority Tamils, who predominantly live in the northern and the eastern parts of the country. Post-colonial Sri Lanka became a polarised society between the Sinhalese and the Tamils, especially in the education and employment sectors (Anuzsiya, 1996; Pieris, 2019). Politically, these were effected through two legal directives, namely the Sinhala Only Act in 1956[22] and the Standardisation Policy of 1971,[23] which restricted Tamils' access to public service employment and university education (Anandakugan, 2020). These discriminatory policies and initiatives on employment and education escalated the tension between the two communities and led to a civil war which lasted for nearly three decades (1983 – 2009). Prior to the civil war, tensions were growing between the two ethnic communities, which led to mass violence unleashed by segments of the Sinhalese population against Tamils. The most destructive of these incidents took place in 1958, 1977, 1981, and 1983 (Tambiah, 1986). The communal riots of 1983, also known as the *Black July of 1983,* significantly impacted the migration patterns of Sri Lankan Tamils, triggering thousands of Tamils to leave Sri Lanka as refugees or on other humanitarian grounds, as they felt that the State could not guarantee their physical security (Jayawardena, 2020; Sriskandarajah, 2005). Moreover, migration

[22] The *Sinhala Only Act* Bill passed in 1956 made Sinhala the only official language (replacing English and excluding Tamil) restricting Tamils their access to government services or public service employment (Anandakugan, 2020).

[23] The *Standardization Policy* in 1971 aimed to provide more educational opportunities for Sinhalese students by requiring Tamil students to score higher than Sinhalese students to be admitted to the Sri Lankan universities (Anandakugan, 2020).

was also about safeguarding their educational aspirations, as Reeves (2013, p.149) notes, “migration became a way for the Tamil middle class to safeguard what they saw as central elements of their own culture, especially the value of education”. The Tamil migration included a large number of Tamil students seeking higher education opportunities overseas, professionals migrating for employment, and many Sri Lankan Tamils seeking protection as refugees and asylum seekers (Fuglerud, 1999, 2001; Jayawardena, 2020; Reeves, 2013; Sriskandarajah, 2002). This number continued to grow due to a number of factors such as (a) many Tamil students and guest workers across Europe and North America already living overseas, who were reluctant to return and lodging asylum claims, (b) professionals and skilled middle-class Tamils migrating to the West for employment and education directly or through informal ways and ending up claiming asylum, (c) refugee flows from Sri Lanka to India and the rest of the world, and (d) migrants arriving on family reunion programmes and as political refugees (Sriskandarajah, 2002). This migrated community became the transnational community of the Sri Lankan Tamil diaspora. The Sri Lankan Tamil diaspora plays a significant role in building knowledge capital, knowledge transfer, capacity building, and investments (Cheran, 2003).

# 5. Contributions

This article-based dissertation incorporates three scientific papers. Each paper brings to light a principal element and illustrates how that element is, in the particular context, impacting the pace and progress of RETs in Sri Lanka. This section discusses the general empirical findings and the theoretical and methodological contributions of the three papers. Of these papers, Paper #1 is co-authored by myself and Arnt Fløysand contributing approximately 80% and 20% of the work respectively. Papers #2 and #3 are single authored.

## 5.1 Paper #1: Mobilising Diaspora for Sustainability Transition in Global University Cooperation

Paper #1, co-authored with Arnt Fløysand, was accepted for publication as a book chapter in March 2023 in the book titled *Universities and their places: Reflections on the work of Paul Benneworth*. This paper, drawing theoretically on the perspective of GIN, investigated the exchange and transfer of codified knowledge through GUC, a formal collaboration. In doing so the investigation identified the role of informal networks in building local innovative and absorptive capacities, thus identifying it as a principal element playing a nuanced contributory and supportive role in helping resolve issues in the Sri Lankan context. The paper introduces the term innovation poverty as a way of signposting the consistent poor innovation state, low scoring on innovation indicators and underdeveloped innovation system, consequently hindering the progress to innovation in countries like Sri Lanka. The paper addresses the question of *how sustainability transitions can be mobilised through global university cooperation in the context of innovation poverty*. Analytically, it studies the engagement and effectiveness of informal networks in the establishment of coupling mechanisms in transferring knowledge from the global to the local. In particular, we explore how the concept of coupling mechanisms can be aligned to a situation of innovation poverty and how such a coupling mechanism can be strengthened contextually through informal networks.

Empirically, we draw on the GUC project involving the transfer and exchange of codified knowledge from HVL to UoJ. The main objective of this GUC is to build applications for the development of CETs such as new-generation solar cells, green

hydrogen production and energy storage technologies using nanomaterials. The role of the Sri Lankan Tamil diaspora network in this GUC process includes applying a GIN frame and supporting the process through many fronts including educational, financial, and mentoring. Having attained educational achievements following forced migration, part of which being denied educational opportunities by their erstwhile country, the Sri Lankan Tamils are motivated to contribute to the country's educational progress including through a voluntarily formed informal network. Established in multiple academic and non-academic fields, the global informal network of the Sri Lankan Tamil diaspora with their global and local knowledge, expertise, skills-set, and network are seen as powerful and dedicated actors in lifting and pillaring knowledge circulation. The paper submits that the transfer of codified knowledge is more effectively performed when academic coupling mechanisms are established with global universities and scholars in a GIN as part of a GUC. In this specific instance, the Sri Lankan Tamil diaspora can be seen as actually functioning as a GIN in its own right. It also illustrates the diaspora in terms of what the coupling mechanism is supposed to be. We argue that taking advantage of informal networks such as a diaspora in coupling mechanism can trigger fundamental changes in a developing country to improve the prospects of overcoming innovation poverty. As such, the paper adds to the wider literature that a sustainable energy transition can complementarily be mobilised through context-sensitive GUC perspectives.

Paper #1 contributes to the literature in two ways. First, it shows the need for transition studies to engage more with informal networks, if available, by showing that coupling mechanisms in GIN can be strengthened through informal networks in transferring codified knowledge from developed countries to developing countries through GUC. Second, it adds diaspora contribution to the literature. An observation not so much discussed in the transition literature is how the diaspora has come to be noted as an informal actor in GIN facilitating domestic knowledge and capacity building by functioning as an effective player of a coupling mechanism. The informal nature of the Sri Lankan Tamil diaspora network, a GIN in its own way as mentioned above, allows it to offer a supportive role to the formal GUC in transferring knowledge.

## 5.2 Paper #2: Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector

This is a single-authored paper peer-reviewed and published online in the *Norsk Geografisk Tidsskrift / Norwegian Journal of Geography* (2022).[24] The paper focuses on the different prevalent narratives in the Sri Lankan electricity sector which highly influence the directionality of the energy pathway of the country. Energy projects and trajectory for sustainable energy transition in developing countries often are faced with barriers to implementation, resistance by stakeholders, and conflict between stakeholder expectations. This is due to narratives-driven local, national and global repercussions for the implementation and operation of new energy initiatives or technologies. These barriers are often related to and embedded within institutions, and within the processes of interaction between different stakeholders. In the process of understanding the web of narratives affecting the transition trajectory, this paper takes a different route and looks at how sustainable energy transition can also be a responsible transition by addressing concerns raised by narratives in resolving the dilemma. RI is crucial, yet it is a relatively new concept for developing countries (Setiawan & Singh, 2015). In answering the RQ on *how RI is understood in processes of sustainable energy transition in Sri Lanka, and how does this understanding inform sustainability transition theory* the paper develops a framework by placing narratives as a feedback tool between sustainability transition and RI. Analytically, this paper narrows this down to emphasise the need for a fusion between the TIS and RI frameworks to stimulate effective sustainable energy transition processes in developing countries. The paper suggests that such a fusion can be achieved and contextualised through the narratives in play (Fløysand & Jakobsen, 2017) by considering them (i.e., narratives) as feedback material between TIS and RI. In operationalising this, the paper pays attention to the contextual underpinnings of entrepreneurial activities and legitimisation functions of a TIS. To achieve stronger integration of RI (viewed as a discourse) with sustainability transition in a real-world setting, including in a setting outside from where the concept originated, the paper

[24] This paper is part of a special issue *Exploring the Geographies of Responsible Innovation*, edited by Svein Gunnar Sjøtun and Marte C.W. Solheim.

underscores the need for nuancing, in this case via narratives, to achieve transition sustainably.

Empirical evidence comes from the Sri Lankan electricity sector which has a collective vision for a sustainable energy pathway for the country. The paper explains how the different stakeholder categories perceive the sustainable energy trajectory in their own presumptive ways as to the responsible way forward. While it shows that each of the different stakeholder's vision for sustainable energy development for the country is of high priority, their claims and perception of a responsible pathway towards achieving this vision are highly contested and conflicting. The *policymaker-centric* and *professional-centric* narratives are related to sustainable energy development whereas the *investor-centric* narrative is related to sustainable technology development. The *policymaker-centric sustainable energy development* narrative highlights that Sri Lanka's sustainable energy development is concerned with providing an affordable and reliable electricity supply and requiring fossil fuels to play a key role in the electricity sector trajectory. The *professional-centric sustainable energy development* narrative calls for a timely shift to exploit the island's abundant sources of solar and wind power with the assistance of foreign and local capacities and resources, but which also identifies the vital need for knowledge incorporation. The *investor-centric sustainable technology development* narrative emanating from investors and developers highlights the absence of an integrated approach and mechanisms for initiating entrepreneurial activities hindering the absorption of RETs. To enable entrepreneurial activity of a TIS, the presence and engagement of active entrepreneurs becomes a key indicator. Sri Lanka's reliance on private sector investments for RETs requires a facilitative and transparent framework to engage and establish a functional TIS. The absence of such a facilitative and responsible framework affects the remaining TIS functions and finally leads to the inability to absorb and legitimise the newer technology trajectory. In addition, the narratives suggest that the concepts of *sustainable* and *responsible* have to be viewed differently in resource poor settings. For instance, sustainable energy in the literature points to the discussions on energy from RETs, however to a large extent in the Sri Lankan context sustainable energy refers to the access to affordable and reliable energy, not necessarily from renewables. Innovation and technology adoption process leading to transitions can be a failure unless they are practised or performed responsibly. This real-world setting reveals that

RI has to be viewed in relation to the place specific factors. In this paper, I relate the meaning of *responsible* to accountable by highlighting that it is the collective duty of stakeholders to give consideration to potential impacts when introducing RETs by being vigilant to the elements of supply and distribution namely accessibility, affordability and reliability.

Paper #2 contributes to the literature on sustainability transition and RI. To achieve this, it develops a methodological framework for merging TIS with RI by way of engaging the two via prevalent narratives in play. Applying this framework to the Sri Lankan electricity sector and engaging with the prevalent stakeholder narratives, the paper highlights that the concepts of *sustainable* and *responsible* are context related, and that multiple narratives create tension and disagreement regarding a way forward. In doing so, the paper simultaneously reaffirms that narratives of powerful stakeholders dominate and exert disproportionate influence (Fløysand & Jakobsen, 2017), marginalising the remaining narratives and reinforcing the existing energy pathway. Finally, the paper brings out empirical evidence to demonstrate how un-managed and unresolved prevalent narratives within the electricity sector can be a barrier in transitioning to more RETs.

## 5.3 Paper #3: The geography of sustainability transition and materiality: Grid-tied solar photovoltaic technology in Sri Lanka

Paper #3, revised and resubmitted to *Regional Studies Regional Science* in May 2023, is single authored. It addresses the role of materiality and engages with the relational dimension. The conundrum as to why Sri Lanka with ample solar irradiation is unable to progress through grid-tied solar technology for energy transition, and why different forms of solar PV technologies need to be tested prompted the question of the role of materiality in transition. The broad field of GeoST has focused on understanding place-based factors and their influence in shaping transitions, i.e., acknowledging the importance of context and geography. While these factors include the role of institutions, actor networks, discourse and local cultures and practices, the role materiality plays in the technology of transition has received relatively less attention in the literature leading one to conclude that its role has been taken for granted. While energy transition is primarily about a technological shift, the emphasis given in the

literature on materiality has been on transition technology being merely an end-product. This paper argues that the literature inadequately acknowledges that contextual particularities equally influence the materiality of technology in shaping the energy pathways and that their interplay should be given careful consideration both in analytical and theoretical terms. In other words, technology needs to be context-tested in transition studies and its relatedness to context clearly understood, especially in developing countries where technologies are imported. To do this, the paper explores the relational materiality perspective by scrutinising: (i) *how the GeoST literature deals with materiality*; (ii) *how relational materiality has influenced and affected the application of solar PV in Sri Lanka*; and (iii) *how the case of Sri Lanka adds to the GeoST literature*.

Supportive empirical evidence comes from studying Sri Lanka's journey into implementing grid-tied solar PV technologies. Sri Lanka, situated close to the equator, and receiving an ample supply of solar irradiation all year round, is hence in a geographical position to exploit this significant potential with the deployment of solar energy technologies. Yet the progress through generalised ground-mounted technology has been sluggish due to the material requirement – primarily land. Land, being a material barrier for solar expansion, highlights the fact that in Sri Lanka land is a contested natural source in an agrarian society with a high population density. The rural land spaces in Sri Lanka are not only contested for livelihood dependent agriculture, but also for income generating tourist parks and wildlife reserves, as well as the island nation's climate related necessity to maintain conservation and reforestation. The imported technologies need to be gradated to be suitable and functional in their new context and thereby achieve society acceptance as a technology fit for purpose. Contextualisation of technology is hence about adapting the technology to befit the social and natural contextual particularities and has to be viewed relationally to the particular context. For instance, solar PV needs to be seen in relation to its material requirement such as land space, roof space, and water space. In turn, these material requirements cannot be viewed as readily available in their absolute forms, but rather their availability needs to be evaluated by studying the prevalent engagement and relationship different actors already have with such absolute materiality. From this perspective, technology for transition cannot be viewed as footloose, off-the-shelf or absolute, hence, in turn has to be modified to benefit the

context. The interaction of the absolute with different stakeholders leads to a relational dimension.

Paper #3 contributes to the GeoST literature by emphasising the need to contextualise technology, i.e., by giving consideration to the role of materiality. It does this by approaching materiality through a relational dimension – relational materiality. The emerging empirical evidence from grid-tied solar PV is that Sri Lanka has faced challenges in implementing the technology as footloose ground-mounted solar PV due to the material barrier of land. This led Sri Lanka to explore the possibility of FPV as an option to benefit from the high solar irradiation. The paper also highlights the fact that those newer technologies and innovation also bring newer uncertainties and scepticisms especially when not designed or nuanced to suit Sri Lanka's particular context. These dawning concerns led to the need to install and study a DP to absorb the relational concerns related to technology, society, the environment and policymaking. Paper #3 emphasises explicitly the need to approach the technology-context interaction through a relational perspective offering a theoretical and analytical approach to materiality. Paper #3 also shows that international collaborations not only enable technology transfers but also encourage domestic innovations, including technological alterations for adaptation, by means of developing and improving domestic capabilities and capacities.

## 5.4 Main findings

The three papers contributing to this dissertation highlight how the elements of sustainability transitions are approached for analysis in the Sri Lankan context. They also inform of the need for adjustment in the application of elements when approaching analysis of sustainability transitions in a developing country context like Sri Lanka. In dealing with the different dimensions related to the technology-context interplay the papers highlight the need to pay closer attention to informal networks, narratives and relational materiality. Taken together the papers bring out three findings that contribute to the dissertation's empirical and theoretical objectives. That is understanding the drivers and barriers to RETs in Sri Lanka, a developing country, and developing a context-sensitive perspective.

The first finding is the empirical evidence for establishing coupling mechanisms with GIN is an effective way to build local innovative capacities for developing countries. The effectiveness comes by way of knowledge exchange, knowledge recombination and knowledge transfers in lifting the country out of innovation poverty. The literature has identified the role of networks in shaping transitions (Markard & Truffer, 2008) and innovation, whereby these networks establish coupling mechanisms, in particular formal networks through cross-border relationships and interactions which enhance the local, regional, and national capacities (Wieczorek et al., 2015). Similarly, informal networks have also contributed to global knowledge through analytical knowledge exchange and transfer. Such a role of informal networks has been key to having access to global knowledge resources as well as to mobilising and transferring them. This is demonstrated through Paper #1, which shows how the global community of the Sri Lankan Tamil diaspora engage in building local capacities through a GUC on higher education and research. Theoretically, Paper #1 highlights that coupling mechanisms can be strengthened through informal networks and informs the literature of the role of informal networks in innovation and transition processes. In this case, the Sri Lankan Tamil diaspora is seen as an effective player of coupling mechanisms and comes across as an ideal example of what a coupling mechanism is supposed to be.

The second finding is related to narratives in play which exerts a significant influence on technology development and absorption in the transition process. The high presence of informal institutions and their prevalent practices have impacted the sustainable energy transition in Sri Lanka. These informal institutions come to light through narratives of the involved and engaged stakeholders. These narratives are seen as either promoting the pathway towards RETs or as a constraint towards achieving the same. For instance, Paper #2 describes the case of the Sri Lankan electricity sector where the discourse of RI or responsible transition is built on three different narratives. While each stakeholder narrative argues with different emphasis for a responsible and sustainable pathway either based on RETs or fossil-fuel based technologies, it is the hegemonic narrative that gains traction due to their underlying power relations (Fløysand & Jakobsen, 2017) without giving much consideration to the merits of alternative facts and settling on a nuanced guidance towards sustainable energy pathway. Paper #2 brings out the influence of place-based institutional factors, in this

case the narratives in play, on *responsible* and *sustainable* transition processes and the country's energy trajectory.

The third finding pertains to the relational perspective. Social, economic, political, and institutional factors have a two-way or reciprocal influence on energy transition pathways. While studies have engaged with these contextual disparities in transitions, this dissertation also highlights the need to contextualising technologies, i.e., technologies modified to be context-relevant and applicable especially for countries dependent on transferred technologies. For instance, Paper #3, states that grid-tied ground-mounted solar PV technology in Sri Lanka is impacted by relational challenges from social and livelihood related contextual factors linked to land material. The alternatives tried out to adapt solar technologies considered suitable in its context (in this case FPV) also met with relational barriers arising from shared material, in this case shared water bodies. A relational barrier concerns the varied relations the societal stakeholders have with the absolute i.e., technology, land, and water. Theoretically, the finding from Paper #3 contributes to the literature on the GeoST informing that materiality is greatly influenced by place-based factors, which are strongly relational. From this perspective, it is not realistic to consider solar PV as footloose as presumed in literature and that such technology also has to be contextualised.

The dissertation's objective centres around developing and applying a context-sensitive perspective for a responsible and sustainable energy transition in Sri Lanka, a developing country. Towards achieving this objective, the dissertation illustrates that priority needs to be given to studying the effects or consequences of technology-context interaction. It offers a perspective whereby the emerging adverse effects arising from technology-context interaction are properly understood and absorbed when planning a sustainable energy pathway for the country. Research carried out as part of the dissertation inform us that such an approach could consider improving innovative capacity over time, taking a consultative route and giving weightage to stakeholder narratives when developing sustainable energy pathways and contextualising technology to be context-applicable and context-relevant. The discussions in this dissertation and the key findings of the scientific papers collectively help answer the RQs and they are elaborated on in the following section.

# 6. Conclusions

The unfolding of sustainability transitions differs between developed and developing countries. This is also due to the fact that the term sustainable energy transition holds different meanings in different parts of the globe. In essence, sustainable energy transition in developed countries translates to a system change to renewables, whereas in developing countries it fundamentally relates to and is understood as access to affordable and reliable modern energy (Bridge et al., 2013). The challenges for developing countries shaping a sustainable energy trajectory are made more complex by the contextual nature of their governance, RET related capacities and the interests of policymakers (Goldthau et al., 2020). This emerging awareness therefore means that a global energy transition is not merely about shifting energy generation from carbon intense to a low or zero carbon energy systems, it is also about securing such a transition and transformation by way of responsible transition to offer equitable, affordable and reliable energy access. GeoST acknowledges the significant role of context in energy transitions (Coenen et al., 2012). It also acknowledges that energy systems are inherently spatial entities making them context-dependent in terms of institutions, infrastructure, land requirement, varied stakeholder engagement and functional governance, user practices and related discourses (Thomas & Erickson, 2021). Understanding energy transition in context requires a detailed understanding of and absorption of the contextual particularities and realities in the transition processes. These contextual attributes become crucial in theorising and conceptualising energy transitions in these settings.

Every technology of transition is linked to a network of actors and institutions, which are viewed as crucial elements for the introduction, development and navigation of technology in context, as acknowledged by transition studies (Bergek et al., 2015). This dissertation has argued that these crucial elements of sustainability transitions when used for analysis in geographical contexts need to be exercised with adjustments, particularly when used in a developing country context. Furthermore, the dissertation underscores the importance of paying closer attention to the role of informal networks, narratives and relational materiality to assess how transitions play out in individual developing country contexts. Empirically, this emphasis is supported through the experiences of the sustainable energy transition process linked to the implementation of RETs in Sri Lanka, a developing country context.

