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RESEARCH ARTICLE



# Advancing a transformative human development approach to climate resilience through local innovation in South Africa

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## ABSTRACT

Climate change continues to exacerbate social and economic development challenges in local communities the world over. This paper advances a human development approach to climate resilience innovations, showing how local innovation initiatives can be conduits for increased equity, agency, efficiency and sustainability vis-à-vis effective responses to climate impacts. Based on a scoping review of literature (journal articles, books, theses, occasional papers etc.), and through a discussion of four case studies focused on technological and institutional innovations in selected rural South African communities, a major finding is that local innovation initiatives vis-à-vis livelihoods are laden with opportunities for improved social, economic and ecological well-being. Appreciating and supporting these local innovations will open up viable and transformative pathways towards effectively responding to the impacts of climate change and variability. The paper contributes to an interdisciplinary integration of innovation and climate change research by exploring climate resilience through a transformative human development lens.

## KEYWORDS

Transformative human development; climate resilience; local innovation; South Africa

## 1. Introduction

Climate change is one of the world's most problematic human development challenges. With global temperatures and sea levels rising and projected to continue to rise throughout the twenty-first century, short-term disasters and the longer-term effects will continue to negatively impact on people's livelihoods and people's abilities to lead healthy lives (UNDP 2009). South Africa is highly vulnerable due to its dependence on climate sensitive economic sectors and high poverty and inequality rates, which compromise the adaptive capacity of most citizens (The World Bank Group 2021). The South African rural populace is even more vulnerable because it forms most of the country's poor and underprivileged who depend either directly or indirectly on land and the environment as sources of livelihoods (Jacobs & Msulwa 2019). Climate change is expected to increase food insecurity and exacerbate poverty within most rural

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communities of South Africa (Jacobs & Msulwa 2019). Climate change is also expected to exert significant management demands on institutions and decision-making processes, especially with respect to regulating access to and the use of increasingly scarce natural resources such as water, and the maintenance of vital ecosystems (Nyamwanza & Kujinga 2017).

It is against this background that this paper uses a Transformative Human Development (THD) approach in exploring how local innovation initiatives contribute and lead to climate resilience. A THD approach is fundamentally about people and the choices and opportunities at people's disposal in dealing with the challenges they face. The central hypothesis of the paper is that appreciating and advancing the role of local innovation in rural communities will open up more transformative opportunities for the most vulnerable to efficiently respond to the impacts of climate change and variability. We ultimately aim to contribute to ongoing conversations around the applied and interdisciplinary dimensions of human development, climate resilience, and innovation research.

## 2. Methods and conceptual reflections

This article was prepared based on a scoping review of literature (journal articles, books, theses, occasional papers etc.) on the conceptual and theoretical aspects, as well as South African empirical cases linking transformative human development, climate resilience and local innovation. Colquhoun et al. (2014) define a scoping review as a form of knowledge synthesis which aims at mapping key concepts, types of evidence, and gaps in a research area or field by thoroughly searching, selecting, and synthesising existing knowledge. For this paper, the key strategy was to explore what has been written on the issues of interest from a broader perspective first, before narrowing down to relevant aspects and ideas that were of assistance in coming up with a solid and focused analysis. This involved casting the net as wide as possible particularly during internet search with free text searches on the following databases: *Academic Search Premier*, *Scopus*, and *Google Scholar*. We mainly used the following search terms: 'transformative human development', 'climate resilience', 'local innovation South Africa', 'institutional innovation', and 'technological innovation'. We then scanned the various articles emerging towards exploring and coming up with a clear understanding of the role of a transformative human development approach in advancing climate resilient livelihoods and institutions as built through local innovation in South Africa.

### 2.1. Exploratory case study analytical approach

A review of empirical cases involving technological and institutional innovations from rural South Africa was used in analysis. The analysis focused on selected case experiences to show how local innovation advances THD imperatives towards climate-resilient livelihoods and institutions. Our case study approach is exploratory in outlook. Exploratory case studies seek to clarify complex concepts, bring new insights to issues, and to assess phenomena in a new light (Yin 1994). The objective is to give as thorough, detailed, and complete an analysis to issues as possible. The literature on case study research does not pinpoint a specific number of cases for use in exploring an issue. It, however, suggests a minimum number of four cases for sound research results and conclusions (Eisenhardt

1989; Leitner & Strauss 2008). Ideally, cases should be selected as to provide examples in vivid analytical and/or geographical spaces in order to maximise lessons (Stake 1995). Following these insights, our analysis zeroes in on cases that focus on innovations in agriculture, water security and decision-making. Apart from dovetailing with technological and institutional innovation imperatives, these selected analytical focal areas are critical, if not central, in building resilient livelihoods and institutions vis-à-vis climate change in rural Africa.