## 6.1 Answering the research questions

This article-based dissertation concludes by answering the RQs as set out in the introduction. While the discussion section (Section 5) of each article contributing to this dissertation gives a detailed account addressing the particular element the paper covers, this concluding section answers each question by way of giving a synthesis of the overall empirical evidence for such answers.

RQ1 asks 'What contextual conditions influence sustainable energy transition processes linked to implementation of RETs in Sri Lanka?'

One contextual factor influencing implementation of RETs in Sri Lanka is its state of innovation poverty as defined and illustrated in Paper #1. The dissertation records publicly available evidence to confirm the country's low ranking in the global innovation index, global competitiveness index and R&D expenditure. Innovation poverty is characterised by the consistent poor innovation state, scoring low on innovation indicators as well as a lack of interaction and interdependence between institutions such as universities and industries leading to an underdeveloped innovation system. This prevalent innovation poverty is seen as a barrier in the domestic transition process in Sri Lanka. The research study also gives empirical evidence as to the causes for this RET-related poverty of innovation and they include (a) lack of skilled labour and a relatively small pool of talent, (b) inadequate system to value, upskill and involve existing talent in innovation, (c) disconnected nature of research, innovation and industry, and (d) scant knowledge diffusion. Such a state hinders transitions from within as well as impedes the absorption of imported RETs and to alter them to suit contexts. To overcome this Sri Lanka needs to tap into the global knowledge sources and resources, and transfer, exchange and recombine knowledge to build the local innovative capacities as well as absorptive capacities. In this regard, the dissertation informs of recent initiatives to bring about a change by means of establishing formal GUC. This research study brought to light an inconspicuously remained but an effective informal network, namely the Sri Lankan Tamil diaspora, which has played a constructive role in uplifting the knowledge and skills base by way of linking GIN to Sri Lanka's universities and renewable energy sector. The global Sri Lankan Tamil diaspora network is considered as a GIN in nature.

This informal network, a particular context factor for Sri Lanka, is a driver in that country to advance the renewable energy transition process.

Another contextual condition influencing sustainable energy transition linked to RETs in Sri Lanka is related to its institutions and power sector governance. The influence of institutions both formal and informal on sustainable energy transitions emerged through different key stakeholder narratives as elaborated in Paper #2. While the identified tripartite narratives related to energy transition is likely be experienced by many countries, this research study identified in particular the system's inability to reach reconciliation or agreement on a consensus strategy that will enable the trajectory to ultimately approach their target of reaching 70% of renewable energy by 2050. The research study brings narratives-based empirical evidence of specific barriers related to system flaws and governance inadequacy which include (a) not adequately addressing stakeholder concerns by way of responsible transition, (b) giving inadequate attention to entrepreneurial activities and legitimisation (functions of TIS), (c) a lack of leadership within energy governance and transition management, and (d) a complicated policy framework less conducive for investment. In order to move in line with the global efforts and goals, Sri Lanka will require the development of, and adherence to, a more inclusive and responsive framework, i.e., besides incorporating local energy priorities, knowledge, and investments, the energy governance needs to be responsive to the criticisms and concerns of stakeholders. The lack of a transparent and investment-conducive transition framework is also seen as a contextual barrier in Sri Lanka's energy transition process. The setting up of a FPV DP is a step the country has taken recently as a way of taking stakeholders on the journey towards a responsible transition, i.e., a legitimisation process as reported through Paper #3.

The third contextual condition influencing sustainable energy transition linked to RETs in Sri Lanka is related to materiality and relational materiality. A technology developed and perfected for a particular context may run the risk if it is considered as a footloose technology. In consequence, diffusion of this technology will potentially be problematic in different contexts. This becomes a barrier to implementing RETs as empirically demonstrated by this research study and elaborated in Paper #3. This is especially connected with the material requirement of the technology and relational

association to the existing material and immaterial factors. The relational materiality affects the implementation of new technologies. New technologies bring in newer concerns and uncertainties in the new context. This research study identified RET demanded absolute materiality as well as the relational existence to that materiality as barriers to RET development. It identified that the transition process, in its planning stage, did not factor in (a) the material demand for multi-located, large-scale ground-mounted solar PV in a high population dense agrarian country context, and (b) the wide and deep relational dimension the rural population had to that materiality. New technologies in new contexts will require persuasion by way of tests, trials and demonstration to legitimise its appropriateness. While Sri Lanka has a good solar irradiation, a convincing solar technology design and mechanism to harness that source needs to be agreed upon. The difficult experience of trying to apply solar technology as a footloose one resulted in the commissioning of a DP with a floating mechanism in Sri Lanka to engage in an innovation process. The DP and the journey that led to the need to implement a DP can be seen as a driver for sustainable energy transition with the opening for innovation.

RQ2 asks 'How does this study inform the GeoST literature in developing countries?'

The dissertation's principal contribution to the GeoST literature is that it unambiguously informs of the need for developing and applying a context-sensitive perspective to energy transition in developing countries. In doing so the dissertation offers a TIS-adjusted analytical framework for understanding the technology-context interaction by way of giving focus to networks, discourse and materiality and thereby taking a RI route to gradually scaling up sustainability transition. Consequently, the dissertation argues that theoretical framework(s) employed to analyse sustainability transitions need to be adjusted when applied to a particular country context. This article-based dissertation particularly emphasises that GeoST literature needs to pay closer attention to the role of informal networks, narratives and relational materiality in assessing how transitions unfold in developing country setting.

The empirical study highlights the need for overcoming innovation poverty and building domestic capacities to steadily progress towards sustainability transition and described the effective role of informal networks in strengthening the coupling

mechanism with GIN to transfer global knowledge that is needed for building domestic capacities. Accordingly, the dissertation informs the literature that coupling mechanisms can be strengthened through informal networks and adds the diaspora's contribution to the GeoST literature pointing out that they uniquely also possess contextual tacit knowledge for a more effective outcome. Secondly, the dissertation highlights the importance of pursuing the narratives in play as a way of recognising the influencing factors and conditions including formal and informal institutions and practices shaping energy transitions. This empirical study reemphasises the fact that hegemonic narratives gain traction due to their underlying power relations (Fløysand & Jakobsen, 2017). The dissertation also informs the literature of the significance of realising RI in developing countries, and it offers a methodological contribution to do so by way of employing narratives as a feedback bridge merging TIS with RI. Thirdly, the dissertation emphasises that GeoST needs to pay greater attention to contextualising RET by giving focus to absolute and relational materiality. The study gives empirical evidence of the adverse impacts on sustainable energy transitions as a result of treating technology as mere end products of transition and not considering the influence of relational materiality on technology.

RQ3 asks 'In what way can the study stimulate policy scaling up of RETs in Sri Lanka?'

The research study has uncovered a number of policy areas which, if adequately addressed, could stimulate RET related policy scaling up in Sri Lanka. Analysis of this narratives-based qualitative study in essence brings to light the need for an inclusive approach to collectively manoeuvre the complex transition processes. The three elements discussed in the articles contributing to this dissertation complement each other, which consequently requires a coordinated approach to absorb the details of those elements to help stimulate policy scaling up.

Empirical evidence suggests that Sri Lanka needs firstly to develop an inclusive and responsive energy transition framework to systematically address the pathway towards its goal of increasing the share of renewables. Additionally, interaction and interdependence between government-universities-industry needs to be encouraged and strengthened. The empirical evidence also suggests that the framework should be responsive to criticisms and concerns of stakeholders and take forward the transition

through a responsible transition pathway. While the stakeholders' role is to ensure that access to reliable and affordable electricity is supplied to the citizens of the country, the action towards delivering them needs to be responsible. As such responsible mechanisms and standards need to be established by combining global knowledge and sustainable practices with local knowledge, practices, and priorities. The framework, as demonstrated by the narrative-based study, needs to also be transparent, easy to follow and hence conducive for investments on RET. Crafting careful strategies through foreign investments and international collaborations play a crucial role in the country moving towards renewables, hence it becomes imperative for the country to have a conducive transparent investing environment by following the global standards and practices for Sri Lanka. In short, stakeholder attestations documented in this dissertation informs that development of an inclusive, responsive and transparent energy transition framework could be the first step Sri Lanka needs to take to help stimulate policy scaling up of RET.

This dissertation informs that another policy area for scaling up RET is related to the implementation process. The experience of the country's energy transition process, as empirically described by this qualitative study, highlights that RET needs to be introduced into the Sri Lankan context through a legitimisation process, such as a DP. Even the most promising technologies can fail because of ethical and societal concerns that come with the technology. When introducing mature or new technologies, policymakers and stakeholders may face implementation challenges, particularly if the technology was not developed locally to suit the context. A DP of the newer technology allows the technology-context interaction to be studied in the native soil to address concerns and reduce uncertainties raised by different engaged and affected stakeholders, and to ensure that such technologies for transitions are not only sustainable but also responsible.

A policy area for the long-term stimulation of RET in Sri Lanka, as identified by the dissertation, relates to encouraging domestic innovation. The study gives empirical evidence as to how Sri Lanka has recently benefitted from international collaboration through GUC projects, to improve RET related knowledge and skills base via GUC, knowledge exchange through RET related conferences and workshops as well as drawing in Sri Lankan universities within networks such as ANCEHA. International

collaborations, both academic and industrial, can greatly benefit every aspect of technological transfer. In the long term, such international collaboration importantly will help build and strengthen local capacities and capabilities and thereby encourage innovation for transition from within. Furthermore, it will also enhance the absorptive capacity to adopt and transform received technologies to suit contexts. Further, as initiated by the CBERC project, the industry-universities collaborations should be furthered within the country not only for absorbing the emerging RET trained skilled workforce but also for steady investment and to see the application, and maturity, of domestic research and innovation in relation to RET.

An inexpensive way for Sri Lanka to connect with global knowledge and resources, and uplift itself from innovation poverty is to engage more with existing global informal networks and find ways to encourage global informal networks to get further involved in knowledge transfer and R&D initiatives. Such engagements can build innovation capacities from within while also linking Sri Lanka in the global process. The Sri Lankan Tamil diaspora is one example. Similar networks or linkages need to be established to obtain their inputs through multiple fronts in transition to RETs in a responsible way. Engaging with such global yet contextual networks will bring long-term advantages not only through access to global resources and practices but also by merging contextual knowledge and practices within learning and innovative process and ultimately being a connector between the local and global resources.

## 6.2 Limitations of the dissertation and avenues for future research

The findings of the three research papers and the overarching result of this dissertation bring with them a few limitations. The empirical evidence presented here relates specifically to the Sri Lankan context. However, the barriers and drivers of this developing country, as well as the influences of the key elements of sustainability transitions on its transition process cannot be directly translated to other geographical contexts. Nevertheless, the dissertation argues that GeoST literature should pay closer attention to the role of informal networks, narratives, and relational materiality to assess how transitions unfold through RETs in such settings, but with adjustments shaped by and customised to that geographical context. In essence, the dissertation emphasises the need for a context-sensitive perspective on sustainability transitions in

individual countries, especially developing countries. The developing country category is a widely heterogenous one, with differing characteristics between individual developing countries, each one with its own contextual particularities, challenges and opportunities. This leads to the first limitation of this dissertation – that it cannot be assumed that all developing countries will benefit equally from the discussions or propositions of this dissertation, for reasons mentioned above.

The empirical case taken for analysis in this dissertation is Sri Lanka, a country recently downgraded as a lower-middle income developing country. A country which has been devastated by a three-decades long civil war. Though the war ended, the root causes of the conflict remain fresh to this day, sustaining the ethnic tension and struggles between communities. Yet, the war also brought other spin-off effects. One such spin-off was that the rebuilding efforts after the war allowed the attraction of newer assistances, collaborations and investments from international NGOs, foreign governments and investors for development, and higher education, and research, particularly in the war affected zones. Another spin-off is the creation of a diaspora, unique in the sense that a large number of people belonging to a particular ethnic body emigrating within a very short period of time and collectively still have blood connections with Sri Lanka. These particular spin-offs add to Sri Lanka's current specific context and have had an impact on the suggestions presented in this dissertation. This, in turn, restricts the adaptation of findings to other developing countries, particularly diaspora based informal network.

Another limitation of the dissertation comes from the complexity of understanding and mapping a complete transitioning of the electricity sector in Sri Lanka, which is affected by myriads of social, political, economic, environmental, and material processes, from the national to the global scale. Sri Lanka lacks a conducive research environment or setting to consistently and systematically address the dynamic nature of implementing sustainable energy transitions. For example, a change in government is not only about change in the governing personnel, but also entails a change in established structures, institutions, and practices affecting continuity of plans and practices as well as the direction of change. These factors affected wider sets of power sector related data collection, and access to experienced and involved personnel for interviews, which might have shed further light on the transitioning process.

Availability and access to data is the third limitation to the study. It is a widely acknowledged fact that in developing countries accessing data can be a challenge, or data may be unavailable (Bulmer & Warwick, 1983; Mollet, 2011). To improve the validity and reliability of this research, the study chose to combine interviews and participant observations with a large variety of publicly available data, such as policies, regulations, annual and evaluation reports, long term plans, websites, and newspaper articles. However, difficulty on accessing personnel, reluctance to share data, the inconsistencies in the available data or lack of it, and outdated statistical data limited this empirical analysis. As a result, this study heavily relied on stakeholder information and views for addressing such gaps. Additionally, fieldwork in Sri Lanka was conducted during a transition in the government following the presidential election in November 2019. This especially had an impact on the interviews with public sector representatives who were hesitant to provide high-quality qualitative data and sharing their views. This was further aggravated by the inability to conduct another round of face-to-face interviews in Sri Lanka due to the travel and social restrictions caused by Covid-19.

This dissertation also opens new avenues for future research related to RET. Social science and transition-related research cannot remain static or end with only one study. Current initiatives, such as HRNCET and CBERC, need continuous support through continuing analysis of progress. Furthermore, identification of newer influencing issues that should provide feedback for further improvement in innovation and transition, and the creation of new initiatives need to be studied through research. Such research is also essential to continue attracting newer investments in RETs. Another avenue of research is related to the much-needed university-industry collaboration on innovation and transition. Such collaboration is important to achieve contextually relevant innovation from within, and not just in the field of energy transition. There is a significant gap in understanding the reasons for limited collaboration between universities and industries in Sri Lanka. Consequently, relevant research methods need to be employed to study effective ways to foster this collaboration.

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# Mobilising Diaspora for Sustainability Transition in Global University Cooperation

Nanthini Nagarajah and Arnt Fløysand

**Abstract**

This chapter investigates the contribution of Global University-University Cooperation (GUC) as a measure extended to overcome the dearth of innovation in the Sri Lankan clean energy sector. The sustainable energy transition to low-or zero-carbon has been high on the global agenda. The global attention to keep up with Paris Agreement has also raised awareness at the regional and national level, with many countries increasingly working towards transitioning to more sustainable energy solutions. Theoretically, we draw on a Global Innovation Network (GIN) perspective, which places emphasis on multi-level networks between actors engaged in solving complex non-decomposable problems requiring broad knowledge exchange and knowledge recombination. We explore how the concept of coupling mechanism can be aligned to a situation on *innovation poverty* and how such coupling mechanism can be strengthened in a contextual manner through informal networks, such as the diaspora community network as reported in this paper. Empirically, we draw on a GUC project involving the Western Norway University of Applied Sciences (HVL) and the University of Jaffna (UoJ) in Sri Lanka. The main objective of this GUC is to build applications for the development of sustainable energy solutions in Sri Lanka using nanomaterials for new-generation solar cells, water splitting for hydrogen production and energy storage through photo-capacitors.

**Keywords**: Sustainability transition, Global University-University Cooperation, Global Innovation Network, innovation poverty, coupling mechanism, informal network, diaspora

## 1. Introduction

Sustainability (energy) transition refers to the decline of existing unsustainable fossil-fuel-based systems and the emergence of systems with sustainable alternatives (Markard, 2020). Innovation becomes the cornerstone by which to bring these changes needed for transitions. However, spatial unevenness (i.e., unequal distribution in geographical regions or spaces) is very evident in global sustainability transition processes. Paul Benneworth, has written about the need for giving attention to spatially sensitive transition analysis to enrich transition research (Coenen et al., 2012). Sustainable energy transition processes differ between developed and developing countries with the latter facing more complex and challenging issues because of their different structural systems, priorities and the way transitions are governed (Köhler et al., 2019). For instance, the Western notion of innovation needed for transition may not be understood from the same system perspective in developing countries (Berkhout et al., 2011; Hansen et al., 2018). Notably, developing countries find themselves in a state of *innovation poverty* (i.e., underdeveloped innovation system leading to consistent poor innovation state and scoring low on innovation indicators as well as a lack of interaction and interdependence between institutions). This is especially due to negligence in building long-term indigenous capabilities leading to a perpetual external reliance on both tangible and intangible resources and skills (Asheim & Vang, 2006). Innovation poverty is also due to lack of, or insufficient, or weak institutions to influence innovation, leading to an absence of interaction between universities/research institutions and firms/industries (Joseph, 2009).

In developing countries, higher education and research institutions such as universities operate under a totally different setting than developed countries with the supply side facing sparse and often low-quality resources and the demand-side stymied with stagnation in innovation, limiting the effective demand for knowledge and competence (Brundenius et al., 2009). In such circumstances linkages to global knowledge networks can play a key role in developing local absorptive capacity and knowledge promotion (Chaminade & Plechero, 2015; Martin et al., 2018). Accordingly, one important step towards reaching sustainable energy transition in developing countries is by way of expanding higher education and research networks and initiating research in universities through Global University-University Cooperation (GUC), enabling innovations based on renewable energy sources, a theme also advocated by Paul Benneworth as a way of addressing spatial unevenness in sustainability transitions. This leads to the research question of this chapter: *how sustainability transitions can be mobilised through global university cooperation in the context of innovation poverty?*

Theoretically, we draw on the Global Innovation Network (GIN) perspective, which places emphasis on multi-level networks between actors engaged in solving complex non-decomposable problems that require broad knowledge exchange and knowledge recombination (Chaminade, 2009). Empirically, we draw on a GUC project, with a transparent interactive process on science and innovation involving the transfer of codified knowledge (i.e., knowledge that is explicit and can be easily transferred to another person) from the Western Norway University of Applied Sciences (HVL) to the University of Jaffna (UoJ) in Sri Lanka. The main objective in this GUC is to build applications through knowledge exchange, knowledge recombination and practices (global and local) for the development of sustainable energy solutions in Sri Lanka using nanomaterials for new generation solar cells, water splitting for hydrogen production and energy storage through photo-capacitors.

Applying a GIN perspective in the case, we find that the diaspora community of Sri Lankan Tamils has been playing an important role in the GUC project, supporting it through many fronts including educational, financial, business, and mentoring. We argue that by taking advantage of informal networks, such as a diaspora as a coupling mechanism (i.e., pairing of actors, networks or institutions for resource transfer, exchange and/or recombination) fundamental change can be brought about in developing countries that could improve the prospects of overcoming innovation poverty. As such, the case indicates that sustainable energy transition can best be mobilised through context sensitive networking utilising GUC approaches.

## 2. Theoretical reflection

### 2.1 Global innovation network and coupling mechanism

The innovation literature identifies different territorial network systems and coupling mechanisms such as the regional innovation system (RIS) (Asheim et al., 2011; Asheim & Vang, 2006), national innovation system (NIS) (Johnson & Lundvall, 2013), global innovation system (GIS) (Binz & Truffer, 2017) and GIN (Chaminade, 2009) for building, exchanging and recombining knowledge and industry bases for promoting innovation in the developed world. Nonetheless, adapting these territorial network systems to different contexts outside the industrial world, especially in developing countries, can be fraught with challenges, due among other reasons, to the immature and disjointed nature of available research-industry collaboration

and their limited and narrow networks.

Binz and Truffer (2017), while highlighting the increasing importance of international linkages in the innovation process, argue that the performance of a system in developing and diffusing innovation depends not only on the coherent sub-systems (RIS, NIS, GIS) but also on establishing structural couplings between them through various actors, networks and institutions regionally, nationally and/or globally. Thus, the concept of structural coupling is viewed as how these networks can connect to different available sub-systems to facilitate access to scarce or non-locally available resources. This places countries, particularly developing countries, to garner transnational cooperation and build exogenous linkages with a variety of globally distributed knowledge networks and actors. Using exogenous linkages enables these countries to create new knowledge, exchange knowledge, to upgrade the knowledge-base and to apply them in their own contexts in order to advance their own domestic capabilities and knowledge base (Asheim & Vang, 2006).

One route for exogenous linkage is by way of establishing coupling mechanisms through tapping into GIN that is linked to a complex network of actors all over the world, and thus creating a globalised platform to access knowledge and innovation activities. Chaminade (2009, p.17) defines GIN as "a globally organized web of [a] complex interaction[s] between firms and non-firm organization[s] engaged in knowledge production related to and resulting in innovation". As such, GIN places emphasis on networks between actors and actor networks that are engaged in solving complex and enduring problems that require knowledge creation, exchange and recombination. International academic and research collaborations, conferences and networking are examples of platforms for such knowledge exchange and recombination. Academics' sharing knowledge through international networks, mobility programmes and collaborative activities facilitate connection to global knowledge by way of further developing academic networks, and consequently impacting significantly and positively on local innovation processes (Benneworth & Fitjar, 2019; Trippl, 2013).