## 2.2. Conceptual reflections

### 2.2.1. Transformative human development

A transformative human development (THD) approach is premised on the four well-known principles that underpin the general notion of human development i.e. equity, efficiency, agency and sustainability. The THD approach, however, departs from extant approaches of human development in terms of the priority ranking of the principles and the greater weight given to structural rather than subjective individual determinants of human development outcomes in existing approaches. To place our characterisation of THD in perspective, it is useful to provide some brief discussion on the four human development principles.

*Equity* is grounded in values of socioeconomic equality and distributional justice and has received increasing prominence in development scholarship and global policy agendas since the turn of the millennium. Bourguignon (2016:78) defines equity as

an ex ante equality concept defined in the space of opportunities or capabilities rather than in the space of results, as would be the case with incomes, consumption and expenditures or any standard measure of economic wellbeing. Normatively, it is clearly related to the social justice literature . . . .

This definition suggests that equity is more than just a soft version of equality which might also be less politically loaded and more palatable in global diplomatic discourse. Redefining equity as equal opportunity does not only disconnect equity from egalitarianism but prescribes how to achieve human developmental outcomes through equal opportunities.

*Efficiency* refers to viable resource use towards productivity growth. Mainstream neoclassical economics rank the efficiency-equity trade off as the leading criterion to guide policy actions about improving human wellbeing. To differentiate between efficiency and equity, neoclassical thinkers elevate the role that economic growth plays in the definition of each concept. Whilst efficiency registers change in the level or rate of economic growth, equity turns on fairness in the allocation of the benefits of economic growth (Bourguignon 2016). Development thinkers and practitioners in this tradition equate efficiency with achieving the highest level of productivity and outputs with the best (theoretically ideal) combination of productive inputs. To the extent that efficiency offers insights into socioeconomic development at economywide or global scales, it merely registers levels of material wealth and prosperity.

*Agency*, as a principle of human development, pivots on the active involvement of human beings, as individuals or collectives, in shaping quality of life outcomes that matter to them. In contrast to the passive recipient of development handouts, this

principle is about active goal-directed or purposeful action and empowering the actors to act accordingly. Agency involves reflexivity, learning and adaptation through internalisation of experiences and information exchanges with others.

*Sustainability* is anchored on the three pillars of economy, ecology and society. The economic dimension links with human welfare, the ecological dimension with environmental integrity and the social dimension human relationships (including social equity and justice). These pillars ‘integrate the notion that for continued human progress, development must determine pathways that both attain economic goals while simultaneously finding a balance with the physical environment and social well-being in varied contexts’ (Bhatasara & Nyamwanza 2018:91). Eriksen & Brown (2011) posit that the notion of sustainability is increasingly being connected to climate resilience due to the realisation that there is need to be critical of how people and communities respond to climate change in terms of effects for poverty and environmental challenges confronting the world.

Given the characterisation of these principles, a THD approach does not begin with measuring indicators but with understanding the objects and processes of change, based on the four principles synthesised above. With the accent on integrating what to transform, by whom and how, this approach prioritises purposeful agency-equity interactions, and hence choices and opportunities. A transformative approach also elevates the sustainability aspect, and, in essence, incorporates sustainability in a double sense. First, sustainability matters in its own right as a principle which registers temporal spill overs of making a living, prolonging the diffusion of livelihood benefits whilst simultaneously preventing its costs for future generations. Second, the approach not only ranks sustainability above efficiency, but also views it as a determinant of efficiency. Sustainability therefore modifies the nature of efficiency in the same way that it can modify agency-equity valuations.

### 2.2.2. *Climate resilience and local innovation*

### 2.3. *Climate resilience*

Climate resilience is now a widely used term, variously interpreted but broadly understood to refer to people’s ability to respond to, recover from and adapt to the impacts of climate change and variability. Following Grist (2018), in this paper we look at climate resilience as consisting of 3 aspects, namely:

- (a) the capacity to anticipate climate impacts – to include undertaking proactive action before adverse climate events happen
- (b) the capacity to absorb and adapt to climate change impacts – to include learning from and adjusting to the effects of climate change and variability, through, for example, livelihoods diversification and switching to stress-tolerant varieties
- (c) transformative capacity – to include the ability to change institutional set-ups and other livelihood practices in a structural way.