Studies reveal that innovation associated with local and regional linkages result in incremental innovation whereas global linkages help achieve a higher degree of radical innovation (Grillitsch & Chaminade, 2018). This is due to the fact that local and regional networks tend to provide similar knowledge to what is in use, while the linkages to GIN provide more diversified knowledge. Further, global innovation linkages are positively linked with the analytical

knowledge base (Herstad et al., 2014). The onus is therefore placed on firms and institutions to develop sufficient absorptive capacity in their workforce and their R&D capabilities (Ashiem et al., 2019) for them to tap into and benefit from the rapidly changing technological developments and analytical knowledge available through GIN.

Analytical knowledge is where the "innovation involves strongly codified and universally valid knowledge, which is relatively easy to transfer over time and distance. Analytical knowledge is not bound to a particular geographical area, which opens up possibilities for global knowledge exchange" (Martin et al., 2016, p.8). Analytical knowledge is highly abstract based on scientific laws and formulas; it can also be transferred digitally and hence such knowledge linkages can be established through research collaborations between firms and research institutions (Liu et al., 2013). Such knowledge linkages are related to knowledge-intense sectors including biotechnology and nanotechnology, as such participants in research collaborations require applied research as well as systematic development processes (Tödtling et al., 2011). This requirement mandates firms to rely on universities or research institutions to take forward innovation. This is where university-industry linkages and related networks play an important role in supporting a workforce that requires more experience in research and university training (Ashiem et al., 2019). Moreover, the advantage of analytical knowledge is that, unlike tacit knowledge (i.e., knowledge that is implicit and difficult to transfer to another person), it does not require local interaction or close proximity for knowledge transfer but can rather be transferred from geographically distant locations requiring only common understanding and interest among actors, for that knowledge to be useful in innovation (Chaminade, 2011) and for building domestic capacities. Accordingly, we argue that by establishing a GUC, a developing country with a deficit in innovation capacity can significantly and consistently build domestic research and innovative capacities using codified knowledge, in conjunction with the domestic university's tacit knowledge of the context.

Linkages for accessing, exchanging and transferring knowledge required for the process of innovation include formal networks and informal networks (Ashiem et al., 2019). The focus of this chapter is on informal networks which largely remain voluntary and inconspicuous (Martin et al., 2018). The informal networks that offer access to global knowledge sources include (i) labour mobility, (ii) online platforms and virtual communities, (iii) temporal professional gatherings such as conferences and (iv) personally embedded networks (Martin et al., 2018). Knowledge transfer by way of skilled labour mobility is effected by cross border movements

of scientists who contribute to the transfer and growth of academic knowledge both at the local and global level (Asheim et al., 2019; Binz et al, 2014; Trippl, 2013). Mobility of people is regarded critical in the international transfer of technology due to the tacit elements of knowledge and skills necessary for innovation and change (Bell & Pavitt, 1993; Wieczorek et al., 2015). This international knowledge flow through skilled labour mobility tend to be multidirectional in nature, sharing the benefits of skilled migration between sending and receiving countries or regions (Trippl, 2013). It is assumed that the country that sends skilled labour will benefit from the return of said labour after acquiring high level qualified knowledge; however, even if the skilled labour failed to return, the sending countries would still likely benefit from unreturned skilled labour (Ackers, 2005; Gill, 2005; Trippl, 2013). This is because of persisting emotional and professional linkages that the skilled labour typically maintains with their home country. One such example is that of the diaspora network of skilled people who have dispersed globally but continue to maintain and transfer knowledge via informal networks to their home countries (Gill, 2005). The transfer of resource via these network linkages promotes interactive learning and facilitates the building of local capacities by utilising locally available human, material and natural endowments, together with global knowledge sources. The OECD (2012, p.5) recognises diaspora as possible "connectors" in building up innovation capacities through building incremental and radical innovation capacities to compete in the global setting. The diaspora is further advantaged by the fact that their:

> transnational networks and ties permit them to function within the national context with minimal dependence on state process, regulation or the need for concessions. Likewise, their non-dependence on statist institutions has enabled these groups to be relatively immune from the coercive and hegemonizing power of the state (Cheran, 2003, p.11).

Diasporic academics have begun to play more explicit institutional roles in the creation of global knowledge networks through informal network(s) that work above and beyond individual institutional affiliations (Larner, 2015).

### 2.2 Developing countries and innovation poverty

In developing countries, the term innovation is generally associated with less formalised low-technology innovation or improvisation through the utilisation of local assets, using indigenous knowledge systems such as *grassroots innovation*, *jugaad*, and *frugal innovations* which are situated outside of R&D laboratories (Hansen et al., 2018; Jeffrey & Young, 2014; Lema et al., 2021; Prabhu & Jain, 2015). Elsewhere the innovation literature terms innovation as radical

development of new technologies based on R&D. Whereas innovations by firms in industrialised countries are new to the world, they are very often "imitative innovation" in developing countries where the technology is imported from elsewhere and tailored in adaptation to local needs (Barnard & Chaminade, 2017, p.4). The principal reason underlying why developing countries express difficulty in conceptualising from a system perspective is that firms in these settings lack the capacity to generate, innovate and diffuse new technologies (Berkhout et al., 2011). This is because they lack the "absorptive capacity" to innovate on the transferred technology (Goldthau et al., 2020, p.324), or to apply scientific knowledge to innovate or improve the technology from nearby universities and research institutes (Asheim et al., 2019). Universities in these settings have little or no experience in industry collaboration and have limited managerial capacity, limited financial and human resources as well as limited capabilities to produce research that can be exploited commercially through spin-offs or patents (Guimón, 2013). The lack of such interaction and networking between firms, industries and universities lead to acute barriers to university-industry collaborations, which are critical to converting codified knowledge into economic and sustainable gain. These countries do not view universities as "agents of innovation" but rather as space for human capital formation (World Bank, 2007, p.94; see also Padilla-pérez et al., 2009). Consequently, developing countries do not construct a well-functioning innovation system with interactive learning, and are left with absent, fragmented or weak linkages between the essential components (Chaminade et al., 2009). In the absence of necessary linkages and collaboration, research in these countries become a standalone endeavour, unable to progress towards innovation (Asheim et al., 2019). Additionally, networking and interaction among actors appears much weaker, and the reliance on informal arrangements is substantial (Kraemer-Mbula & Wamae, 2010).

Another reason why innovation within firms or regions remains largely underdeveloped in developing countries is the "lack of cooperation between firms as well as due to innovations being developed informally and in isolation" (Cirera & Maloney, 2017, p.149). Ashiem et al. (2019) suggested that, although universities and research institutions in developing countries perform high-quality scientific work, their focus is primarily on publishing papers rather than developing knowledge and technological advances for innovation. We have termed this underdeveloped innovation system with consistent poor innovation state and scoring low on innovation indicators as well as a lack of interaction and interdependence between institutions, as exhibiting innovation poverty.

## 3. Methods

The first author of this paper is involved as a beneficiary-implementer-researcher within a GUC project on Higher Education and Research in Nanomaterials for Clean Energy Technologies and Capacity Building and Establishment of Research Consortium involving a university-university collaboration between HVL and UoJ. This is a research position described by McNiff and Whitehead (2006) as action research, where the practitioners themselves investigate their own practices and the researcher becomes an insider researcher by being part of the situation s/he is investigating. This participatory process deals with a real-world problem and the process in our case involves improving and changing the existing situation while also generating global knowledge through those actions (Burns, 2009; Greenwood, 2007).

Accordingly, an action research methodology was employed as the suitable method to explore *how sustainability transitions can be mobilised through global university cooperation in the context of innovation poverty*. The primary data collection was undertaken by way of semi-structured interviews. Choosing informants was based on a purposive sampling method which enabled the researcher to recruit informants based on a predetermined set of criteria under defined research objectives (Guest et al., 2006; Tongco, 2007).

The interviews were conducted in two phases. In Phase 1, the entry point for interviews was through key informants in the Sri Lankan electricity sector. Key informants were identified by following articles and interviews pertaining to the Sri Lankan energy sector in local newspapers, TV channels and by attending an international conference and pre-conference discussion organised by the GUC project (February 2019). To expand beyond the key informants, snowball sampling was used which added more stakeholders as the study progressed. This led to 30 interviews with 29 face-to-face interactions and one email interview after a brief informal meeting. These interviews were conducted in Sri Lanka from November 2019 to February 2020. Participant observation was practiced during the above conferences and at an expert panel discussion at an international conference (January 2020), at a floating solar panel launch and through site visits to two power station locations (a coal power plant, and an off-grid hybrid power station) in the same period.

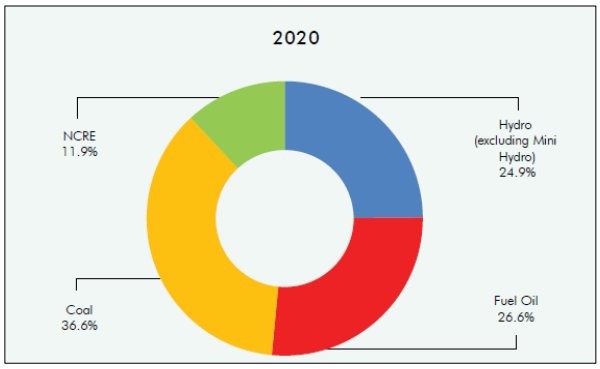
The Phase 2 interviews were conducted in Norway from August 2020 to March 2021. The selection of informants was based on the list of the *Norwegian innovation and investment delegation to Sri Lanka* in 2018 as part of the GUC project. Ten out of 26 delegate members in the list responded with a willingness to participate in the interview, with one additional

participant obtained via the snowball technique. Thus, 11 delegates and participants became interviewees in total. Ten interviews were held digitally due to COVID-19 pandemic related restrictions, while one interview was held by email. The 41 interviewees from Phase 1and 2 represented public sector (14), private sector (15) and academics and energy experts (12). The interview questions focused on Sri Lankan electricity sector progress, commitments, drivers and barriers, long-term plans, knowledge diffusion and innovation issues. Secondary materials came from organisational publications, evaluation and annual reports, strategy documents, newspaper articles and websites. These were used in-conjunction with field notes derived from participant observations. Interviews were voice recorded (except two) and were transcribed manually. The interviews which were held in the local languages (Tamil or Sinhalese) were subsequently translated to English by the first author. The analysis was conducted manually to identify categories and themes. The data analysis was an iterative process between transcripts, recordings, documents, and observations. Data saturation was reached when similar claims rather than new information were brought in the interviews (Saunders et al., 2018). The identified findings were fed into the project process through one-to-one discussions.

## 4. The case

### 4.1 Sustainable energy transition and innovation in Sri Lanka

Sri Lanka, a lower-middle-income country has a population of 22.1 million in a land area of 65,610 sq. km (Central Bank of Sri Lanka (CBSL, 2021). Sri Lanka has the vision to achieve carbon neutrality by 2050. Sri Lanka's global share of $CO_2$ emissions in 2017 was 0.06% with the largest share of emissions generated from transport and electricity (Ritchie & Roser, 2020). A negligible contributor, the country is highly vulnerable to the impacts of climate change as per United States Agency for International Development (USAID, 2018). The 2018 Climate Risk Index ranked Sri Lanka 6$^{th}$ for being adversely affected by climate change (Sönke et al., 2019). The geo-climatic setting of Sri Lanka is particularly conducive to harnessing renewable energy sources including biomass, hydro, solar and wind, which remain the primary indigenous energy sources for the country. Until 1996, the largest share of electricity generation came from major hydropower plants when it shifted from a predominant hydropower system to a mixed hydrothermal power system due to the increasing energy demand and the nearly exhausted hydro potential. Currently, the country's electricity generation is dominated by imported fossil




**Source:** Annual Report 2020 Central Bank of Sri Lanka (CBSL, 2020, p.80)

**Figure-1:** Electricity generation mix - 2020

fuels (Figure-1). Sri Lanka has relied on external assistance for technology transfer, knowledge, and investment to cater to growing energy demand ever since the British Colonial period. For instance, records show that Gilbert Gilkes and Co. Ltd, recognised as the oldest manufacturer of hydraulic turbines and pumps in England, were the largest turbine suppliers to Sri Lanka with the first turbine arriving in 1887 (Consultants, 2014; Silva & Silva, 2016). Sri Lanka recently (2020) opened its first wind farm (104 MW installed capacity). This was funded by the Asian Development Bank and built by Vestas Asia Pacific AS, a world-renowned Danish wind turbine manufacturers who were also pioneers in introducing the technology to Sri Lanka through a demonstration project in the late 1990s (Vestas, 2018). Such reliance on external support highlights the poor level or lack of innovation capabilities within the country. Low and poor levels of innovation is highlighted as one among other reasons why Sri Lanka has remained trapped in the middle-income category for a long time (CBSL, 2019).

With regard to innovation, Sri Lanka was ranked 95 out of 132 countries on the Global Innovation Index (GII) with a score of 25.1 on a scale of 0-100, where 100 is the most innovative (World Intellectual Property Organization (WIPO, 2021). The World Economic Forum (WEF) ranked Sri Lanka 84 out of 144 countries in the Global Competitiveness Index (GCI) in 2019. Under its innovation capability pillar, Sri Lanka scored 3.6 for R&D expenditure (0.1% of total GDP), and 2.3 for prominence of research institutions on a scale of 0-100 (WEF, 2019). The GII has not shown improvement over the years. Different commentaries by interviewees confirmed Sri Lanka's slow progress in innovation, and some viewed the dependence on external sources as a hindrance factor to local innovation process:

> We do not have the capacity to absorb the technology. We do not have manufacturing

> sites as well as the expertise. So, we are just bringing in technology. We depend on technology from the outside. We get the equipment, but the knowledge is with the supplier. We are not able to absorb that because we do not have that mechanism.
>
> (Academic/energy expert, 2019)

In addition to scoring low on GII, R&D and GCI, Sri Lanka is also believed to remain a challenging place to make investments with the main reason being unscalability, primarily due to the lack of skilled labour and a relatively small talent pool (United States Department of State, 2020). However, the observations by the interviewees in terms of talent was that the country has talent, but it has not made the effort to make use of it:

> What are our engineers doing, we are producing thousands of engineers every year. In terms of talent, Sri Lanka has that but using it and creating a value addition is what we need. That should be a policy element and then the industry can thrive and move forward.
>
> (Public sector employee, 2020)

Further, the disconnected nature of research and industry, with a lack of progress beyond research publication, was also highlighted as a reason for the existence of poor or low innovation capacity:

> Our value additions are low, and our innovation is very low. If we don't have an innovative society, we can't go forward, because innovation is the ***one***. Our research is not targeted really to the user need. Research work ends up with a report, promotion or publication in a journal and that's it. We have lots of research, but none goes to the society but only stays on the shelf.
>
> (Academic/energy expert, 2019)

Innovative performance through R&D and knowledge exchange and diffusion are crucial factors in determining innovative capabilities and national progress, and this includes addressing global challenges such as climate change and sustainable development (Organisation for Economic Co-operation and Development (OECD, 2007). However, according to the interviewees, knowledge exchange and diffusion are curtailed in Sri Lanka:

> Knowledge diffusion is not happening. With knowledge diffusion competitiveness is developed in the economy. When people know how to do things then a lot of industries are coming, and more competitiveness is developing. In countries like Sri Lanka that is curtailed.
>
> (Academic/energy expert, 2019)

The country's innovation poverty, as evidenced by the illustrated interviewee quotes, the low GII, R&D, and GCI scores, and the disconnect between industries and research institutions, and lack of optimal use of skilled labour, remains a major barrier for the electricity sector to move at scale with solutions from within towards achieving its demanding climate action goal.

### 4.2 GUC between universities in Norway and Sri Lanka

A GUC project was established between HVL and UoJ in 2017. The four-year (2017 - 2021) collaboration was enabled through financial support from NORPART[1]. This GUC was established following a pre-study (NORPART funded) which identified the need to improve the quality of higher education and research on nanomaterials for clean energy applications in both institutions. The GUC project focused on developing nanomaterials for clean energy applications utilising locally available sources, building local knowledge and capabilities. This included capacitating both staff and students from Norway and Sri Lanka to work on clean energy applications using nanomaterials. The GUC activities included (i) establishing research groups with staff and students from the universities in both countries to work on clean energy applications using nanomaterials for new generation solar cells, energy storage through photo-capacitors and water splitting for hydrogen production, (ii) research groups working on synthesis, modelling and simulation studies on advanced nanomaterials to identify novel materials, (iii) staff and student mobility, joint supervision of Masters students, (iv) participation in international conferences and co-authoring publications, and (v) development of a Master curriculum on clean energy technologies (CET). However, the primary challenge in initiating the project activities and transferring knowledge was the initiation of the process from ground zero at the UoJ:

[1] Norwegian Partnership Programme for Global Academic Cooperation

> The challenge was that there wasn't a single student at UoJ interested [in CET] and there wasn't a Master program. The lab facilities were very basic.
>
> (Academic, March 2021)

Notably, this required student motivation and building student confidence to absorb Sri Lankan students into the field:

> I have to say that the talents and the brains are there, no doubt about it, but we have to guide them, direct them and coach them.
>
> (Private sector, November 2020)

In order to build and strengthen the project and to make use of different resources, knowledge and networks efficiently and effectively, the project was extended to involve the universities in Agder and Bergen (both in Norway), the University of Peradeniya and the National Institute of Fundamental Studies (both in Sri Lanka) and Coimbatore Institute of Technology (in India) where scholars were engaged in similar research activities. Parallel to local knowledge and capacity building, the following were identified as important requirements to building local CET capacities and establishing a local CET hub in Sri Lanka, (a) a clean energy research laboratory with state-of-the-art technological equipment to improve the quality of experimental research in Sri Lanka, (b) a research consortium engaging the private sector and academics from both countries to collaboratively work on CETs with a particular focus on industrial collaboration in addition to academic and research collaborations, and (c) an in-depth study of the Sri Lankan energy policy and governance to facilitate foreign private sector investment in renewable energy technologies in Sri Lanka. Additional funding to strengthen the on-going GUC project activities to address the additional needs was received from the Royal Norwegian Embassy in Colombo, Sri Lanka in 2017 in the form of a follow-up grant.

While joint supervision from Norway and Sri Lanka helped capacitate students, the staff and student mobility programmes involving short and long research stays in Norway and India provided international exposure and experience on the variations in the research methodologies of the different research institutions. However, the project needed additional support to build, strengthen and absorb both the students and the project.

Scholars in the engaged research institutions also included scholars from the Sri Lankan Tamil diaspora and they came to provide the additional support and guidance to strengthen the students and the project. The diaspora network within the project was further established through the participation of global scholars from the Sri Lankan Tamil diaspora in a 2019 international conference organised by the GUC project at UoJ. The Sri Lankan diaspora provided mentorship and guidance to students and staff working on nanomaterials and emerging technologies. The diaspora engagement and knowledge transfer, besides engaging in the project as participants, also occurred at a more personal and informal level, supplementing the project activities in Sri Lanka in the field of education, research, and industrial collaborations. They supplemented the projects by providing material, finance, business, and cognitive support in building both physical and knowledge resources to successfully embed and sustain the projects. As the research activities were focused on developing analytical knowledge skills, the knowledge transfer was made possible with scholars from different parts of the globe without requiring proximity or their presence, but simply with the provision of necessary infrastructures:

> What was more helpful with our research activities was that we were able to train, guide the research groups remotely through webinars, and connect them with institutions in Norway, India, Sri Lanka, and elsewhere digitally.
>
> (Academic, March 2021)

In the three and half years from its commencement, the project has yielded emerging competence with seven students working on experiments on nanomaterials for clean energy applications with continuous supervisions from researchers globally while three more students have been recruited to work on new nanomaterials.

> I got myself a Master student that I would help teach how to do theoretical and computational modelling, so that in the long run UoJ at least could have their own computational and theoretical group so they could also do both experimental and theoretical modelling.
>
> (Academic, January 2021)

The Master curriculum initiative has triggered interest in the field of clean energy with 16 students enrolled in 2020 and who are following the course through online lectures conducted

by global experts and researchers. The research consortium established through the GUC project has taken the initiative to bridge the disconnect between universities, researchers and industries by means of engaging researchers and industrialists from both countries. The research consortium also consisted of members from the Sri Lankan Tamil diaspora. As the first step, the GUC facilitated a 26-member delegation from Norway including private companies travelling to Sri Lanka in 2018 to explore the opportunities and study the energy landscape. Through this project, a pilot floating solar plant with a capacity of 46kW was launched in early 2020, placing it in a pond at the UoJ premises along with a reference plant of 5kW (on land) for research purpose. Currently, multiple studies are being conducted through this demonstration floating lab which is monitored not only by researchers and stakeholders in Sri Lanka but also by Norwegian solar companies and the Norwegian Institute of Energy Technologies. Meanwhile, student placements in industries in Sri Lanka and Norway are also earmarked. The active engagement and presence of the Sri Lankan Tamil diaspora physically and digitally has thus not only strengthened the project but brought positive outcomes and enabled new funding from NORPART in 2021 to further expand the project, including widening the partnership to include the Eastern University in Sri Lanka.