Pathways of change towards climate resilient livelihoods and institutions therefore include shifts in knowledge and technologies, skills, creation of partnerships, and inclusive decision-making processes which boost capacities of response to climate change impacts.

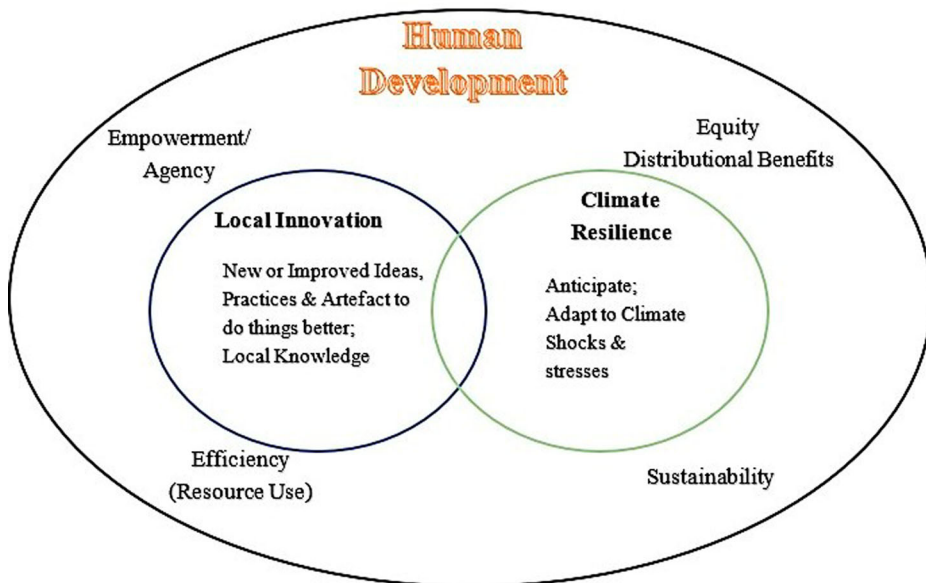
## 2.4. Local innovation

Hoffecker (2018:4) defines local innovation as

the process and product of developing and introducing into use new and/or improved ways of doing things compared to existing practice within a specific local context, which involve local people and resources in addressing challenges and opportunities present within that context.

The process of local innovation has also been referred to as ‘grassroots innovation’, meaning that it is generated more from within the local community, rather than from outside it (Asseffa et al. 2009). Grist & Harvey (2017: 7) articulate that ‘a grassroots innovation may have one or more of the following five characteristics: newness; adaptation from other efforts; collective and socially cohesive interactions; application of new knowledge content; and new or improved learning pathways’. Innovation may therefore involve new or improved ideas, new or improved technologies, novel applications of existing technologies, establishment of new or improved processes and/or institutions, or ‘more generally, new and/or improved ways of doing things in a place or by people where they have not been used before’ (Juma et al. 2013:2). As Rodima-Taylor et al. (2012) note, the litmus test for successful innovation is ultimately a combination of analytical judgements about durability, and normative judgments about context-specific positive impact.

Figure 1 schematically illustrates how climate resilience interacts with innovation through a human development conceptual framing. To read this schematic illustration, especially its key concepts and human development principles, the ideal starting point is the Venn diagram in its centre. Even though climate resilience and innovation are independent processes, their integration takes place in the zone where the two central circles or spheres overlap. It is in this overlapping area of the Venn diagram that constituent



**Figure 1.** Human development approach and links with local innovation and climate resilience.

elements of innovation (new or improved ideas and practices) intersect with the substance of climate change resilience. [Figure 1](#) also situates climate resilient innovations in the four human development principles. These principles enable us to think through the extent to which different agents in a specific social context participate in climate resilient innovations and if the novel adaptations to climate change stresses are equitable, sustainable and efficient.