### 4.3 The emergence of Sri Lankan Tamil diaspora and their educational engagement

The Sri Lankan Tamil diaspora emerged as a result of Sri Lanka's protracted civil war which lasted for nearly three decades (1983 – 2009). The discrimination against the minority Tamils by the majority Sinhala community through education and employment in post-colonial Sri Lanka was a core factor causing the conflict and leading to civil war (Pieris, 2019). Prior to the civil war, there were repercussions as a result of the growing tension between the two ethnic communities which lead to mass violence unleashed by segments of the majority Sinhalese population against Tamils. The most destructive violence took place in the year 1983, also known as *Black July*. This had a significant impact on the migration patterns of the Sri Lankan Tamils. During the period of war, instability, lack of opportunities to progress in education and employment, lack of hope, political victimisation, injustices and insecurity forced many from the minority Tamil community to migrate to other countries including Europe, North America, India and Australasia in search of better prospects (Sriskandarajah, 2005). This group of migrants was categorised as *forced migrants* as they were forced to leave their home country due to an internal armed conflict rather than because of economic need or the wish to forge a new life abroad (Jayawardena, 2020; Wayland, 2004). The early migrants were mostly skilled

professionals (Pande, 2017) but later, a large number of conflict-generated people from both communities emigrated. This has led many skilled and talented leave the country:

> There is so much *buddhi galanaya* [2] happening and we are losing. People are talented, that I can guarantee. Technology is borrowed and imported from other countries and the only issue I see is the migration of talented people to other countries.
>
> (Private sector, December 2019)

The post 1983 Tamil emigrants, living in varied countries formed their own networks which became the transnational Sri Lankan diaspora and carried with them and shared among them a collective memory of pain and trauma, and have been building a vision for their homeland (Cheran, 2003). According to Pande, (2017, p.52),

> diasporas tend to develop an ambiguous relationship with the homeland; on the one hand, they develop close social networks to help their co-ethnics and keep alive their hope of being able to return but, on the other hand, most of them start living settled lives by acquiring citizenship in the host countries.

Following on from their initial struggle to establish themselves in the host countries, the Sri Lankan Tamil diaspora have also developed multidimensional linkages that strengthen the nexus between different diaspora settlements across the world and with their erstwhile homeland (Fuglerud, 1999, 2001; Sriskandarajah, 2002, 2005). Their transnational activities and linkages, therefore, not only continue to transform their lives in their host countries, it also has the power to transform the lives of those in their erstwhile homeland (Erdal & Stokke, 2009). Through outperformance in profession and education, the Sri Lankan Tamil diaspora have further developed multidimensional and multinational linkages with governments, investors, donors, research institutions, industries and other global actors in their related professions (Erdal & Stokke, 2009; Fuglerud, 1999). They are well placed to take on the role of drivers of change in their home countries. They have a strong cultural norm valuing education and believe that education is the most worthwhile legacy one can pass on to future generations (Perera, 2001). In particular, the first-generation diaspora, with their strong native bond, cultural links and educational aspirations, have a desire to pay back to their country and its people in

[2] *Buddhi galanaya* refers to brain drain in Sinhala language.

sectors and subjects related to their fields of expertise and more confidently through STEMM[3] education for capacity building:

> Coming from a war-torn country and you have this feeling that you have to pay back to your country and your people. Education is part of our culture. Sentimentally Tamils' commitment to education is such that they will give anything to achieve it. There was a time when everyone wanted to be educated but now, I can see it declining. Education is our driving force. We are hardworking and value education but what we lack is innovation. Norwegians are very good at innovation. I want to instil that skill there. Every person in the diaspora feels the same and they want to contribute and help in their fields.
>
> (Academic, March 2021)

The Sri Lankan Tamil diaspora also plays a significant role in building knowledge capital, knowledge transfer, capacity building, and investments (Cheran, 2003). For example, a Sri Lankan diasporic community in Norway - the *Tromsø Tamil Sangam* in collaboration with the University of Tromsø has helped to establish the Faculty of Medicine in the Eastern University and the Faculty of Fisheries in the UoJ (Cheran, 2003; Pande, 2017). The USA based diaspora are founders of Vannitech in Kilinochchi[4], providing IT training by effectively utilising the expertise and resources available in the diaspora (Cheran, 2003; Pande, 2017). In relation to sustainable energy transition, this is exemplified through the implementation of the GUC

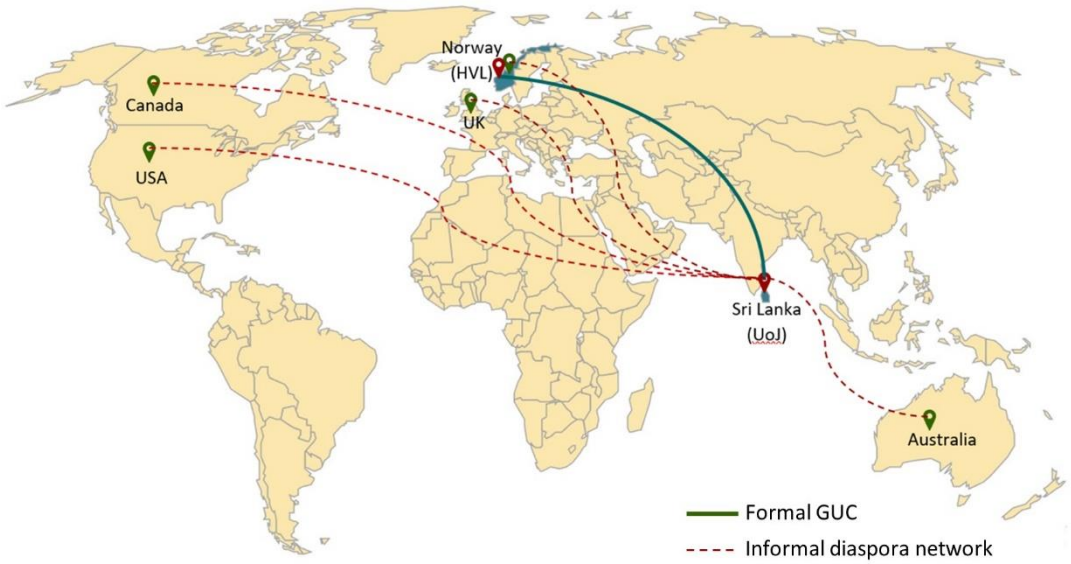



**Figure-2:** GUC between HVL and UoJ

[3] STEMM - Science, Technology, Engineering, Mathematics, and Medicine

[4] A district in the Northern Province in Sri Lanka.

project (Figure-2). Though a collaboration between universities in Norway and Sri Lanka, the capacity-building project on clean energy applications using nanomaterials is not solely limited to researchers from these countries: it also includes like-minded Sri Lankan Tamil researchers from universities globally. This global engagement was evident during the interviews:

> Online lectures are carried out by staff not only from Sri Lanka but also India, Norway, Sweden, the USA, and Germany.
>
> (Academic, March 2021)

These researchers, apart from providing online lectures, also provided mentoring and guidance for students absorbed into the project. This skill and knowledge exchange has helped build a knowledge base and played a role in the emergence and nurturing of a new domestic CET hub in Sri Lanka.

> The diaspora played a very important role in this project. First, they did not have a channel to approach. But through this project, several supported. They provide mentorship, lectures, and coaching. The diaspora engagement is an important channel for capacity building. Contacts and network expansion is through this channel.
>
> (Academic, March 2021)

The diaspora is strong in their belief that their advanced educational background and their local contextual knowledge combined with their professional ties and networking in their host countries, bestows them with the right formula to help their erstwhile country become innovative:

> As a Sri Lankan, our education has given us that strength in my view, having worked with so many nationalities - systematically and methodologically. I am proud to be a Sri Lankan and proud to be a Tamil. So, when you put this methodology together with systematic processes and with the talent and ability as a Sri Lankan, then you create a very successful formula.
>
> (Private sector, November 2020)

Their role is a two-way process. While they help with initiatives based in the homeland, they also share knowledge and ground realities for the development of viable CETs with host countries offering suitable openings for new sustainable partnerships and collaborations. This was exemplified in the case of the floating solar demonstration project:

> Education is kind of the key thing for progress and makes real changes. I am very happy to see this R&D initiative between HVL and [UoJ] Sri Lanka. I think it is good to have this cooperation and this exchange program, it is not like you are learning a lot, but we are learning a lot with you and these are relationships that are carried on into the future. (Private sector, December 2020)

The potential capability and power of diaspora as drivers of change is well illustrated by the GUC project. The case highlights that the diaspora network itself functions as a GIN. The GUC fosters a formal coupling, however the informal network of the diaspora strengthens and sustains the projects. Besides being a catalyst for launching the projects, the diaspora link between their host countries (largely developed) and their developing country helps to bridge the gap to bring about the necessary change contextually. In this case, 'bridging the gap' refers to not just building capacity but importantly it is also about stimulating innovation in the field of nanomaterials and clean energy applications to achieve sustainable energy transition in Sri Lanka.

## 5. **Discussion**

The case illustrates that Sri Lanka is confronted with a state of innovation poverty. This is exemplified by the country's poor score on GII, R&D, GCI, lack of interaction between institutions especially universities and industries and a poor or inadequate workforce competency. Among other reasons innovation poverty is seen as hindering the country's sustainable energy transition process. External funding through grants and loans, though desperately needed, is not the outright solution to raise these countries from innovation poverty and capacity deficiency. Bringing in skills, expertise, and materials from external sources for implementing sustainable energy transition, while acknowledging that they help initiate such projects, may not benefit developing countries in the long term. This case also informs that GUC initiatives could make a difference when innovation poverty is a hindrance factor for progress including in sustainable energy transition.

To overcome innovation poverty, developing countries require initiatives that leads to knowledge building in the domestic higher education and research sectors, as well as in firms and industries. Towards this goal, GUC participants need to productively exploit processes taking advantage of international linkages. As shown by the case, codified knowledge transfer through GUC can enable developing countries to become involved in knowledge sharing to build up and contemporarily upgrade the domestic knowledge and skill base. In short, the GUC project is helping Sri Lanka to gradually uplift its knowledge base and thereby address innovation poverty. The case also illustrates that the transfer of codified knowledge is more effectively performed when academic coupling mechanisms are established with global universities and scholars in a GIN as part of the GUC. This view resonates with that of Binz and Truffer (2017) specifically regarding structural couplings connecting different sub-systems facilitating resource exchange. However, this GUC is not only about the formal coupling between the universities but also about the informal coupling that actually strengthens and sustains this particular GUC. In this case the informal coupling is the Sri Lankan Tamil diaspora.

The case illustrates the diaspora in terms of what a coupling mechanism is supposed to be. An observation not so much discussed in the transition literature is how the diaspora has come to be viewed as an informal actor network in GIN, one that facilitates domestic knowledge and capacity building by functioning as contextual partners of a coupling mechanism. The GUC gain further credence in that it was initiated by the diaspora possessing the experiential knowledge of existing gaps for innovation in their erstwhile country and being able to activate their native links to carry through a mutually planned and agreed bottom-up process of building the knowledge base and capacity building. GUC project was possibly able to achieve what they did because the Sri Lankan Tamil diaspora involved were the first generation with their ambitions linked with their expectation and drive for education as the key factor for bringing about innovative changes. This aspect makes this exemplified diaspora coupling contextual and possess the near-perfect attributes to uplift the knowledge base of their home country in order for Sri Lanka to equally obtain benefits and competence through the available global networks. These qualitative attributes would be missing if the developed country frameworks were applied directly via an external body with no contextual experience, knowledge, or contacts to successfully bring about enduring developments including sustainable energy transition in cash strapped developing countries. Since its initiation, this supportive diaspora has gradually

expanded their network globally, to bring in investors, educators, scholars, and mentors as highlighted above, thus sustaining the focus on overcoming the innovation poverty gradually but steadily and in a contextual way.

The approaches in GIN studies do not give much focus on the role of informal networks such as diaspora in shaping and transforming local innovation environments particularly through human mobility (Mahroum & De Guchteneire, 2006) and capacity building. The diaspora, within a coupling mechanism, gives an additional edge to the exchange and absorption of globally and freely available knowledge in a contextually appropriate way. In contrast to their tangible investments, their intangible investments (e.g., building knowledge capital, knowledge transfer, capacity building through educational aspirations) remain below the radar. It is reasonable to point out that, without couplings with global innovation and knowledge networks, countries like Sri Lanka will have difficulty overcoming innovation poverty by addressing its specific challenges to achieve sustainable energy transition since its own capacity to grow through local and regional networking is limited. Thus, the diaspora communities, as key informal actors in the GIN, represents an inexpensive source of networking and knowledge transfer to their former countries. Besides facilitating the transfer of codified knowledge, the diaspora coupling also brings with it contextual tacit knowledge which is difficult to transfer. Thus, the study shows how academics sharing knowledge by way of international informal networks, mobility programmes such as international conferences for example, and collaborative activities and projects could facilitate spread of global knowledge to local and regional actors leading to significant and positive impact on the domestic innovation process (Benneworth & Fitjar, 2019; Trippl, 2013).

## 6. Conclusion

Returning to the question of *how sustainability transitions can be mobilised through global university cooperation in the context of innovation poverty*, this study underlines the importance of accounting for contextual circumstances when facilitating sustainable energy transition in developing countries through GUC.

GUC initiatives can assist developing countries to improve the state of innovation poverty through knowledge exchange. Applying a GIN perspective in the GUC case, we find that the diaspora community of Sri Lankan Tamils has been playing an important role in the GUC project, supporting it through many fronts including educational, financial, business, and

mentoring. We argue that by taking advantage of informal networks, such as a diaspora as a coupling mechanism fundamental change can be brought about in developing countries that could improve the prospects of overcoming innovation poverty. The case indicates that structural couplings can be strengthened through informal networks and adds diaspora's contribution to literature.

In addition, research on sustainable energy transitions in many developing countries necessitates the need to be theorised taking into account contextual circumstances such as innovation poverty and available and accessible informal contextual networks. Innovation system research not only looks at innovation as science and technology, it also looks at learning, innovation and competence building at different levels of innovation capacity (Lundvall, 2008). For countries like Sri Lanka, establishing such a system and the process starts from a very low base. The GUC project and the diaspora or similar informal GIN are therefore suitable additions to the existing systems stockpile to bring about sustainable energy transitions under defined circumstances.

This chapter has its limitations as it draws evidence for this paper solely from the specific case of HRNCET and CBERC. In other cases diaspora may not function in a similar capacity as actors within or facilitators of a coupling mechanism. Nevertheless, this case shows that the coupling mechanism can be strengthened through informal networks and adds diaspora contribution to the literature.

**Acknowledgement**

This paper was supported by the Capacity Building and Establishment of Research Consortium (CBERC) project funded by the Royal Norwegian Embassy in Colombo, Sri Lanka.

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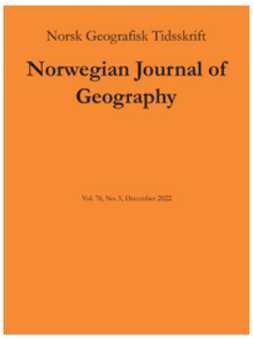


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Norsk Geografisk Tidsskrift - Norwegian Journal of Geography

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/sgeo20

# Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector

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**To cite this article:** Nanthini Nagarajah (2022): Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector, Norsk Geografisk Tidsskrift - Norwegian Journal of Geography, DOI: 10.1080/00291951.2022.2136108

**To link to this article:** https://doi.org/10.1080/00291951.2022.2136108



Published online: 08 Nov 2022.

**Norsk Geografisk Tidsskrift–Norwegian Journal of Geography**
https://doi.org/10.1080/00291951.2022.2136108



# Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector

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**ABSTRACT**

Global efforts towards sustainable energy transition remain uneven. Developing countries are embedded in a vulnerable setting requiring rapid but responsible action to meet increasing energy demands due to their specific projected economic and population growth. Consequently, such countries have addressed the challenges of achieving sustainable energy transition differently compared with developed countries with regard to renewable energy development and its governance. Theories of sustainability transition and responsible innovation (RI) have their origin in developed countries, and the application of this Western-centric version has been found incompatible with the contexts of developing countries. The aim of the paper is to explore how contextual understandings of RI are discursively constructed and how such understandings enable or constrain sustainable energy pathways in developing countries. The author draws on empirical evidence relating to the power sector in Sri Lanka and analyses three narratives in play revealed by a qualitative case study. The findings indicate that developing countries must place greater emphasis on aligning technological innovation systems with RI in efforts to achieve sustainability transitions by being vigilant with regard to contextual narratives on RI. The author concludes that prevalent narratives should be regarded as a bridge for linking sustainability transitions to RI.

**ARTICLE HISTORY**
Received 24 January 2022
Accepted 7 October 2022

**EDITORS**
Marte Solheim, Catriona Turner

**KEYWORDS**
narratives in play, renewable energy, responsible innovation, Sri Lanka, sustainability transition

Nagarajah, N. 2022. Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector. *Norsk Geografisk Tidsskrift–Norwegian Journal of Geography* Vol. 00, 00–00. ISSN 0029-1951.

## Introduction

Research, innovation, and investments are vital for our efforts to respond to climate changes. The efforts have to be global, too, to bring about rapid radical structural transformation by employing low-carbon technologies (Gül 2020). In this global effort, developing countries have shown slower progress in their transition process as a result of them being embedded in more vulnerable settings with economic constraints, survival priorities, and inadequate and restrictive governance mechanisms (Walsh & Hallegate 2019; Saculsan & Mori 2020). However, they need rapid production of energy to meet their increasing energy demands arising from projected economic and population growths and priorities (OECD & International Energy Agency 2011).

The literature on sustainability transition, with its roots in the Western context, presents analytical frameworks that conceptualise sustainability transition as major structural changes. Authors advocate a shift to a new system requiring systematic long-term co-evolutionary processes with the involvement of many actors and sectors, leading to fundamental restructuring of production and consumption in societies (Farla et al. 2012). Two examples of such analytical frameworks are the multilevel perspective (MLP) (Geels 2002) and the technological innovation system (TIS) (Hekkert et al. 2007; Bergek et al. 2008). Scholars have also emphasised the need to expand the geographical scope of sustainability transition research to gain a richer understanding of how transitions unfold across different geographical contexts and the reasons

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why transition successes and failures are context-dependent (Lachman 2013; Herman 2021; Wang & Lo 2021) by calling for more sophisticated empirical research and appropriate analytical frameworks for developing countries (Sovacool 2014; Wang & Lo 2021).

Responsible innovation (RI) is a Western-centric construct. RI emphasises the ethical and societal benefits of making innovation more responsible (Macnaghten et al. 2014). In RI, the public, political processes, and institutions are routinely and systematically attentive to and responsible for political and social aspects, while also addressing institutionally defined priorities, values, and concerns (Owen & Pansera 2019; Owen et al. 2021). The effectiveness of directly transposing such a Western-centric approach to the Global South cannot and should not be taken for granted (Macnaghten et al. 2014). Countries in the Global South have different sets of debates centred on their own needs and priorities, their contexts differ from those in the Western world, and they rely on external support for technologies, innovations, and investments to enable transitions (Theiventhran 2022), thus making innovations in sustainability transition new to their place rather than radical innovations (Edsand 2019). Furthermore, countries in the Global South differ from those in the Global North with regard to their institutional architecture, energy trajectories, sociotechnical order, governance, and approaches to sustainability transitions (Macnaghten et al. 2014). Given the focus on sustainability transition in this paper, the word 'responsible' is applied to include a collective duty to give consideration to potential impacts when introducing renewable technology, such as for the supply and distribution elements comprising accessible, affordable, and reliable energy.

When introducing and expanding new technologies to a country, engaged stakeholders significantly influence the decision-making process, which means their views, perceptions, and actions regarding innovation and energy trajectories are decisive for policy decisions (Reusswig et al. 2018; Komendantova 2021). It is therefore necessary to understand existing tensions between different narratives within the energy sector that influence the energy trajectory. The term 'narratives in play', which was introduced by Fløysand & Jakobsen (2017), is used in this paper because it relates to existing and emerging discourses that influence stakeholders' behaviours, actions, decision-making processes, investment decisions by firms, and ultimately innovation and the energy trajectory of a country.

This paper focuses on developing countries or, more broadly, the Global South (the non-Western nations). I question the current dominant Western-centric discourse and its global approach to addressing climate change and facilitating sustainability transitions. Greater emphasis should be placed on aligning a TIS with RI in efforts to achieve sustainability transition that befits the specific context of developing nations. The empirical evidence required to substantiate this link is drawn from an investigation of the power sector in Sri Lanka.