### **2.5. Climate resilience innovations**

In this paper, we consider climate resilience technological and institutional innovations as being built through tailored and improved climate-specific changes in knowledge, partnerships, capacities, and decision-making processes (after Grist & Harvey 2017). In assessing how innovation improves climate resilience, we combine an observation on markers of climate resilience discussed earlier in this section, and aspects of how innovation works and succeeds. To that end, climate resilience innovations will, therefore, have one or both of the following:

- (a) The innovations have been adopted and demonstrated changes in one or more aspects towards climate resilience
- (b) The innovations are/can be considered to be improvements to the previous or current solutions used by communities

## **3. Results**

### **3.1. Empirical cases – lessons from South Africa**

The four empirical cases in this section cover new or improved technological and institutional initiatives to responding to climate change and variability, which expand people's choices and opportunities and/or empowers them to adapt to climate challenges in a sustainable manner, in line with key THD imperatives. As will be shown, the cases ultimately point to pathways for resilient livelihoods and/or institutions in the context of climate change and variability.

#### **3.1.1. Technological innovations**

Economic theory distinguishes technological innovations depending on their impacts on inputs and outputs (Zilberman et al. 2017). For example, distinctions can be made between risk reducing, quality improving, capital saving, and labour-saving technological innovations. Discussion in this paper mainly focuses on the first two aspects (i.e. risk reducing and quality improving); revolving around technological innovations in agriculture and water security, with specific examples on rainwater harvesting and the use of drought tolerant crops drawn from Northern Cape and Limpopo provinces.

## **4. Case 1. Rainwater harvesting**

Rainwater harvesting (RWH) refers to all practices of rainwater collection, storage, and efficient utilisation for agriculture and/or domestic uses (Biazin et al. 2012). Water



harvesting has been used for centuries in dry areas to collect and utilise rainfall more efficiently (Botha et al. 2017). Proper husbandry of rainwater also feeds into integrated water resources management as it promotes groundwater recharge, balances water resources demands, and advances ecological sustainability (Botha et al. 2017). From that angle, the THD principle of sustainability is in-built within the RWH technology. There is a growing realisation that, in the context of climate change and variability, conventional irrigation practices are becoming unsustainable for most dryland subsistence farmers in South Africa, and that, in the context of resource constraints, the potential for improving farm productivity, livelihoods and family incomes can be enhanced through tapping into such enduring technologies as RWH (Mwenge Kahinda & Taigbenu 2011).

#### 4.1. Rainwater harvesting in the Northern Cape province

Farmers in Northern Cape communities around Clanwilliam, north east of the Cederberg mountains and north of the Roggeveldberge mountains have adopted the *Saaidamme* RWH technology. *Saaidamme* is an Afrikaans word for ‘planting dams’ (Figure 2).

The area where this technology is being utilised is characterised by a flat desert landscape and it averages annual rainfalls of 100–200 mm. Rivers in the area typically have minimal or zero-base flows. Denison & Wotshela (2009) note that, as in most arid areas, minimal natural vegetation and occasional high-intensity rainfall in the area results in high rainfall run-off with some localised floods. To capture the fertile, silt-laden flood-water running off from distant mountains (some of which are 100 to 150 kms away), structures are built to divert the water into a series of large, flat basins which extend between 1 and 100 ha in size each. By capturing fertile, silt-laden flood water from distant mountains, this contributes to the THD aspect of ecological and social sustainability in the area as it enhances the productive capacity of soils in dry landscapes around the created flat basins for better yields. Each basin is ringed by an earth wall which measures between 1 and 2 metres deep and which is effectively a shallow dam. Water accumulates in the basins up to 1 m deep for between 1–3 days to saturate the very deep alluvial soils. Through this initiative, resource-poor farmers in this area are

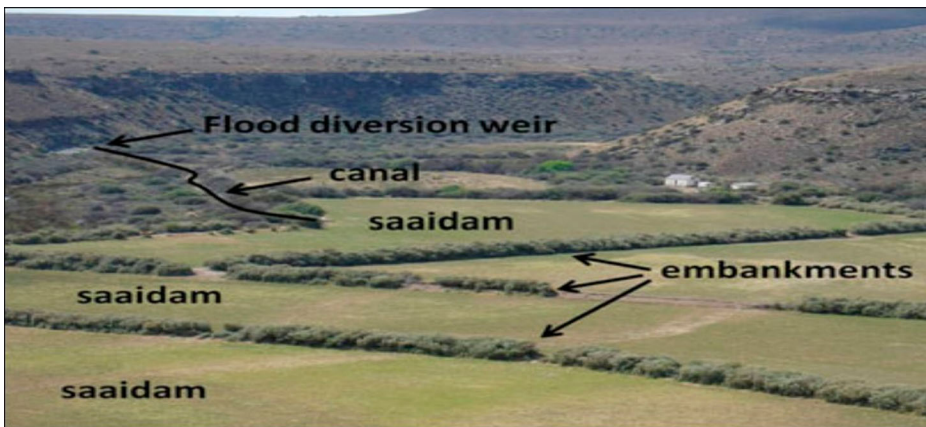


Figure 2. A *Saaidamme* system. Source: Denison & Wotshela (2012).