Sri Lanka, with its commitment to becoming carbon-neutral by 2050, is yet to achieve its distribution elements. Among other reasons, there is dissonance between the country's acceptance of the necessity to invite private investment for clean energy transition and the offer of a suitable environment for rapid and successful investment through investor-friendly pathways, processes, and governance (World Bank 2019), which could expedite the process. I answer the following research question: *How is RI understood in processes of sustainable energy transition in Sri Lanka, and how does this understanding inform sustainability transition theory?*

I first describe the theoretical underpinnings of the study on which this paper is based by elaborating how sustainability transition and RI can be made more context-sensitive by aligning them with narratives in play. Thereafter, I outline the methodological choices and considerations. In the empirical section, the narratives in play are evinced through three different contested narratives that emerged from interviews with groups of key stakeholders. Following a discussion of the findings from the qualitative case study, I present my main conclusions.

## Theoretical framework

### *Sustainability transition*

Global effort is required to expand research geographically in order to capture the different microlevel nuances involved in shaping energy transitions. The literature on sustainability transitions, which has its roots in the Western context, presents theoretical frameworks conceptualising long-term energy transition governed through radical transformation in existing carbon-intense systems. The most widely used analytical frameworks are the multilevel perspective (MLP) (Geels 2002) and the technological innovation system (TIS) (Hekkert et al. 2007; Bergek et al. 2008).

Innovation, whether heralding radical change to the world or bringing existing technology or practices to new locations, is held to be the cornerstone of sustainable change (Markard & Truffer 2008). Furthermore, sustainability transition studies consider that mature

and stable old technologies have been at the centre of analyses, even though novel technologies capture the focus of sustainability transitions (Markard & Truffer 2008). The TIS framework, which is centred on technology, has been used to study long-term technological change and is often applicable across geographical boundaries (Hekkert et al. 2007). It also focuses on the following: the interaction between actors, institutions and networks; the interplay between seven key functions of an innovation system described in detail by Hekkert et al. (2007) and Bergek et al. (2008); and the diffusion and use of established technologies (Markard & Truffer 2008), which is the case in developing countries. Importantly, a TIS also involves framing, lobbying, and legitimising technology, both attracting support for it by states with conducive policies and enabling engaged stakeholders to succeed in attracting further investment (Njøs et al. 2020). Despite being criticised as being too inward-looking and paying less attention to contexts (Markard & Truffer 2008, 610), I nevertheless consider the TIS framework appropriate for this study of a developing country in light of the above-mentioned attributes.

Technology for sustainability transition needs to be developed within the appropriate context in order to bring about discernible and beneficial changes that are acceptable to society. However, Hekkert et al. (2007) note that the focus on innovation systems is primarily on analysing the speed and direction in bringing about technological change, and the activities that foster or hamper innovation. Thus, such an approach neglects the contextual distinction and inadequately prioritises a responsible two-way communicating process between the technology and the context.

In this paper, I regard context as a 'setting' moulded by political, economic, social, cultural, and environmental structures; hence, the context is embedded within these contextual complexities. Decision-makers and implementors respond and give credence to such complexities by being responsible and accountable, ensuring that the complexities are taken into account, while also being conscious of not triggering new inequalities and injustices (Wang & Lo 2021) when employing either new or relatively new technologies. Thus, to be responsible, innovations and technologies are developed by taking into consideration that the individual country context is important, but they also need to inspire the trust of private, public, academic, and society actors through appropriate dialogue, negotiations, and expositions. Furthermore, technological development means that the new technologies must be sustainably built in a responsible manner and resilient for the long-term.

Carlsson & Stankiewicz (1991, 111, original emphasis) define a technological system 'as a network of agents interacting in a *specific economic/industrial area* under a particular *institutional infrastructure* or set of infrastructures and involved in the generation, diffusion, and utilisation of technology'. The functionality and effectiveness of technological change involving a TIS can be measured through the seven functions of an innovation system that consists of both individual and collective actions (Hekkert et al. 2007; Bergek et al. 2008). As TISs in developing countries has focused on the formative stage of innovation and been mainly influenced by the exogenous contextual factors affecting the absorption, growth, and diffusion of those TISs, wider contextual analysis is required than has hitherto been done (Edsand 2019). For developing countries that leapfrog with imported technology, functionality is about understanding the capability of the country to receive the technology successfully (Edsand 2019). Additionally, they need to attract entrepreneurs and investors to bring in and legitimise the technology in order for the technology to grow and diffuse. Two among the seven TIS functions described by Hekkert et al. (2007) and Bergek et al. (2008), *entrepreneurial activities* and *legitimisation* play key roles in the absorption and growth of a technology in a developing country. *Entrepreneurial activities* involve the crucial role entrepreneurs play in developing an innovation system by bringing in technology though market opportunities. Through societal support, *legitimisation* helps to achieve broad acceptance and compliance with relevant institutions (formal and informal rules), government, research, and industry actors. Therefore, it is vital to conceptualise how a technology is absorbed and placed within the context of a developing country characterised by its intricate social, economic, political, and cultural factors, while also giving consideration to the mechanisms that hinder its progress. The relationship between both technology and innovation and the contextual environment can be challenging. Consequently, the innovation process has to be an interactive, reflexive, and transparent operation with a conciliation mechanism. Njøs et al. (2020) highlights the existing gap in TIS literature as the failure to engage sufficiently with narratives to understand the dynamic interplay between the different functions of TISs. The aim of this paper is to fill this gap by engaging with the narratives in order to gain a better understanding of the context of responsible absorption of technology.

## Responsible innovation as a topic of discourse

The responsible innovation (RI) policy discourse emphasises the importance of aligning research and innovation to the values, needs, and expectations of

society and ensuring sensitivity to societal values in innovation process (Owen et al. 2021; Stahl et al. 2021; Rödl et al. 2022). The discourse also underlines the need to anticipate both positive and negative societal impacts of innovation and to take actions to mitigate the latter in an ethically acceptable and socially desirable way (von Schomberg 2013; Macnaghten et al. 2014; Fløysand et al. 2021). The purpose of RI is to create spaces for discussions of aspects of innovation that are of public interest or concern, with the aim of 'taking care of the future through collective stewardship of science and innovation in the present' (Stilgoe et al. 2013, 1570). Therefore, by advocating 'forward-looking approaches, methods and frames of reference for reflecting on the societal impact of research and innovation' (Fløysand et al. 2021, 3), RI can be considered a topic of discourse. For example, the governance of emerging technologies has been placed at the core of RI, thereby emphasising the inclusion and participation of all affected stakeholders (government, academia, industry, civil society) of innovation and having a collective responsibility to reflect more appropriately on the values and interests of the wider group of actors instead of only promoting the technology per se (Vasen 2017). The RI discourse also highlights that the dissemination and social appropriateness of emerging and mature technologies are not solely about the economic dimension; importantly, they include the appropriate placement of the technologies within all sectors of society (Vasen 2017). Therefore, RI not only attempts to understand the complexities of the contexts in which innovation occurs, but also acts as a 'double feedback loop' to inform those responsible for innovation and technology about the most responsible way to proceed, given the fact that societal aspects always exist in the context and that those contextual underpinnings need to be explored and absorbed.

Scholars have cautioned that RI frameworks focus mainly on emerging technologies, based on a European set of institutionally defined priorities, values, and concerns (Macnaghten et al. 2014; Vasen 2017). Notably, the risks, uncertainties, unintended consequences, and challenges of aligning technology with societal expectations are not limited to emerging technologies. They also exist for proven and mature technologies that are new in a place. These barriers are more conspicuous in the context of developing countries, where technologies are imported from elsewhere and allied investors and developers are typically uninformed about such barriers to the successful absorption, maintenance, and adoption of technology change, as well as societal expectations concerning acceptance. These requisite factors remain relatively unexplored. The RI discourse and its functionality as a double feedback loop help understand real world complexities and to inform and negotiate societal expectations with the technology developers and stakeholders as to how well the technology can be absorbed and placed within a given society.

Thus, the RI discourse needs to be translated beyond the Global North by engaging with the Global South to achieve suitable, bespoke frameworks that befit the nuances of the geographical context in question (Macnaghten et al. 2014; Vasen 2017). Such an outcome depends on dialogue between the Western-centric approaches and the sustainability transition agenda of developing countries, especially to align with United Nations Sustainable Development Goal 7: 'Ensure access to affordable, reliable, sustainable and modern energy for all' (United Nations n.d). Through such dialogue and outcomes, the differentiated needs and the significant heterogeneity of such countries could be addressed.

## *Narratives in play*

There has been limited research to date to achieve a link between TIS and RI frameworks. Also, the way that innovation systems' structures and functions can be reconfigured remains unexplored (Owen & Pansera 2019). In this paper I attempt to show that fusion between the TIS and RI frameworks is important and that narratives in play can be the link to achieve such fusion (Fig. 1).

Enriching TIS through RI necessarily involves engaging and acknowledging the narratives that inform an understanding of the existing tensions among stakeholders in moving towards a sustainable energy pathway. However, RI norms and values are not explicitly visible in the actions of key stakeholders but are often reflected or implied through their claims and statements related to what they perceive as the right energy pathway for their country. Thus. it is important to understand the narratives used by key stakeholders and the established deep-rooted practices that influence innovation processes in countries. Such prevalent narratives, rules, and practices may influence and even undermine and/or dominate innovation and technology development, in turn leading to a particular energy technology to be absorbed and accepted, while overriding stakeholders with other


**Fig. 1.** Centrality of narratives in the link between sustainability transition and responsible innovation.

justified and legitimate but conflicting and contesting details and facts.

Analysing narrative in play and absorbing their meanings through engagement in discourse can help us to understand how contextual factors impact RI for sustainability transition, as shown in Fig. 1. Discourse is seen as a structure for producing shared meaning related to a phenomenon that shapes the perceptions and practices of people, whereas narratives are specific perceptions or modes of explanation promoted by an actor or group of actors within a particular discourse (Fløysand et al. 2021, 4). Thus, a discourse is built on the back of many narratives. The use of narratives in energy transition to achieve a low-carbon future is expanding (Veland et al. 2018). However, competing multiple narratives within debates create tension, leading to narratives by powerful stakeholders dominating, influencing, and/or reinforcing a nation's energy pathway and precipitating path-dependency.

## Methodology

This article is based on a qualitative study in which a case study approach was adopted, with an exploratory and descriptive research design focusing on the Sri Lankan power sector. Data collection was done using semi-structured interviews, document reviews, and participant observation. Interviews were held with stakeholders engaged in the Sri Lankan power sector in the following categories: public sector, private sector, and academics and experts specialising in energy.

Initially, potential Sri Lankan key informants for the interviews were identified via local media channels, and one potential interviewee was identified at an international conference on renewable energy held in Sri Lanka, which I attended in February 2019. Thereafter, I used snowball sampling to find more stakeholders to interview. A total of 41 interviews were held: 14 with public sector stakeholders, 15 with private sector stakeholders, and 12 with academics and energy experts. Of the 41 interviews, 29 were face-to-face interviews conducted during the fieldwork in Sri Lanka from November 2019 to February 2020 (i.e. four months in total). Due to travel restrictions relating to the COVID-19 pandemic, 10 interviews were conducted online via Zoom meetings and 2 through email exchanges from Norway during the period August 2020 and March 2021. I am a member of a research collaboration project between Norway and Sri Lanka, which consists of Norwegian academic and industrial partners: Capacity Building and Establishment of a Research Consortium (CBERC). The project is run jointly by the Western Norway University of Applied Sciences and the University of Jaffna, Sri Lanka, and is funded by the Royal Norwegian Embassy in Colombo, Sri Lanka; the project period is 2017–2022. A total of 10 Norwegian stakeholders were identified through both the collaboration and networking. Interviews were held with Norwegian stakeholders in only two of the three categories, namely the private sector, and academics and energy experts.

Each interview lasted 15–120 minutes and covered questions relating to the study objectives, as well as to the energy sector, governance, commitments towards renewables, opportunities, barriers, and the way forward in Sri Lanka. All interviews except three were voice recorded and then simultaneously transcribed and translated from the local languages into English. Document reviews were conducted of strategic documents from the Asian Development Bank, the World Bank, and the United Nations, as well as annual and evaluation reports, plans, newspaper articles, government institution reports, and websites that all related to Sri Lanka. Additionally, during the fieldwork, participant observation during three site visits (coal power plant, floating solar launch, and off-grid hybrid power plant), as well as participation in two conferences and one talk, all of which related to renewable energy development in the country, provided insights into the complexities of implementing different energy technologies in Sri Lanka. The fieldwork in Sri Lanka was stopped when no new data or no new themes emerged, meaning data saturation had been reached (Fusch & Ness 2015).

As the study focused on narrative analysis, the stakeholder's commonalities in arguments and claims were built into three different narratives for analysis and discussion. The document sources were initially used to understand the energy sector and the related challenges and subsequently to validate the interviews. When going through the interview recordings and transcripts and between documents and interviews, the process was iterative. However, in the absence of sufficient or updated information in existing documents, the analysis relied on interviewees' claims and observations.

## Narratives in play in the power sector in Sri Lanka

### *The Sri Lankan power sector*

Sri Lanka is a signatory to the Paris Agreement (United Nations Framework Convention on Climate Change n.d.) with a commitment to achieve carbon neutrality by 2050 (Presidential Expert Committee 2019). Compared with other South Asian countries, Sri Lanka remains relatively better off in terms of electric energy access. In 2016, 99.3% of the Sri Lankan population

had access to electricity from the national grid, with a per capita electricity consumption of 651.8 kWh per annum (Central Bank of Sri Lanka 2020). In 2019, the country's population was 21.8 million, and as the country covered 65,610 $km^2$, its population density was 350 per $km^2$ (Central Bank of Sri Lanka 2020). The island has a tropical climate, which is influenced by monsoon winds.

As an island nation, Sri Lanka has a small isolated electric grid, a night peak load, and a localised energy system to manage its domestic power production and consumption. The geo-climatic setting of the island is particularly conducive to harnessing its indigenous energy sources of biomass, hydro, solar, and wind power, yet the country remains totally dependent on imported coal and oil for power generation, which strains the country's foreign exchange reserves. The electricity generation mix consists of 36.6% coal, 26.6% oil, 24.9% hydro, and 11.9% from non-conventional renewable sources (Central Bank of Sri Lanka 2020, 80). Electricity demand is projected to increase by 4.9% annually (Ceylon Electricity Board 2019).

The history of Sri Lanka's power generation dates back to the British colonial period when mini hydropower fulfilled the energy requirement for motive power and in-house lighting for the large-scale tea factories. Hydropower, which was then the only indigenous energy source, accounted for the largest share of electricity generation through major hydropower projects until 1996, when the electricity sector switched from a predominately hydropower system to a mixed hydro-thermal power system. The accelerated electricity demand, in tandem with rapid economic growth and severe droughts, led to capacity additions with thermal power plants as the potential of nation's hydropower resource diminished. Initially, the then state-owned Ceylon[1] Electricity Board (CEB) was the sole entity engaged in power generation, transmission, and distribution until 1996, when private sector investors were commissioned to build, own, and operate small power plants to generate renewable energy and sell it to the sole buyer (CEB) with a feed-in-tariff. Portfolio diversification in energy supplies provided opportunities for local and global investors and developers to promote renewable energy technologies, particularly solar and wind. Faced with capacity shortage, the country has recently commissioned new technology power plants (Asian Development Bank 2019).

Historically, public financing paid the CEB for the purchase of power plants. By contrast, non-conventional renewable sources, including wind and solar power, are typically financed through either private sector participation or international financing (World Bank 2019).

## The narratives on sustainability transition

The Sri Lankan power sector trajectory towards sustainability transition is a contested phenomenon. Based on the interviewees' statements, these contestations can be interpreted as three different narratives in play:

1. The *policymaker-centric sustainable energy development narrative*, which highlights that Sri Lanka's sustainable energy development is about providing affordable and reliable power supply, and requiring fossil fuel to play a key role in the power sector trajectory.
2. The *professional-centric sustainable energy development narrative*, which calls for a timely shift to exploit the island's abundant sources of solar and wind power with the assistance of foreign and local capacities and resources, but which identifies the vital need for knowledge incorporation.
3. The *investor-centric sustainable technology development narrative*, which emanates from investors and developers.

The energy sector's conundrum is related to the direction of movement (trajectory) towards renewables. This is unveiled by the first two well-established narratives (i.e. policymaker-centric and professional-centric), which fundamentally influence meanings and understandings of the concepts 'responsible' and 'sustainable' in the minds of interested parties. The policymaker-centric narrative has a narrower and simpler understanding of 'responsible' and 'sustainable' as providing affordable access and uninterrupted power supply to power the nation and its economic growth, continuing with the major contribution from fossil fuel in the energy mix. The professional-centric narrative, which interlinks with global scientific knowledge and community, places greater emphasis on the concepts of 'responsible' and 'sustainable' by including long-term accountability. It sets out to achieve the same outcome as asserted by the policymaker-centric narrative, but advocates achieving it by also legitimising and earnestly exploiting available ample domestic resources that promote environmentally friendly renewables and the building of local capacities through a policy of 'investing now for future dividends'.

The views of the different stakeholders were not limited to a committed narrative but were interlaced with the acknowledged need for interim steps for immediate access:

[1]In 1972, Ceylon became the Republic of Sri Lanka.

> As a citizen of the country, I believe people should be first given access to electricity, whether it be from coal or otherwise. When we reach that level, we can think of renewables. (Energy expert, 2019)

The policymaker-centric and professional-centric narratives continue to exist without much conciliation between them, and therefore progress to establish a working power sector trajectory has been held back.

The investor-centric narrative emanates from Norwegian private firms with technological know-how and expertise. They had responded to calls to exploit abundantly available opportunities for renewable alternatives aimed at investment dividends and firm development. Thus, their narratives are centred on energy governance, policy pathways to investments, and resources.

## Sustainability transition and the RI discourse

While the three narratives influence and affect the trajectory of the power sector in Sri Lanka, the interviewees' statements also helped identify contextual issues affecting the sustainability transition process and RI practices within it. The empirical evidence provided by the interviewees were categorised as follows: (1) access to and limitations of low-carbon technology; (2) resources to absorb low-carbon technologies; (3) power sector governance; and (4) investment for low-carbon solutions. However, there was considerable overlap between the four categories.

### Access to and limitations of low-carbon technology

While many of the interviewees' adverse reactions to renewables generally related to technical limitations (e.g. seasonally related fluctuations in power generation, with wind and solar power limiting reliability and dependability), they also disclosed specific contextual limitations. Sri Lanka currently receives one-third of its power from fluctuating generation sources, including hydropower and other renewables. This context confers the sense of a barrier, due to the need to additional reliance on renewable technologies that are affected by seasonal changes in the weather. One interviewee explained the issue as follows:

> Being a small country, the small power sector can create certain instability in the network. Because of that, there is reluctance to connect more renewables as they are intermittent. The storage options are there, but expensive and again the financial constraint. (Public sector employee, 2019)

For a financially constrained country, which opts for least-cost options even in its long-term planning (Ceylon Electricity Board 2021), the capacity for taking costly mitigating steps to secure grid stability such as storage was considered unrealistic and impractical:

> We are government-owned and going with breakeven without profit. We can't run at a loss. Therefore, we are going with the least-cost options. When you are promoting renewables, these technical barriers have additional cost. (Public sector employee, 2020)

An energy expert with long engagement in the Sri Lankan power sector said that 'renewables mean trouble because of reliability' and recounted his experience:

> Before 1995, we had 100% hydropower except one oil plant, and this even now gives blackouts. If rains don't come, then no option. With a growing economy, you can't have that sort of uncertainty. (Energy expert, 2020)

The expert highlighted that coal and thermal plants were needed as backup power plants due to frequent and prolonged drought conditions, which affected hydropower generation (i.e. green energy). The cost of solutions, including hiring diesel power plants during such periods, are levied from customers (Presidential Expert Committee 2019), and the energy expert feared that additional costs to consumers would continue with renewable energy generating technologies. However, those with a professional-centric narrative countered such arguments by pointing to the high potential for achieving grid stability through an integration process with wind and solar power:

> The Northern Province has a capacity to harness 3000 MW of wind power. Also, solar power has a good potential in this province and if we integrate and have a hybrid unit with wind and solar power, our reliability will be high. Both have their disadvantages and advantages but if we integrate them, we have good potential. (Academic, 2019)

The academic's view was supported by another interviewee:

> Our total peak demand is 2400 MW. In Poonakary and Mannar[2] we have huge potential to generate from renewable sources. We will be able to meet today's demand and the demand of the future through solar power, wind power, and traditional hydropower, and the option is cheap. (Public sector employee, 2019)

### Resources to absorb low-carbon technologies

Human and financial resources, or the lack of them, were major issues concerning sustainability transitions in which unfamiliar technologies were used:

[2]Poonakary village and Mannar town are both in the Northern Province in Sri Lanka.