exhibiting agency by proactively tapping into enduring traditional technologies used over the years in Africa and beyond, in responding to local climate-related stresses (i.e. prolonged droughts, occasional high intensity rainfall and localised floods in this case). This is because the *Saaidamme* are based on similar models of floodwater irrigation used along the Nile River in Egypt for thousands of years and follows after the flood plate system used in Pakistan and Morocco. This case study, therefore, clearly reflects the THD principles of agency and sustainability with respect to climate resilience. The case also brings out the efficiency aspect vis-à-vis the efficient utilisation of rain water for both productive and household uses in a drought- and flood- prone area.

## 5. Case 2. Drought-tolerant crops

Drought and increasing heat conditions are becoming some of the top constraints to agricultural activity in South Africa due to climate change (El Chami & El Moujabber 2016). The country's Crop Estimates Committee, for example, reported that during the 2018/2019 season the country harvested 20 percent less maize because of drought conditions (SAGIS 2020). The drought problem is likely to become worse if projected trends in climate change are to play out. Smallholder farmers will be the most affected because many do not have irrigation technology and rely on rainfall for their crops. Increasing incidences of drought and heat conditions and the accompanying increasing crop pests and diseases will severely compromise the cultivation of staple crops such as maize, wheat and rice (Johnson 2017). The main challenge vis-à-vis climate resilience in this context is around starting to focus on cost-effective crops and varieties with drought-tolerant and heat-resistant traits for different South African agroecological zones (El Chami & El Moujabber 2016). Dinesh et al. (2017:4) articulate that drought tolerant crops and varieties offer much needed answers as 'one of the best bet innovations for climate adaptation and resilience in agriculture'.

### 5.1. Adoption and cultivation of Bambara groundnut crop in Limpopo province

Farmers in the Capricon district of Limpopo province in South Africa are adopting Bambara groundnut (*Vigna subterranea*) in response to progressively adverse climatic conditions in the area. Capricon district is characterised by a predominantly flat topography. It is semi-arid and characterised by wet and hot summers and cool dry winters. Mpandeli et al (2019) note that Capricon district has been experiencing low rainfalls, high temperatures and recurring mid-season droughts in recent years. Their analysis shows that drought events in the district have been occurring at an average of one drought event in every 3 years. Rainfall is becoming more erratic, starting late, and affecting the length of the cropping season. There has also been an increase of severe heat waves during summer seasons, and heavy storms and cyclones around the period January to March (Mpandeli et al. 2019). These conditions make the adoption of the Bambara groundnut crop timely. Known as *Izindlubu* in South Africa, the crop is an African indigenous legume which shows great potential particularly in semi-arid regions. Adopting this indigenous legume emanating from local production systems expressly exhibits the THD agency aspect. The crop has high drought resistance and can produce reasonable yields with minimal inputs in areas of low rainfall and poor

soil fertility thereby bringing out the THD aspect of efficiency. In his study investigating the adoption of the Bambara groundnut in the district, Cook (2017) notes that the majority of those adopting the crop were old (65 years of age and above) and they were mostly female, producing the crop primarily for household use hence expanding food security opportunities and exhibiting THD equity imperatives vis-à-vis resilient livelihoods for the most vulnerable in society. The main factors underscored by those who had taken up Bambara groundnut cropping as having been critical for them to adopt the crop included: (i) the crop's high drought resistance, (ii) the crop's ability to intercrop well with maize, (iii) its high nutritional value, (iv) the nitrogen fixation properties of the legume, and (v) its ability to improve soil fertility. In this case, the adopted crop, therefore, contributes to ecological and social sustainability imperatives by combining various ecological and nutritional advantages (through e.g. its high nutritional value, intercropping compatibility, and its nitrogen fixation properties). THD principles of agency, efficiency, equity and sustainability are, therefore, clearly at play in this case study as farmers in the area seek to build resilience against increasing drought conditions.

### 5.1.1. Institutional innovations

Institutions are critical for climate resilience in rural communities because, as Agrawal (2010) articulate, they play key roles in 2 aspects: they mediate between individual and collective responses to climate change impacts, and they act as a mode of delivery of external support for climate impact response measures. Transitions to changing and highly variable climate patterns do not occur in an institutional vacuum, therefore efforts to generate appropriate climate resilience mechanisms require innovative institutional arrangements which adapt to new and changing demands. Institutional innovation refers to changes made in redefining roles and responsibilities of different organisations, customs, and/or individuals to deliver more positive returns (Tenywa et al. 2011). Following Rodima-Taylor et al. (2012), institutional innovation in this paper is conceptualised around three main aspects, namely: (a) visible changes in institutional arrangements brought about through intentional interventions, (b) changes in underlying rules-in-use in collective choice arenas, and (c) solutions to governance dilemmas which communities face due to and in dealing with climate change and variability.

Institutional partnerships which facilitate the involvement of different knowledge systems are powerful sites of local innovation towards responses to climate change. As Rodima-Taylor et al (2012:108) articulate, 'since the effects of climate change are felt mostly by the poorest populations and social groups, special attention should be directed to local structural inequalities and towards the amplification of the voice and representation in decision-making of these groups'. The two cases discussed in this section touch on issues around multi-institutional collaboration and co-production of knowledge important in addressing new and worsening climate challenges. Both cases are drawn from the Limpopo province.

## 6. Case 1. Farmer-extension-research collaboration and joint learning for biopesticide development in Limpopo province – Chuene et al. (no date)

Limpopo province is characterised by dry spells and increasingly high temperatures. Most insect pests thrive in conditions of high temperatures and this has resulted in

difficulties in managing pest infestations in such districts as Sekhukhune, especially for smallholder farmers. It is reported that aphids, for example, increase their developmental rate when temperatures are high, which means with high temperatures, aphids will develop faster with increased numbers of generations leading to increased aphids populations (Phophi et al. 2020). Vegetable and livestock farmers in Sekhukhune district could not afford expensive modern pesticides. They therefore came up with a combination of plants to develop their own recipes for pest control/biopesticides, exhibiting the agency aspect of THD. Local extension workers, working with and building on farmers' knowledge, and in collaboration with researchers from Limpopo's Department of Agriculture (LDA), established a joint learning process. This joint learning process in the development and promotion of the pesticide provided an equal platform for local farmers to work with other players in developing products useful in their livelihood endeavours thereby advancing THD equity imperatives. The partnership aimed at conducting formal experiments to test the performance of the biopesticides, and to develop a market for it. The process also involved the Agricultural Research and Development (ARD) Limpopo Hub, an interinstitutional body of stakeholders collaborating in agricultural research for development. The hub consists of the Agricultural Research Council's Technology Transfer Academy, the Universities of Venda and Limpopo and the LDA. According to the LDA, communities in the area 'did not realize the value of their knowledge and the extent to which this information can benefit them, for example by generating income from it and by using policies to gain benefit from knowledge sharing' (Chuene et al, no date: 78). Under the collaborative activities, the ARD hub developed a strategy for the promotion of the biopesticide in the province. Activities under this strategy also include the development of promotional materials in print and audio media.

The ARD hub became a platform to utilise the expertise of different stakeholders and outline the role that each can play in research and in the development of improved biological pesticides in the area. The different stakeholders worked together and identified ways to support the local initiative, including the extent to which they have influence on the outcomes and the scaling up of the initiative. They also explored efforts required to develop the biopesticide on a wider scale, its mode of action, dosage, shelf life, and marketing in order to draw farmers who originated the pesticide into the mainstream economy. The LDA, in particular, undertook to develop a database for indigenous plants used in developing the biopesticides, assist with the financing of nursery for cultivation of the plants used for the purposes of scaling up, further testing of the efficacy of the biopesticides on different pests and diseases, and promoting the commercialisation of the biopesticide product. Most farmers expressed satisfaction with the operation of the joint learning platform, and the financial benefits realised point to the perpetuation of the learning forum into the future thereby contributing to THD sustainability imperatives in terms continuity of the initiative and its benefits. The biopesticide developed by the group is now used as a broad-spectrum pesticide and is marketed locally to other farmers in the province through an umbrella body called Phadima Farmers Association (PFA). In terms of building resilience in the context of increasing dry spells and high temperatures, the locally developed biopesticide initiative has therefore efficiently filled in for the more expensive modern ones, which local farmers could not afford – thus combining THD equity and efficiency imperatives in this regard.