> Renewable energy technology integration is a new subject to us. So, the engineers in the planning branch have to develop their capacities in the use of new technology. That is not happening. There is no policy for training. (Public sector employee, 2020)

Despite the fact that technologies have been evolving over many years, and that both the literature about them and the outcomes achieved by other countries using such technologies are readily accessible, such resources have not been accessed and used by the energy sector in Sri Lanka, thus indicating inadequacy in the prevailing system:

> In terms of talent, Sri Lanka has that, but using it and creating a value addition is what we need. (Public sector employee, 2020)

A large number of engineers graduate annually, yet their skills and knowledge, as well as those of academics and researchers, have been inadequately exploited to bring about a positive outcome through integration, consultation, and incorporation within policy development, planning, research and implementation of nationally agreed projects to help achieve sustainable energy transition in a responsible manner. In reflecting on immature governance, institutional limitations, and system flaws, one interviewed opined as follows:

> Academics can do a lot, but academics are not consulted by the policymakers. They undermine the skills of academia. I don't think academics can do much in the country. In Sri Lanka, decisions by policymakers are made based on their own views or the views of the people around them. (Academic, 2019)

The resultant loss of talent, in particular high-end human resources, to other countries was not only highlighted by Sri Lankan stakeholders but also pointed out by foreign experts in the energy sector as a major barrier to industry development:

> I see a lot of brain capacity leaving the country. So, then I ask them [scholars], why are you leaving? There is no future. Because you need to be politically connected to move up in the system. This is, of course, extremely discouraging and it is difficult to build something that can last, that is sustainable. (Norwegian private investor, 2020)

Some public sector interviewees also pointed to the non-applicable nature of reports submitted by foreign consultants on integration plans to take forward sustainable energy transition:

> When we did the integration plan, since we didn't know the subject, we engaged some [foreign] consultants. They did the studies and gave some recommendations. What they proposed was not practical for Sri Lanka. (Public sector employee, 2020)

The quotation further illustrates that the resources, which include technical expertise, cannot simply be transferred: they need to be modified according to the context.

### *Power-sector governance*

The power-sector governance factor pervaded through and was identified within all the contextual categories in the empirical evidence. Stakeholders promoting *the professional-centric* and the *investor-centric* narratives in particular regarded the power-sector governance in Sri Lanka as immature and as impeding entrepreneurial activities and the legitimisation process. Despite having large potential for renewable energy, as supported by the interviewees' responses, Sri Lanka's efforts to take and use available opportunities and incentives have been very limited. Lack of leadership within energy governance was described as follows:

> Sri Lanka's national policies are generally dormant documents. These policies are generally used by the researchers and the presenters to say that this is what it is, and we hardly see the policies being met or implemented. There are certain principles, strategies, and milestones. These are not seriously followed. (Energy expert, 2019)

Other mentioned barriers that the power sector needed to reflect upon and reform in order to build a responsible framework for sustainability were scant progress in workstreams requiring serious action, lack of or disconnection between policy, planning, and implementation, and mismatches between declarations and practice. A perceived need for a responsible policy framework was shared by the interviewees:

> If the government is declaring a [renewable energy] policy, then there is a policy target [and] there is a policy cost, and that policy cost should be given to the utility that is implementing that [policy]. That is not happening here. (Public sector employee, 2020)

Above all, the interviewees revealed system flaws, such as the non-existence of a structure or the energy governance system being manipulative and politicised for individual gains rather than for national gains, which one academic termed 'mandatory sponsorship', meaning that practice was systematised. The system and governance flaws have huge impacts on renewables in terms of them gaining a foothold in the country, particularly when that is dependant on foreign investment. This was evident from the perception of one interviewee:

> There is no system and systematic approach to doing projects. There is so much corruption. There should be [a] strong political will. Imagine a foreign investor. It is difficult. (Public sector employee, 2020)

Foreign and established investment firms are used to functioning within an integrated framework involving government, researchers, and private sector stakeholders with defined policies, regulations, and directionality. However, when looking for investment opportunities and expecting a similar investment milieu in Sri Lanka, they have found that the situation is more complex, conflicting, and incompatible with RI because it is less inclusive and less transparent, there is a lack of firm policies; the returns on investments are dismal, and there are manipulative and unproductive practices:

> There is a lack of transparency and actual knowledge sharing. We have to know that the money will be paid back and [we] cannot risk that[it will not be paid back], but if those things are in place, it will be of huge interest for developers. Make very sure that there is no sort of corruption in the system. (Norwegian private investor, 2021)

The overall impact of the adverse governance factors is on credibility:

> The government needs to make changes in regulations, policies and so forth. Only action will give evidence that they do as they say, and not say and do something different. It is about credibility. (Norwegian private investor, 2020)

### *Investment in low-carbon solutions*

Norway has a long-standing legacy of economic and technology cooperation with Sri Lanka. Thus, the empirical evidence related to influencing factors in renewable investment was drawn from Norwegian private investors. Norwegian firms see huge openings in the renewable resources markets in Sri Lanka, especially solar power, but have found the existing policy framework less conducive for market entry:

> The sunshine in Sri Lanka is one of the best in Asia and it [the sunshine] is perfect, everything is there, but it is a matter of opening up from the political side. I think the private industry is fully capable and the market is large. Also, they would like to go for bigger projects, but that is not happening. So, involving the private industry on a larger scale, and giving them a more relaxed framework to work under will be very positive. It would be a lot easier to involve academia and research in the development [of renewable energy]. (Norwegian private investor, 2020)

Investors' expectations for profitable investment in renewable energy were not being met, partly due to restrictive offers:

> We are not only looking to be an equipment supplier, but also to own and operate power plants, selling power. To attract investment, to make things happen, is to have a transparent system of doing the bids. (Norwegian private investor, 2021)

Norwegian investors found engagement with policymakers and the energy governance system in Sri Lanka unpleasant and convoluted:

> We tried, through various angles, to get into Sri Lankan renewable markets, but it all made it impossible due to their [Sri Lankan's] view on letting renewables compete into the market, [which] made it extremely difficult and [they] more or less sabotaged foreign private initiatives to get in. (Norwegian private investor, 2020)

A high-level barrier experienced by the Norwegian investors was the lack of policies, processes, and skill sets in the energy sector, which hindered and discouraged a business environment for private investors, and revealed governance and institutional limitations:

> From the investor's viewpoint, we look at the process, and skill set. They don't have a policy in place, don't have regulations in place, [and] don't have standardisation. (Norwegian private investor, 2020)

Foreign investors were further discouraged by the lack of set tariffs and returns on investments, due to the high-risk, widely fluctuating local currency:

> In terms of foreign investments, we don't have a set tariff. If someone secure a [piece of] land to do a 10 MW project, there is no published area. Foreign investors have to realise that they are going to have it in Rupees and cents, and not many are going to be excited by that. (Private sector representative, 2019)

To summarise, the three narratives and the interconnected contextual aspects characterise and highlight the barriers, tensions, and the immature energy governance pertaining to RI for sustainability transition in Sri Lanka.

## Discussion

The aim of this paper is to explore the narratives related to sustainable energy transition in the Sri Lankan power sector and to discuss how this case can inform the broader literature on RI and sustainability transition in the context of a developing country. Furthermore, this paper offers a framework (Fig. 1) to comprehend sustainability transition and RI through narratives in play related to the absorption of low-carbon technology into the Sri Lankan power grid. Although stakeholders in the country's sustainable energy transition have a collective vision to move towards a sustainable pathway, their claims and perceptions of a responsible pathway towards achieving it are contested. This is expressed through two co-existing narratives: the *policymaker-centric narrative*, in which it is argued that assurance

of distribution needs to be the responsible way towards achieving sustainability, and the *professional-centric narrative* in which it is argued that there is a need for a more inclusive approach that integrates knowledge and the existing abundant natural and human resources to achieve it. Whereas the two narratives are contested and give rise to a muddled trajectory, the *investor-centric narrative* informs about the shortfalls and adverse elements in Sri Lanka's current sustainability transition process.

While the three narratives inform, influence, and affect the trajectory of the power-sector in Sri Lanka, the interviewees' statements also helped to identify contextual issues affecting the sustainability transition process and RI practices within it. The tensions between the narratives, which were evident from the claims and statements made by the interviewees, reiterated that, as concepts 'responsible' and 'sustainable' are context-related. The empirical evidence relating to Sri Lanka, which was sourced from the interviewees, reflected that the sustainability transition in the country has fallen short of acknowledged and promoted RI practices. In particular, immature energy governance and ineffective transition-management leadership were prominent factors affecting the energy transition. Also, the lack of agreement between the contested narratives and the absence of a reconciled policy trajectory with a planned step change towards sustainable energy transition reflected poor leadership in energy governance.

Sri Lanka's shift towards renewables is currently dependent on the engagement of and investments by foreign private sectors, which requires a facilitative framework for such involvement. An entrepreneurial activity in a well-functioning TIS will take advantage of business opportunities, not only to turn knowledge, networks, and market into concrete actions but also to diversify business for the firm's development (Hekkert et al. 2007). Thus, the presence and engagement of active entrepreneurs is a key indicator of the performance of a TIS and lack of such presence and engagement will influence the remaining functions of a TIS (Kooijman et al. 2017), in turn affecting the ability to create legitimacy for a newer technology trajectory. The investor-centric narratives revealed that there was a desire to invest and a motive for business development, and that there was ample opportunity for such investment in the field of sustainable energy development. However, there were concerns about the lack of a responsible framework for the absorption of investments and technology. Sri Lanka needs to change course and overcome the not-so-insurmountable issues of the existing manipulative practices, resistance to change from the existing technology regime, and the non-conducive investor environment that hinders firms from entry and investors from engagement in the energy sector. Sri Lanka also needs to heed feedback from the *investor-centric narrative*, which highlighted the absence of an integrated approach and mechanisms for initiating entrepreneurial activities, and that the prevalent and established practices were institutionalised and resulted in unyielding barriers and vulnerabilities to the absorption of innovations and technologies.

Scholars have echoed the need for the integrated role of multiple actors in mobilising low-carbon transition strategies (Wang & Lo 2021). Knowledge exchange, integration, and development are fundamental for innovation, absorption, and development, not only for reducing uncertainty and ensuring sustainability, but also for progressive and appropriate decision-making, especially in a context in which technology absorption requires interaction between government, academics, international institutions, competitors, and the market. Policy decisions need to be consistent with national commitments, and to take account of the changing norms, values, and practices. In the studied Sri Lankan case, the empirical evidence highlighted the absence of these considerations in the planning and decision-making processes, as well as the underutilisation of resources, including academics and technocrats in the energy transition process, and the fact that the country is leaning towards more ad-hoc decision-making with prevalent manipulative practices. The Sri Lankan case also highlights the importance of effective energy governance, which will help to fuse a TIS and RI and thus achieve a resilient sustainable energy transition.

Legitimisation of innovations and technologies (a responsibility of the state), which strongly deviates from established institutional practices will be challenging. These technologies need to overcome resistance by gradually becoming part of the incumbent regime and creating an environment to legitimise a TIS through a RI process, thus making the established practices redundant and paving the way for alternative institutional practices to penetrate institutional traditions. Actors with vested interests and powers often oppose such changes (Kooijman et al. 2017), as exemplified by the dominant *policymaker-centric narrative*, which supports reinforcement and/or continuation of fossil fuel technologies, deviating from the narrative holder's own climate commitment, and marginalising the knowledge, perceptions, and views of *professional-centric* and *investor-centric* stakeholders. It was noticeable that new investments in renewable technologies, which are crucial for technological change, were being held back by supporters of the dominant *policymaker-centric* narrative. Therefore, it falls on stakeholders

who promote renewable technologies, both local and foreign, to find progressive and innovative ways to challenge and/or deinstitutionalise this dominant narrative with a framework that is aligned both with the United Nations Sustainable Development Goal 7 (United Nations n.d.) and with RI principles. In doing so, the insistence on 'reliable, affordable energy access to all' by supporters of the dominant narrative needs to be accommodated before manoeuvring for a technological shift.

The Sri Lankan case informs that giving serious attention to the many critical appraisals within the three narratives and taking a corrective course could be the first step to interlocking RI with the sustainable energy transition.

## Conclusions

Responsible innovation (RI) in sustainability transition is about responsible interplay between the functional elements of a TIS, together with the acknowledgement that operationalising RI can be challenging, as the framework cannot capture all of its elements tangibly. The innovation has to be 'responsible' by also being context-sensitive in order for transition to be appropriate and sustainable. While RI may be considered by scholars as a 'luxury argument' for developing countries (Vasen 2017), its positive impacts can still be realised if they are applied in tandem with a TIS by engaging in the energy discourse flowing from different responsible stakeholders' narratives regarding the way forward.

This study of the Sri Lankan power sector highlights that, as concepts, 'sustainable' and 'responsible' have different meanings in resource-poor settings. For Sri Lanka, RI in sustainability transition is first and foremost about affordable and reliable energy access for all. Thus, 'sustainability' has to be conceptualised in a more generic form, as well as in term of context, which means that the social aspect of distribution needs to be initiated in tandem with sustainable technological change for it to be accepted without dissent. For this to take place, Sri Lanka will need to have an integrated approach by incorporating knowledge with policy and investments.

There is a dearth of empirical studies of RI and sustainability transitions across different geographical contexts in the literature. The findings of the qualitative empirical research presented in this paper inform that aligning RI with sustainability transition is also about being cognisant of the discourse arising from prevalent narratives. In view of this, this paper proffers a methodological contribution by placing prevalent narratives in context as a necessary bridge to link sustainability transition with RI in order to be able to take forward the energy transition process effectively (Fig. 1). The findings from the data analysis suggest that sustainability transitions in developing countries can be better understood by being vigilant with regard to contextual narratives on RI. Further research in different geographical contexts will be needed to enhance the conclusions presented here.

## Acknowledgements

The work was funded by the Royal Norwegian Embassy in Colombo, grant number LKA-3182/LKA-16/0001. Professor Arnt Fløysand is thanked for discussions and development of earlier drafts of the paper. Professor Dhayalan Velauthapillai is thanked for his contributions to the early development of the paper. Special thanks are due to guest editor Marte Solheim and two anonymous reviewers for providing valuable input.

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# The geography of sustainability transition and materiality: Grid-tied solar photovoltaic technology in Sri Lanka

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**ABSTRACT**

The geography of sustainability transition (GeoST) literature views solar photovoltaic (PV) as an off-the-shelf, footloose, absolute technology for bringing about a technological shift in locations with high solar irradiation. Herein, I argue against viewing solar technology in these ways, highlighting that consideration should also be given to the configuration of solar PV that suits the contextual conditions. To this end, I offer empirical evidence for the need to approach solar PV diffusion through a relational perspective. Accordingly, different solar PV technology formats may become necessary for its successful implementation in diverse contexts. Supportive empirical evidence comes from Sri Lanka's large-scale grid-tied solar PV implementation. I conclude the paper with an analytical consideration of the influence of material factors as being as important within GeoST as that of intangible factors, and that technological shift should be pursued within a location's contextual relational materiality.

**KEYWORDS**

Geography of sustainability transition, absolute materiality, relational materiality, solar photovoltaic, land, Sri Lanka

## 1. INTRODUCTION

Solar photovoltaic (PV) is considered a promising technology for countries in energy transition, offering substantial potential and a least-cost option for sustainable energy transition to electricity generation. Fundamentally, sustainability transition of energy systems refers to the technological shift from fossil fuel-based technologies to renewable energy-based ones, making energy technology and technology development central to this transition. The geography of sustainability transition (GeoST) literature, looking beyond technological fixes, has paid increasing attention to the broader perspective of socio-technical transitions such as policies, discourses, institutions, and actor networks related to restructuring energy consumption and production systems (Truffer, 2012; Truffer et al., 2015; Köhler et al., 2019), while also acknowledging the importance of considering context in the transition process (Coenen et al., 2012; Binz & Truffer, 2017).

However, the GeoST literature (e.g., Global Innovation System [GIS]) presents solar PV as a generic, off-the-shelf, globally applicable technology (Binz & Truffer, 2017). In doing so it pays less attention to the element of relational conditions of the technology's natural material requirements (e.g., land) and context-related stakeholder rationalities that are necessary for the successful implementation of solar PV. A presumption within transition studies has been that once technologies mature, they can be imported and assembled relatively easily utilising industrial processes, business models, financial investments, and policy transfers within any context (Kirshner et al., 2019).

Acknowledging the importance of considering solar PV and context as key for sustainability transition, the paper examines how materialities affect energy transitions in Sri Lanka from both a theoretical and analytical perspective by focusing on the implementation of

large-scale grid-tied solar technology including a demonstration project (DP) on floating solar PV (FPV).

To understand the influences of materiality in the context of solar PV technology in Sri Lanka, a middle-income country, this paper explores the following: (i) How the GeoST literature deals with materiality; (ii) How relational materiality has influenced and affected the application of solar PV in Sri Lanka; and (iii) How the case of Sri Lanka adds to the GeoST literature. Theoretically the paper contributes to a reorientation of the extant literature to pay heed to materiality when contextualising transitions. In consequence to this enquiry, this paper offers empirical evidence for the need to approach solar PV diffusion through a relational perspective. It informs that land, the absolute materiality, needed for large scale grid-tied ground-mounted solar PV, is a fiercely contested matter and that alternative forms of PV technology needs to be considered to exploit and achieve sustainable energy transition from the country's plentiful sun irradiation.

In presenting empirical evidence as to the need for a relational approach when contextualising technology, this paper begins by discussing the GeoST literature's approach to materiality followed by the methods section. The empirical section describes the implementation of grid-tied solar PV in Sri Lanka, presenting sequentially the conundrum in scaling-up with ground-mounted solar PV, considering FPV as an alternative, and going for a DP to legitimise the alternative as a solution. The paper finally offers a discussion on the case with conclusions.

The case presented in this paper raises awareness of the complex contextual characteristics and adverse materiality factors impacting on the scaling up of large-scale grid-tied ground-mounted solar PV. The case also highlights that the alternate solution is better legitimised by means of a DP.

## 2. THE GEOGRAPHY OF SUSTAINABILITY TRANSITION AND MATERIALITY

### 2.1. Role of materiality in GeoST

In conceptualising transitions, major structural changes have been referred to as socio-technical transitions rather than only technological transitions (Markard et al., 2012), as they are based on a contextual understanding of the technology (Grin et al., 2010). In the electricity sector, sustainability transition centres on implementing emerging sustainable energy alternatives, while phasing out unsustainable technologies and revisiting policies, practices, and ways of organising (Markard, 2020). Thus, sustainability is concerned with innovation-based change to energy generation and consumption.

The GeoST literature, a broader field, highlights the need to explicitly focus on embedding territorial particularities of the contexts in which a transition occurs (Coenen et al., 2012; Truffer & Coenen, 2012). It also signals the need to attend to the global interconnectedness of processes (Truffer et al., 2015; Wieczorek et al., 2015; Mura et al., 2021; Truffer et al., 2022) and innovative practices associated with transitions (Coenen et al., 2012; Hansen & Coenen, 2015; Binz & Truffer, 2017). Thus, the primary focus of GeoST has been on "understanding how and why transitions are similar or different across locations" by evaluating the influence of place-based factors such as institutional settings, local cultures, social networks, and infrastructure or resource endowments on transitions to sustainability (Köhler et al., 2019, p.14). GeoST is also about understanding how transitions "travel" between and/or across different scales, like related innovations, knowledge, and technologies "beyond where they were initially conceived" (Köhler et al., 2019, p.14). GeoST (energy) further deals with the distribution of different energy-related activities across a particular geographical space and the connections and interactions between it and other spaces (Bridge et al., 2013). Transitions are thus context-dependent, take different directions, and unfold at different speeds

with interconnected underlying processes (Markard, 2018). A local transition process is therefore impacted by its place-specific context, greatly influencing and contributing to geographical transition unevenness (Coenen et al., 2012).

Despite this, transition studies place technology and technology development at their centre. Technology development involves linkages between heterogeneous elements (Grin et al. 2010), typically attending to the broader perspectives of socio-technical transitions that encompass institutional structures, lifestyles, and infrastructure "beyond a mere diffusion of specific technological fixes" (Truffer, 2012, p.182). GeoST literature is populated by discussions of intangibles (Köhler et al., 2019) such as the roles of discourse and institutions in transition policies (Kern, 2011), the involvement of multiple actors (Bekirsky et al., 2022), the roles of power, politics, and how policies shape transitions (Geels, 2014; Hess, 2014; Normann, 2017), changes in user practices, and the governance and management of transition towards sustainability (Kemp et al., 1998; Rotmans et al., 2001). It also looks at the need to support novel technologies, business models, organisations, and infrastructure (Markard, 2020). The engagement with context-related debate and materiality (i.e., contextualising technology) within the GeoST literature is limited and appears to have been taken for granted, given the fact that: (i) the global sustainability transition concept primarily refers to a sustainable technological shift; and (ii) this technology change is greatly influenced by its place-specific social and natural material requirements.