## 7. Case 2. Recognising the role of indigenous ‘Makhadzi’ rainmakers in climate resilience in Limpopo – Kaya (2016)

Vhembe District in South Africa’s Limpopo Province is well-known for its biodiversity and cultural richness. Its sacred sites have been under the cultural custody of the elder women of the communities, known as *Makhadzis*, over the years. These elderly women are historically known as ‘rainmakers’ in the area because of their capacity to invite rain through cultural rituals. Because of years of colonisation and the encroachment of western institutions on traditional set-ups, the *Makhadzis* became increasingly marginalised and silenced. Also, their traditional roles as advisors to chiefs on various social, environmental, and other community issues were undermined. Recently, however, with support from a South African non-governmental organisation (NGO) called the Mupo Foundation – an organisation focused on social and environmental justice in South Africa, the *Makhadzis* are finding their voices again. They have now been placed at the forefront in protecting Vhembe’s network of sacred forests and to set an important legal precedent for South Africa’s natural and cultural heritage. In the face of climate change, the health and vitality of ecosystems is important. The *Makhadzis* are now being integrated into decision-making community structures by being allowed to join elderly men and chiefs of the community towards forming a community-based organisation called *Dzomo la Mupo* (which means Voice of the Earth), for the purposes of ‘protecting nature in all her forms, and especially indigenous forests ... [and] to protect and preserve sacred sites in Vhembe’ (Ratiba 2015).

According to the *Makhadzis*, loss of forests is one of the reasons for and manifestations of climate change and its impacts hence the need to conserve the forests; and the *Dzomo la Mupo* platform is assisting them in gaining their voice in this regard. The inclusion of these previously marginalised elderly women (the *Makhadzis*) into natural resource conservation platforms such as the *Dzomo la Mupo* platform has resulted in critical advances in biodiversity conservation in the area in the context of climate change, thereby advancing THD equity and sustainability principles. Within local forests are also a lot of springs of water that feed into one of the major local rivers (the Luvuvhu river). The river catchment provides water for the surrounding land and communities, and as the *Makhadzis* now emphasise, the forests should be revered as sacred as they act as sources of water for different uses in the context of increasing droughts in recent years. It has now become the responsibility of the *Makhadzis* therefore, as the traditional custodians of these sacred forests, to ensure that the forests and all ecosystems in them are safeguarded and respected towards both ecosystem and community livelihood resilience. This case reflects areas where institutional innovation initiatives have advanced all the four principles of THD in the form of agency and equity with respect to participation of hitherto marginalised groups in local community decision-making as well as efficiency and ecological sustainability vis-à-vis dealing with biodiversity loss.

## 8. Discussion

The cases discussed in the preceding section provide clear examples of how local innovation initiatives may advance human development objectives in transformative ways

vis-à-vis climate resilience in local communities. What comes out clearly across all the four case studies is particularly the prominent role of equity, agency and sustainability imperatives, with efficiency aspects contributing to expanded choices and opportunities vis-à-vis the building of resilience against climate challenges. The two technological innovation cases presented, for example, both bring out the centrality of indigenous knowledge-inspired initiatives towards responding to climate-related stresses by local farmers. Institutional innovation cases discussed are mainly anchored on agency and equity vis-à-vis climate resilience in communities involved. Both institutional innovation cases discussed, for example, show instances and the importance of the involvement of previously marginalised groups into decision-making processes. The inclusion of hitherto marginalised groups, women, and grassroots community groups in devising climate change response mechanisms allows for and promotes community-level ownership of adaptation planning and implementation processes. Rodima- Taylor et al (2012) articulate that much climate action in recent years has shifted towards and concentrated mostly on building local resilience through participatory techniques and community empowerment. Local institutional innovation initiatives which build participatory platforms therefore promote community agency towards response to climate impacts. In the two institutional innovation cases presented, there are new and/or improved forms of institutional arrangements with ability to facilitate stronger responses to climate perturbations.

## 9. Conclusion

This paper utilises the THD approach in showing how local innovation can lead to climate resilience. Using cases of technological and institutional innovation initiatives from rural South Africa, the paper advances the point that aspects of the human development approach i.e. efficiency, equity, agency and sustainability, can be realised through local innovation and these may, in turn, lead to transformative resilient climate action in local communities. As highlighted in the introduction section, the paper contributes to scant but important conversations on the applied and interdisciplinary dimensions of human development, climate resilience and innovation research.

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