### 2.2. Technology as an end-product of transition

GeoST considers sustainability transition-related (energy) technologies as an electricity sector end product and considers the above-mentioned socio-technical dimensions to play crucial roles in shaping such implementation. For example, the GIS (e.g., Binz & Truffer, 2017) literature analyses technological innovation processes in transnational contexts using generic GIS configurations. For instance, authors consider solar PV as a footloose GIS categorised under

"standardised valuation", leading to it becoming a standard product with "relatively undifferentiated preferences" by end users globally, or a product supplied "without much need for adaptation" to specific contexts (Binz & Truffer, 2017, p.1289). This technology generalisation fails to recognise that what is considered a sustainable practice or solution in one place may not be so in another (Fontaine 2020). Technology in the GeoST literature has thus far been presented generically, especially as solar PV becomes "extremely affordable at grid-scale and is being installed rapidly in many countries" (Sareen & Kale, 2018, p.270). This reflects a lack of nuance or discussion about why certain designs or infrastructure based on the same technology category (e.g., solar PV) are preferred over others in different contexts.

### 2.3. Contextualising technology

Freeman (2001, p.156) stated that "technologies cannot be taken 'off the shelf' and simply put into use anywhere", to which Hansen and Coenen (2015, p.95) added that "sustainability transitions are geographical processes – they are not pervasive, but happen in particular places, i.e., actual geographical locations with a materiality to them". Different contexts provide different potentials and challenges, which influence innovation and technology progress (Jakobsen et al., 2019). Similarly, McCann and Soete (2020, p.17) stated that "the challenges faced by different contexts differ, and therefore actions need to be tailored to the local context". This is also true of technology. Within different contexts, even footloose technology hardware must be changed to navigate social and environmental factors differing from those for which it was perfected (Gandenberger & Strauch, 2018). In the absence of such modifications, newly imported energy technologies will likely face tensions, contestation, negotiation, and/or rejection for context-specific reasons. Thus, technology should be defined relationally as "technologies-in-context" (Rammert, 1997, p.176) by also attending to its physical aspects. Similarly, from an innovation perspective, Fløysand and Jakobsen (2011) highlighted that innovation practice should be viewed as relational. These authors focus on the actor network,

knowledge flow, related assets, and network interconnectivity that allow for a relational view of the innovation practice.

The geographical locations of many low-and middle-income countries offer them strong potential for generating solar energy (Suri et al., 2020; World Bank, 2020). Yet their contextual challenges restrain them from rapidly harnessing this energy source using the footloose technology described in the GIS literature (Calvert et al., 2022; Yenneti et al., 2016). Those in countries suggesting that the use of end-product solar PV technology is unproblematic overlook the fact that natural materiality (e.g., land, rooftops) for such implementation are finite, and may lead to new controversies and resistance to these technologies (Fontaine, 2020). Large-scale land use for solar PV can invoke local socio-culture barriers (Konadu et al., 2015). For example, the population of a large proportion of low-and middle-income countries depend on agriculture; thus, the installation of large-scale ground-mounted solar PV creates competition and raises livelihood and social issues (Taye et al., 2020; Sanseverino et al., 2021; Stock, 2022) in addition to material barriers to technology deployment. Silva and Sareen (2021) have shed light on this issue through a study of people's perceptions of ground-mounted solar PV infrastructures and their effects on the local community.

### 2.4. Relational materiality

The availability of renewable natural resources such as solar irradiation may be restricted to within a physical territory (e.g., open space) and renewable energy generation can be socially and politically impacted by actor networks across different scales (De Laurentis & Eames, 2016). While the general motive of key stakeholders is to produce sustainable electricity, different actors have varying – and often contested – rationalities regarding technology development. The complex phenomenon requires an understanding of motives, practices, conflicting interests, tensions, and negotiations. In the discussion on urban materiality, Rutherford (2014) stated that contestation of change processes and practices is a result of the

diverse ways in which people understand and engage with materials and the influences of materials on their living spaces. The motive of some stakeholders for adopting ground-mounted solar PV is mainly economic. For instance, according to Ockwell et al. (2008), technology transfers for sustainability transitions from technologically developed countries to those countries dependent on the import of technology leads to commercialisation, financially benefitting the involved companies. In contrast, the marginalised peasants who have ground-mounted solar installed in their vicinity experience disruption to their lives and livelihoods (Stock, 2022). Within GeoST, this local-level relational materiality cannot be considered in isolation or taken for granted.

Within the literature, sustainability narratives are not always consistent with observed realities (Fløysand et al., 2017). Thus, technology not being solely an end-product, energy transition technology also affects particular settings and subsumes varying material and immaterial relations (Figure-1).

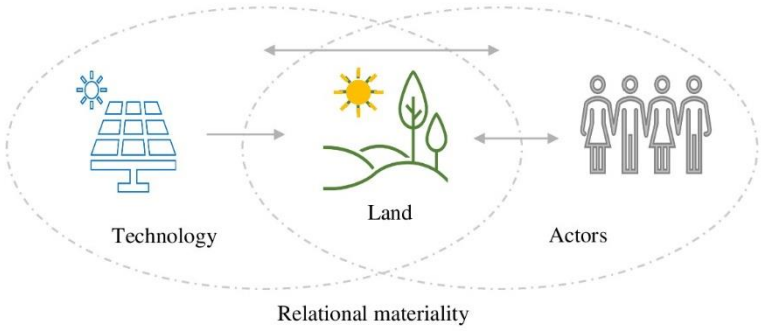


**Figure-1** Relational materiality — interactions among technology, natural environment, and actors

Thus, the GeoST literature has been passive regarding the implications of energy transition on social relations to land and surrounding environments (Calvert et al., 2019; Hansen & Coenen, 2015) and has taken relational materiality for granted – i.e., it views technology as the absolute solution. I argue herein that it is important to attend to this relational materiality

when contextualising technology, for example in the development and application of large-scale solar PV infrastructure.

## 3. METHODS

This study is part of the Capacity Building and Establishment of Research Consortium (CBERC) collaborative project between Norway and Sri Lanka. The project, established in 2017, aimed to strengthen university research collaboration and industrial partnership on clean energy technologies between both countries. CBERC is comprised of Norwegian and Sri Lankan researchers and industrialists. The project includes research on identifying influencing factors on the process of applying renewable energy technologies in Sri Lanka.

This study employed a qualitative case study approach to provide in-depth contextual inquiry on a real-world phenomenon (Yin, 2009). Empirical evidence emanating from collected data is used in this paper to illustrate the role of materiality in energy transition. The data relates to large-scale grid-tied solar technology implementation in Sri Lanka. My data collection comprised 50 semi-structured interviews, participant observations and document reviews. The interviews were carried out in four phases with individuals connected with the Sri Lankan electricity sector including the public sector, private sector, academics and energy experts. Additional data were collected by participant observation in sustainable energy generation-related conferences and the launch of the FPV-DP held in Sri Lanka as well as reviewing energy sector-related Sri Lankan documents. Interviewees were initially identified by attending a Sri Lankan conference on renewable energy and later snowball sampling was practised to find more interviewees. In-depth semi-structured interviews were carried out with stakeholders in Sri Lanka and Norway. In Phase-I, in Sri Lanka, 30 face-to-face interviews were carried out in the four months between November 2019 and February 2020. This was with stakeholders engaged in renewable energy technology implementation in Sri Lanka which included representatives

from public and private sectors, academics and energy experts. While in Sri Lanka, the author attended the launch of the country's first FPV-DP (Kjeldstad et al., 2022) as well as a related stakeholder conference. The DP was part of the CBERC project. Phase-II interviews with 11 Norwegian stakeholders from the private sector and academia connected with Sri Lanka's renewable energy programme were carried out digitally on Zoom from August 2020 to March 2021 due to the COVID-19 pandemic lockdown. The interview questions in Phase-I and II were not specific to the implementation of grid-tied solar technology, instead captured diverse themes on the transition to renewable energy technologies in Sri Lanka. Phase-III involved 8 digital group interviews carried out in May 2021 and Phase-IV involved one face-to-face interview in Norway in September 2022. The questions in Phase-III and IV were exclusively focused on Sri Lanka's solar and FPV-DP implementation. I have also studied a number of secondary sources with a summary provided in Table-1. Interviews were audio-recorded, transcribed verbatim, and analysed manually together with documents and participant observation. The interviews were mainly conducted in English, but some of the interviewees preferred to respond in their mother tongue (Tamil or Sinhala).[1] The data production and protection complied with Norwegian Centre for Research Data's ethics of informed consent and safe storage of data. The categories and data related to absolute materiality were primarily drawn from documents, while those relating to relational materiality were mainly taken from both interviews and participant observation. The entire research process has been iterative between audio-recordings, interview transcripts, documents and notes from participant observation, and the recategorisation of the data.

[1] Translations from Tamil or Sinhala into English were carried out by the author.

**Table-1:** Summary of data used for the analysis of grid-tied solar implementation in Sri Lanka

| Phase | Data type | Timeframe | Details |
|---|---|---|---|
| I | Primary | November 2019 - February 2020 | • Participation in stakeholder conferences<br>• Participation in the launch of the FPV DP<br>• 30 face-to-face interviews (Sri Lanka) |
| II | | August 2020 - March 2021 | • 11 digital interviews (Norway) |
| III | | May 2021 | • 08 digital group interviews (Norway and Sri Lanka) |
| IV | | September 2022 | • 01 face-to-face interview (Norway) |
| | Secondary | | • Central Bank of Sri Lanka: annual reports<br>• Ceylon Electricity Board: Long-term generation expansion plan and annual reports<br>• Sri Lanka Sustainable Energy Authority: reports, website<br>• Asian Development Bank and World Bank: reports, websites<br>• Newspaper feature articles<br>• Pre-feasibility report<br>• Letter from local authority<br>• General reports, newspaper articles, and websites |

## 4. IMPLEMENTATION OF LARGE-SCALE GRID-TIED SOLAR PV IN SRI LANKA

Electricity generation from solar PV is expected to become the most abundant, lowest cost, and most relevant energy source in the mid-to-long term (Breyer et al., 2017). This has led to a growing number of reports across the GeoST literature about successful solar PV driven energy transitions in different contexts. For example, studies have highlighted the use of solar PV technology as a substitute system in coal-powered regions of the European Union where utility-scale installations on abundantly available land increasingly attract institutional investors and electricity companies (Bódis et al., 2019). Countries such as Australia identify solar PV as an effective technology for decarbonising their cities (Newton & Newman, 2013). Solar PV has also been regarded as an ideal technology for countries near the equatorial belt because of their stable solar energy irradiation (Kabir et al., 2018). These countries are therefore expected to drive the global expansion of solar PV capacity and the market for solar PV, thereby contributing to local and global reductions in $CO_2$ emissions (Dobrotkova et al., 2018; Shahsavari & Akbari, 2018). Countries in this geographic belt are largely categorised as developing (Foroudastan & Dees, 2006) and many of them face impacting contextual factors due to the need for rapid renewable energy implementation as mentioned above.

### 4.1. Absolute materiality

Sri Lanka, a tropical island on the equatorial belt with substantial solar energy resources most of the year and an average temperature of 28°C in dry areas, is ideal for solar PV (Gunaratne, 1994). According to the National Renewable Energy Laboratory (Renné et al., 2003), the country has an annual average global horizontal irradiation range of 4.5–6.0 kWh/m$^2$/day, further evidencing its ample solar resources for year-round PV application (Renné et al., 2003; RMA Energy Consultants (RMAEC), 2014) with a potential to deploy ~16 GW solar power (Asian Development Bank & United Nation Development Programme, 2017; Bellini, 2022). Nevertheless, and primarily because of contextual materiality factors, only 0.01% has been generated through solar power by 2016, despite the expectation that 32% of the country's annual electricity demand would be met this way (Ministry of Power & Energy, n.d.; Perera, 2016). With solar PV costs decreasing globally, Sri Lanka's Long Term Generation Expansion Plan (LTGEP) 2022–2041 stipulates the use of solar to reach 2,874 MW by 2030 (Ceylon Electricity Board (CEB), 2021). The International Renewable Energy Agency (2022) informs that the country had reached 434 MW of installed solar power by 2021. Exploitable solar energy potential estimates are based mainly on access to land with competing demands, site accessibility, and electrical transmission network access (RMAEC, 2014). While the latter two have financial implications, land-related material issues carry more crucial social implications, often involving serious socio-economic and environmental consequences.

### 4.2. Relational materiality

Added capacity for generic ground-mounted solar PV modules requires considerable land space (Sanseverino et al., 2021). Ground-mounted PV solutions require 1-2 hectares to generate 1 MW of power (RMAEC, 2014). Sri Lanka, which covers an area of 65,610 km$^2$ and has a population of 22.1 million people, is regarded as the 19th most densely settled country in the world, with a population density of 353 people per km$^2$ (Central Bank of Sri Lanka, 2021; Food

and Agriculture Organization, 1999). Land is thus in high demand, with 40% used for agriculture, 30% covered by forest and wildlife reserves, and the remaining 30% available for all other activities, including urban and infrastructure development (Mapa et al., 2002). Approximately 77.4% of the population reside in rural areas and depend on agricultural livelihoods (Department of Census and Statistics, 2021). Four-fifths of the country's poor depend on the rural sector and almost half of the rural population are small-scale farmers (International Fund for Agricultural Development, 2019).

In general, rural spaces are sought-after for large-scale infrastructure technology development such as solar because of their exposure to high solar irradiation but the land space is also contested for diverse economic and livelihood activities. Land is scarce in Sri Lanka because of high population density and high dependence of the population on land spaces for livelihood dependent agriculture. The country also needs land for income generating tourist parks and wildlife reserves, and to maintain conservation and reforestation. In view of these factors, competition for land between the above mentioned requirements and solar development becomes inevitable (Kjeldstad et al., 2022; Sanseverino et al., 2021; Stock, 2022) in countries such as Sri Lanka. Consequently, rural land becomes contested materially and discursively (Calvert et al., 2022; Stock, 2022). The northern, eastern, and southern regions of the country, which are reportedly better than the western region for generating solar energy (CEB, 2021), are also where the rural population resides and is tied to land use for farming, shelter, leisure, social and other income-generating activities. Installing panels in their midst means recasting land use and livelihoods, from cultivation, cattle-and sheep-grazing pastures, and integrated farming to the construction of houses and other buildings, cutting down trees, and clearing green spaces. As shade from solar panels is also expected to decrease crop yields, installing large scale panels on peoples' most productive farmland is unlikely to be in their best interests (University of Massachusetts Amherst, 2022). Scholars have also highlighted that extensive use

of land for large solar PV installations will displace other uses and create vulnerabilities (Adeh et al., 2019; Sanseverino et al., 2021; Stock, 2022). A private sector representative stated the following:

> When you say 100 MW, it requires a vast amount of land and that land has to go through the criterion that it is not cultivatable, because once you install it, it is there for 20 years minimum. So that land will not be available for anything else. Normally these lands are not available in the suburban or urban areas [but rather in rural areas].
>
> Private sector-December 2019

While the LTGEP commits to increasing renewable energy generation, production through ground-mounted solar PVs has thus far been slow due to high competition for land from population density, prioritising the preservation of rich biodiversity, agricultural needs, and reforestation (Kjeldstad et al., 2022; World Bank, 2021). Apportioning land for solar farms amidst demands for diverse land use creates novel social and environmental problems. Installing grid-tied solar technology in close proximity to human settlements also creates uncertainties, and health and environmental concerns. Theiventhran (2021) pointed out that solar farm protests by rural Sri Lankan residents were in part due to health fears of heat emissions from large solar panels. Environmentalists fear that tree loss from these projects, including the palmyrahs – that are native to places with rich renewable resources, will disrupt natural biodiversity (National Wind Watch, 2016). The interviews also reflected rural residents' concerns regarding the ecological effects of infrastructure installations. A public sector representative revealed the following:

> The materials have been brought but the public is protesting. The public is in the mindset that these [solar PV] will affect the environmental cycle and they don't see this as a positive initiative. The other issue is the land. When we try to install it on private land

there will be a lot of issues and protests. To do the interconnection, we have to put up new transmission lines. To do that we have to cut down trees, clearances have to be obtained and there will be protests from the public when cutting down trees.

Public sector-December 2019

Identifying and allocating suitable locations for solar farm project is a materialistic conundrum for Sri Lanka, given its need for swathes of land for nature conservation and tourist parks, as these protected forested and wildlife areas bring this economically constrained country much-needed revenue. Sri Lanka's expansion of ground-mounted solar is thus challenged by demands for too much of its contested land and because different stakeholders relate to the technology differently regarding its effects on social and natural environments.

In 2016, Sri Lanka also introduced a rooftop solar scheme through the *Battle for Solar Energy Programme* effort to shift to low-carbon energy generation (CEB, 2021; Dutt, 2020). This offered electricity consumers the opportunity to become prosumers, allowing them to either sell excess power to the CEB or bank it for future use. Fast-tracking rooftop solar is a necessary policy and exercise, yet without tangible incentives such as upfront grants or installation loans, its wide uptake has also been slow in economically constrained Sri Lanka. One interviewee expressed the following:

> Most of our domestic consumers consume less than 60 units [monthly], which is approximately Rupees[2] 300 - 400. Approximately 4–5% of consumers consume more than 400 units [monthly], and obviously pay a very high bill. For them, going for solar-rooftop maybe worthwhile economically.

[2]Sri Lankan currency

Interviewees asserted that the rooftop solar initiative became increasingly popular among high-end electricity users who invested in it and were able to eliminate their monthly bill and even sell their surplus. However, this was not an option for most low-end users because of a high upfront investment costs and low power consumption.

## 4.3. Floating solar PV (FPV) alternative

FPV technology was considered a better option for overcoming the difficulties experienced with grid-tied ground-mounted solar PV in Sri Lanka, and possibly for countries where land is at a premium and electricity grids are weak (World Bank, 2018). The first commercial FPV installation was in California in 2007, with the main purpose of reducing evaporation from irrigation tanks (Sanchez et al., 2021). The technology has since moved from smaller DPs to larger-capacity developments in countries such as India, Laos, Thailand, Vietnam, and China (World Bank, 2021). FPVs are preferred for evaporation reduction, avoiding soiling due to dust, and augmenting electricity generation through water cooling (Boduch et al., 2022; Fereshtehpour et al., 2021; Rosa-Clot et al., 2017; Sanchez et al., 2021). Engineered as conventional solar panels atop structures like floats and pontoons anchored in calm waters and connected to onshore electrical connections (Merlet & Thorud, 2020), FPVs complement conventional ground-mounted and rooftop PVs. FPVs may hold great potential for countries with high solar irradiation, ample waterbodies, and land contestation. This option is additionally attractive in Sri Lanka, as energy experts have identified the availability of large, suitable, and diversely distributed natural and man-made waterbodies (DailyFT, 2020).

In 2017, Sri Lanka embarked on the idea of FPV initiated by a private Norwegian solar company. In following up on this idea of FPV, the private Norwegian solar company carried out a pre-feasibility study in 2018 (Solheim, 2018). This study was undertaken in Badaragama,

a village in the western province, with a view to installing a 50-kW FPV pilot plant. Despite the study and stakeholder consultation, local authorities and residents could not be persuaded to give consent for the project, primarily because the target waterbody (tank) irrigates the village's cultivable land. A large segment of land surrounding the tank is used for human settlement, industry and service activities (Solheim, 2018). Moreover, the tank water is used for paddy, banana, and vegetable farming:

> The local farmers did not see the bigger picture of renewable energy as opposed to the local power plants, so they didn't have that scope of thinking, and the local authorities also did not see any big advantage for them.
>
> Private sector-May 2021

This relational materiality factor halted the project when local (public sector) authorities wrote to express their constituents' concerns about the technology and its effects on biodiversity, the community, and their livelihoods. Phase-III group interviews disclosed another perspective, that certain segments of society were strongly attached to their place and agrarian way of living and thus sceptical of modernisation:

> Sri Lanka is an agrarian society. Farming, land, and water are three precious things. Anything to do with these needs real convincing.
>
> Academic-May 2021

Ongoing research on FPV examines different aspects of the technology (Boduch et al., 2022), and its social and natural environmental implications. FPV is a globally respected technology, yet the idea and technology were new in Sri Lanka. The offer of placing this new technology on a waterbody heavily exploited by the residents was thus accompanied by concerns, questions, and ultimately resistance, despite experts opining that FPV was superior to ground-mounted solar and thus an appropriate solar solution for the country. The stakeholder

responses and reactions to the initial FPV idea in 2017 necessitated further research on the suitability of this technology to overcome these relational materiality concerns.

## 4.4. Legitimisation through FPV-DP

Reinforced by the outcome and experience of the initial FPV idea as presented above, a DP was initiated through the CBERC project. The need for an FPV-DP was identified and supported by a delegation of Norwegian private companies visiting Sri Lanka in 2018 to explore and study the energy landscape as part of the CBERC project. The placement of a DP was decided in order to demonstrate that FPV is an innovative technology suitable to Sri Lanka's context and to allay stakeholder relational materiality concerns via the following: (i) evaluating technical feasibility; (ii) openly displaying the effects and interactions between the technology and natural and built environments; (iii) responding directly and with evidence to stakeholder concerns and questions; and (iv) developing solar policy through a consultative process.

Consequently, an FPV-DP with a 46-kW capacity (in a pond) and a 5-kW stand-alone reference plant (on land) was launched at the University of Jaffna in northern Sri Lanka (Image-1) in early 2020.

**Image-1** Floating solar PV demonstration plant
**Image source:** University of Jaffna, Sri Lanka

The Norwegian energy group Equinor AS in conjunction with Innovation Norway, a state agency promoting innovation and industry development, provided financial support to Current

Solar AS Norway who designed and implemented the project. Initially, the purpose of the DP was to test, display, learn, improve and convince stakeholders by placing the experimental FPV in Sri Lanka's climate; however, it became an innovative initiative itself.

Despite falling short of a real-world placement, the university premises with its learning ambience was selected to mitigate concerns and scepticism through education and interaction. One academic stated the following:

> There will be many challenges to having it elsewhere…people will ask many questions. This is why we decided to have the plant at the university…people wanted to first learn about the technology.
>
> Academic-May 2021

The private sector also undertook this initiative to tap local industrial development potential through joint Norway-Sri Lanka ventures. As expressed by one private sector interviewee:

> With Sri Lanka's number of reservoirs and lagoons, it has been estimated that there is huge potential for developing FPV if one only utilised 10–15% of this surface. With such enormous potential, there should be ample opportunity to use clean energy in the future and develop a local industry in the process. The potential is gigantic.
>
> Private sector-January 2021

The plant currently functions as a floating research lab carrying out multidisciplinary research including technical, economic, social, and environmental studies to innovate the technology to suit Sri Lanka's context.

> A lot of data is going into the system and the specification is unusual and we have a lot of measuring instruments related to this system that you would not ordinarily find if the purpose were only to produce electricity.
>
> Private sector-May 2021

Although FPV panels are similar globally, the floating structures are context-specific, with their designs and mounting mechanisms dependent on the type of water, flow, waves, and wind speed.

> Solar panels need to be mounted and need to float. Calculations are needed, and material and material sizes as well as floating structures have to be developed according to the context. In this DP, we placed the panels in a zigzag design to float. The panels will thus absorb the sunlight in the morning and evening, whereas the ground-mounted ones only receive sunlight from one direction. Our study on this FPV plant has shown that it produces 8% more than the reference plant, which was also the main purpose of the DP.
>
> Academic-September 2022

The DP encountered difficulties before and after the launch. Based on data collected from technical observations, appropriate DP modifications have been made. For example, FPV is expected to increase the cooling effects, leading to increased output. However, research from this DP showed that, for Sri Lanka's temperature, additional instruments and designs were needed to monitor this cooling effect:

> The pond is small, and the water temperature is equal to the air, so it does not provide a lot of additional cooling. This was a surprise to us. Night-time is hotter in the water than in the air. Another surprise is that in the dry season, it dries out completely.
>
> Private sector-May 2021

These effects were also a result of the DP covering a small portion of the pond surface, the rest of which was exposed to the sun. The researchers noted that evaporation can be mitigated by expanding the water body surface coverage. A recent study at this DP showed that the technology performs stably throughout the year (Kjeldstad et al., 2022). To date, the DP is considered successful considering that it has received local media publicity and visits from financial institutions, students, and public sector officials; it appears to appeal to policymakers who set national capacity targets, as evidenced by the recently published LTGEP 2022-2041; and exploration of installing FPV within the parliamentary complex is underway (Razeek, 2022). An excerpt from the LTGEP 2022–2041 reads as follows:

> A floating pilot solar power plant with a capacity of 42[46] kW was installed at the University of Jaffna in 2020[,] marking the country's first such project as a pilot project. Moreover, the Sri Lanka Sustainable Energy Authority has identified multiple potential reservoir locations to develop large[-]scale floating solar projects, and detailed techno-economic assessments for each resource site are required for long term investment decisions[.]
>
> (CEB 2021, [no pagination])

Currently, electricity produced by this DP meets the consumption needs of the University of Jaffna (Kilinochchi). One academic opined that, for Sri Lanka, the model for introducing a

renewable technology is as follows: an initial DP, followed by a private project, and finally, scaling up through government projects to ensure suitability and uptake.

## 5. DISCUSSION

The GeoST literature primarily focuses on "understanding how and why transitions are similar or different across locations" by evaluating how place-based factors influence institutional settings, local cultures, social networks, and particular infrastructure or resource endowments towards transitions to sustainability (Köhler et al., 2019, p.14), acknowledging the importance of geography (Hansen & Coenen, 2015; Truffer & Coenen, 2012). While conceding that place-based factors influence the pace of transitions across locations, GeoST literature has not given much attention to technology itself playing an impactful role on geographical transitions. Energy transition primarily concerns a shift from one technological system to another – a material, tangible shift. Yet the GeoST literature has overlooked the need to contextualise technology, or rather has confused technological fixes with absolute materiality by presenting technology as the mere needed end product of a transition process. GeoST needs to acknowledge that materiality plays a crucial part in the application of transition processes and that materiality is context specific. The intent herein has been to explain that inadequate attention has been paid, both theoretically and analytically, to the role of materiality in transitions in geographies.

Theorising transition needs to embrace the idea that innovation and technologies are created in one part of the world and spread to other countries through technology transfer (Köhler et al. 2019). When embedding these technologies to the local contexts, they need to be altered to befit the context and to be used to purpose or rather they too need to be contextualised using local capacities and knowledge, and by also encouraging innovations from within (Ghosh et al., 2021). Therefore, technology in transition cannot be regarded as footloose or off the shelf

(Freeman, 2001) but instead needs to be adapted suitably to fit within the social and natural contextual particularities of a target context (Fontaine, 2020; Gandenberger & Strauch, 2018). Analytically, this contextualisation of technology cannot be studied in isolation or in its absolute form but must instead be viewed in relation to its natural material requirements (e.g., land, in the case of ground-mounted solar PV). However, land and technology in their absolute forms must also be viewed in relation to varying stakeholders' rationalities, emphasising the need for the literature to attend to relational materiality (Figure-1) when contextualising technology in GeoST.

This paper began with the illustration of a solar PV system as a footloose technology in the seminal work by Binz and Truffer (2017, p.1289), where it is placed within a "standardised valuation", revealing that "end-users have relatively undifferentiated preferences that are uniform in various parts of the world". Herein, I argue against this, highlighting that even proven technologies such as PV, which is globally regarded as footloose for generating energy from solar, must be adapted to befit a particular context, that different solar PV technology formats may be necessary to fit different contexts, and that those differing technologies are not footloose but context-affected and require context-relevant changes.

The empirical case of grid-tied solar PV implementation in Sri Lanka was analysed herein. Many actors in Sri Lanka did not view the implementation of footloose, multi-located, large-scale, ground-mounted solar PV as a solution to sustainable energy transition. The gigantic solar potential described by interviewees demands large-scale land use, which may only be plausible in its absolute form, in isolation from a relational perspective. In reality, the island nation is challenged with diverse land use that stretches beyond agricultural livelihoods and includes established allocated lands for forest and wildlife reserves, conservation of rich

biodiversity, other land-based economic activities besides urban and infrastructure development. Further making space for large-scale solar power generation in closer proximity to human settlements adds to the conflict between their living space and electricity generation through solar. Such developments largely take place on rural spaces and their peripheries where the lives of people are well intertwined and engaged with the land space. As evidenced by this study all these factors lead to conflicts and resistance and in the end a barrier to technology development.

Aside from electricity production, such large-scale technology implementation compels a community to choose between survival needs and sustainable energy – or a context in which livelihood, personal, and/or local benefits are prioritised and embraced over global-level benefits (Komendantova, 2021). For policymakers, the choice is often a trade-off between large-scale implementation for sustainable energy, and conservation of biodiversity and people's welfare. For foreign private investors, Sri Lanka's geography is ideal for solar energy and technology set up for profit and growing dividends. The differences in priorities, concerns, choices, and actions – drawn out through discursive claims articulated by actors across networks (public, private, academic and energy experts) – empirically confirm that land space is a contested valued materiality in Sri Lanka, and one not easily granted for ground-mounted solar PV. Such differences also show that land (absolute materiality) is tied to varied relationships among stakeholders (relational materiality). These contextual, real-world factors emphasise the need to find alternative PV technology in order to realise its benefits. The empirical evidence herein also highlights that footloose solar PV technology, as it is conceptualised in the literature, is unlikely to be implementable as such in countries like Sri Lanka.

The case also illustrates that the prevailing relational dimension of materiality in Sri Lanka, presenting as a relative material barrier to ground-mounted solar PV, prompted a rethinking that eventually led energy experts, private sector stakeholders, and policymakers to propose FPV as a possible alternative solution for the country and to innovate context-relevant designs, consequently becoming a driving force for local innovation.

The influence of contextual factors on sustainability transition engenders trials, tests, and verification by native researchers, and negotiations with stakeholders and users. The contextual factors also encourage stakeholders to alter and uncover alternatives while offering opportunities for developing, improving on and utilising local capabilities for innovations. The initial plan for a pilot FPV plant resulted in rejection because concerns raised by the local authority and the community that was heavily reliant on the waterbody were insufficiently addressed by the relevant stakeholders and because it was believed that FPV would affect marine biodiversity. In other words the fact that relational materiality was not given due consideration by the actor networks contributed to the initiative being discontinued.

In light of this empirical evidence and experience, the initiative to bring together Norwegian and Sri Lankan academics and private sector stakeholders, to combine local contextual knowledge with global technological expertise to demonstrate to the native stakeholders and users of the suitability of FPV through a DP confirms the usefulness of collaborative work. By being responsive to the contextual particularities and attending to the interrelatedness between the indigenous energy sources, landscape, infrastructure, and human-environmental relationships, the DP has led to a tailored innovative process as revealed by short-term assessment. DP is an absolute materiality. How different actors, nature, and the immediate environmental characteristics connect and relate to this materiality is what

determines whether the project will prompt acceptance of the new technology, to achieve low-carbon solutions. In this case, while the main purpose of the FPV-DP was to display, learn, and shape the technology to befit the context and produce sustainable electricity without placing greater competition on already-contested land space, there have also been other consequential benefits. These have included, as mentioned by the interviewees, academics exploring improved electricity production efficiency (Kjeldstad et al., 2022) in their own context, the private industries incentivised as a result of legitimisation of adapted technology, policymakers securing a legitimised alternative solar option for large-scale expansion (CEB, 2021), contested rural landscapes avoiding further demand for land space, and a local university engaging in sustainable energy generation in its own context through research, national and international collaborations, and networking (University of Jaffna & Western Norway University of Applied Sciences, 2022).

It is also true that while the DP herein was not a purely real-world setting for observations or soliciting feedback and perspectives of residents living nearby, it does illustrate the expectations of different stakeholders. Importantly, the case shows that absolute materiality (technology, land, water) is not isolated from the relational dimension, and that renewable energy technologies for sustainability transition demands the absorption of contextual relational materiality (rationalities of actors towards the absolute) for an effective and sustainable transition process.

## 6. CONCLUSION

Within the literature, insufficient attention has been paid to materiality, and technology has been taken for granted as an end-product in a transition process. This is despite the contextual heterogeneity within the GeoST. The technological characteristics of the tangible have received scant analytical or theoretical consideration. A presumption within transition studies has been

that once technologies mature, they can be imported and assembled relatively easily in other contexts (Krishner et al., 2019). This presumption is especially the case for solar PV technologies, instigated by falling prices of PV panels and the fact that their improved performance is considered ubiquitous (Markard, 2018). A few studies have highlighted that the innovative process has resulted in the growth of solar PV by way of revisiting their political, economic, and cultural energy landscapes (Kirshner et al., 2019). Nonetheless, scant consideration has been given to relational materiality within the GeoST, i.e., how footloose solar PV is influenced by social and natural place-based conditions. Sri Lanka's grid-tied solar energy transition journey leading to requiring the legitimisation of FPV by means of a DP, affirms that successful implementation of technologies not only demands legitimisation/acceptance among a broad set of social actors such as policymakers, financial institutions, and other key stakeholders (Njøs et al., 2020), it also demands alignment with the technology's natural material requirements. Failure to acknowledge the contextual relational dimension of technology (e.g., that land for ground-mounted solar energy generation is finite) can create controversies and hamper transitions (Fontaine, 2020). While rural land related contestation for any development activity is a global fact, in relative terms, conflicts arising from demands for sizable land such as for ground-mounted solar PV is significantly more acute in population dense countries like Sri Lanka, again bringing to the fore the need for a context sensitive approach to materiality and consideration of alternate forms of solar PV technology.

By engaging with real-world conditions in the realisation of solar PV technology in Sri Lanka – this paper illustrates how important it is to contextualise technology by paying closer attention to the relational dimension. Similarly, by scrutinising the role of relational materiality in contextualising technology, this paper underscores and informs the extant literature that the materiality (tangible) aspect of solar PV technology development is as important as the

intangibles widely discussed in the GeoST literature. This study also affirms that establishing and strengthening international collaborations not only enables technology transfers but also encourages domestic innovation, including technological alterations for adaptation, by means of developing and improving domestic capabilities and capacities.

Thus, the paper contributes to the literature by offering empirical evidence of how and why relational materiality influences the uptake of footloose technology. While the GeoST field is broad, this study contributes a single case study. Further research in different geographical contexts will be needed to validate and generalise these case study findings.

## DISCLOSURE STATEMENT

*The author reports there are no competing interests to declare*.


## FUNDING

This work was funded by the Royal Norwegian Embassy, Colombo, grant number LKA-3182/LKA-16/0001.

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**Information sheet and consent form:**

# Are you interested in taking part in the research project *Renewable energy sector governance in Sri Lanka: Drivers and barriers in clean energy transition*

This is an inquiry about participation in a research project where the main purpose is to understand how the renewable energy (RE) sector in Sri Lanka operates and to map out the drivers and barriers existing within the sector. In this letter, we will give you information about the purpose of the project and what your participation will involve.

**Purpose of the project**

The purpose of this research is to understand the governance dynamics of the renewable energy sector in Sri Lanka and the existing drivers and barriers within the sector in the development of renewable energy technology.

The objectives of the project are three-fold

- to map the drivers and barriers existing within the RE sector in clean energy transition,
- to understand the governance dynamics within the RE sector in Sri Lanka, and
- to serve as a guide for future RE technology investors and developers

The research questions are as follows:

How does the literature on Technological Innovation Systems (TIS) explain clean energy transition and how does this resonate with clean energy transition in the developing country context of Sri Lanka?"

1. What characterize processes of clean energy transition according to the TIS literature?
2. What are the drivers and barriers pointed at by the stakeholders that make up the renewable energy sector/ RE technology in Sri Lanka?
3. How can the energy sector governance in Sri Lanka stimulate drivers and relax barriers to sustain a scaling up of RE technology in Sri Lanka?
4. In what way does this study of clean energy transition in Sri Lanka - a developing country context inform the TIS literature on clean energy transition?

This research is for a doctoral thesis. The data collected will be solely used for the research of the particular PhD programme.

**Who is responsible for the research project?**

Western Norway University of Applied Sciences is the institution responsible for the project.

**Why are you being asked to participate?**

The participants for this research are mainly representatives of different renewable energy sector institutions both public and private, energy experts, environmental activists, private investors in renewable energy technology such as solar (in both Sri Lanka and Norway) and

academics. The research will use purposive sampling. I aim to interview representatives of relevant institutions and organizations. I will also be using the snowball approach to a certain extent, in which I will follow any relevant recommendations to others from interviewees.

**What does participation involve for you?**
If you chose to take part in the project, this will involve an interview. It will take approximately 1 to 1½ hours. The interview includes questions about the ongoing renewable energy transition in Sri Lanka, the processes involved within the renewable energy sector, and the drivers and barriers in the development and diffusion of renewable energy technology. Your answers will be recorded using a voice recorder.

**Participation is voluntary**
Participation in the project is voluntary. If you chose to participate, you can later withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

**Your personal privacy – how we will store and use your personal data**
We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

- I am (PhD student) attached to the Western Norway University of Applied Sciences and will have access to the collected data.
- I will replace your name and contact details with a code. The list of names, contact details, and respective codes will be stored separately from the rest of the collected data.

I will annex a list of interviewees to my thesis carrying the name, occupation, and the institution they represent.

**What will happen to your personal data at the end of the research project?**
The project is scheduled to end by 02-04-2022. At the end of the project, I will store the data collected for a period of two years for any further verification and follow-up. The collected data will be stored by me (the data controller/PhD student).

**Your rights**
So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

**What gives us the right to process your personal data?**
We will process your personal data based on your consent.

Based on an agreement with Western Norway University of Applied Sciences, NSD - The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

**Where can I find out more?**
If you have questions about the project or want to exercise your rights, contact:

- Western Norway University of Applied Sciences via Prof. Arnt Fløysand (Arnt.Floysand@hvl.no) and Prof. Dhayalan Velauthapillai (Dhayalan.Velauthapillai@hvl.no).
  Our Data Protection Officer: Halfdan Mellbye by email: personvernombud@hvl.no.

- NSD – The Norwegian Centre for Research Data AS, by email: (personverntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Researcher/PhD student

**Participant consent form**

I have received and understood information about the project “Renewable energy sector governance in Sri Lanka: Drivers and barriers in clean energy transition” and have been given the opportunity to ask questions. I give consent:

- ☐ to participate in an interview
- ☐ for my name, designation, and institution to appear in the list of interviewees as an annexure in the thesis of the above research
- ☐ for my personal data to be stored after the end of the project for a period of two years for verification and follow-up studies

I give consent for my personal data to be processed until the end date of the project, approx. [02-04-2022]

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(Signed by participant, date)

## Interview Guide

I will be carrying out semi-structured interviews with different stakeholders representing different authorities, institutions, and organizations making up the renewable energy sector in Sri Lanka in order to understand their reflections on how they see and witness the energy transition, what they see as the drivers and barriers and how can the way forward be for Sri Lanka. To do this I will be interviewing representatives from relevant

1. Public sector institutions making up the renewable energy sector in Sri Lanka
2. Private sector investors such as investors in technologies such as solar in Sri Lanka (investors can be from Sri Lanka and Norway), independent and small power producers, and other institutions identified while my data collection and research progress.
3. Experts in renewables and academics
4. Environmental activists

*The interviews will be conducted in English, but if the need arises the interviews will be held in the local language (Tamil or Sinhala)*

**Public sector stakeholders:**

*The interview questions will focus on the following*

1. Renewable energy sector networks:
   Questions will focus on actors, networks, institutions, working mechanisms, and processes existing within the sector.
2. Renewable energy sector governance:
   Questions will focus on promising energy technologies for Sri Lanka, the development of renewable energy technologies such as solar, managing energy transition (both fossil fuel and renewables), the drivers and barriers existing within the sector, and steps taken to stimulate drivers and relax barriers.
3. Private sector engagement:
   Questions will focus on the response of the private sector towards renewable energy technologies, its future, drivers, and barriers in the engagement of the private sector, and suggestions to strengthen the engagement,
4. Way forward:
   Questions will focus on the way forward for Sri Lanka and suggestions for the country to achieve its target

**Private sector stakeholders:**

*The interview questions will focus on the following*

1. Private sector engagement and renewable energy transition:
   Questions will focus on reflections regarding the private sector engagement and energy transition and contributions

2. Drivers and barriers:
   Questions will focus on drivers and barriers in the renewable energy sector, engagement of the private sector in renewable energy technologies such as solar, and the phasing out of fossil fuels.
3. Promising technologies for the country:
   Questions will focus on their reflections on the future of renewable energy in Sri Lanka and the future and potential of solar in Sri Lanka
4. Way forward:
   Questions will focus on the way forward for Sri Lanka, suggestions for the country to achieve its target, and the contributions of the private sector.

**Experts and academics:**

*The interview questions will focus on the following*

1. Reflection on transition and progress:
   Questions will focus on how they see the transition and the progress with regard to renewable energy and the promising technologies for Sri Lanka and their limitations such as in the case of solar
2. Drivers and barriers:
   Questions will focus on the drivers and barriers in the energy transition within the renewable energy sector
3. Resources:
   Questions will focus on the resources Sri Lanka has for transition and the additional support the country needs to accelerate the transition
4. Way forward:
   Questions will focus on the way forward for Sri Lanka, suggestions to achieve the country's target, and the contributions from the expert and research community.

**Environmental activists:**

*The interview questions will focus on the following*

1. Reflection on transition and progress:
   Questions will focus on reflections on transition, the progress with regard to renewable energy, promising technologies for Sri Lanka and their limitations such as in the case of solar
2. Drivers and barriers:
   Questions will focus on drivers and barriers in the energy transition within the renewable energy sector
3. Environmental impacts:
   Questions will focus on the environmental impacts when it comes to renewables and the level of acceptance.
4. Way forward:
   Questions will focus on the way forward for Sri Lanka, and suggestions to accelerate the transition and achieve the set targets.