Chapter 4
Conceptual Premises for Climate Change Adaptation Education in African Universities

Marcellus Forh Mbah, Brain Harman, and Petra Molthan-Hill

Abstract Africa is especially vulnerable to the deleterious effects of climate change. Unless there is a significant shift in current trends, many African countries are likely to continue facing extreme weather events that will threaten their food security, water resources, human health, and biodiversity. Consequently, there is a pressing need to ensure that climate change mitigation strategies (strategies to reduce carbon emissions) and climate change adaptation strategies (strategies to circumvent the deleterious effects of climate change) are rolled out across all courses at African universities. Universities serve as both knowledge hubs and vehicles for societal change. However, African universities have traditionally adopted a Eurocentric approach to education that delegitimises Indigenous knowledge and reinforces colonial narratives. To overcome these historical shortcomings, African universities must engage with local populations and leverage Indigenous knowledge systems to co-create place-based climate solutions that provide transformative change for all. In this chapter, we call for African universities to reposition their orientation by reconsidering their conceptualisation of climate change education.

Keywords Climate change education · African universities · Epistemological plurality · Polycentrism · Knowledge co-creation

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Introduction

The all-encompassing magnitude of the existential threat posed by climate change constitutes a "wicked," problem (Cross & Congreve, 2021). Indeed, predictions of the dire downstream consequences associated with average temperature rises above 1.5 degrees °C are already well documented (IPCC, 2018). Climate change education (CCE) is considered an essential tool in countering environmental degradation and redressing societal imbalances (UNESCO, 2020). Mainstreaming CCE within all levels of education is critical to achieving a sustainable future (Molthan-Hill et al., 2022). However, CCE must adopt multidisciplinary, interdisciplinary, and transdisciplinary approaches to help shift societal norms and individual mindsets towards sustainable practice (Dupigny-Giroux, 2010).

Traditionally, CCE within universities has focused on teaching climate change science education. This reliance on science education has come at the expense of the other two aspects of CCE, namely climate change mitigation education (CCME) and climate change adaptation education (CCAE). There is now a pressing need to ensure that climate change mitigation strategies (strategies to reduce carbon emissions) and climate change adaptation strategies (strategies to circumvent the deleterious effects of climate change) are rolled out across all university courses (Molthan-Hill et al., 2022). CCE promises the potential of a "multiplier effect" through the broad diffusion of knowledge across society and between disparate communities (Mochizuki & Bryan, 2015). However, the lack of training relating to climate change mitigation and climate change adaptation currently limits the potential for widespread societal change.

Within the Global South, Climate Change Adaptation (CCA) strategies are especially important because countries in this region are often forced to confront extreme climate change. CCA strategies are therefore vital to help secure the lives and livelihoods of those living in the Global South. Importantly, research suggests that CCA strategies are scalable and transferable across different contexts (Paytan et al., 2017). Nevertheless, for CCA strategies to be effective, they must align with the culture of the resident community (Johnson et al., 2022). However, to date, the heavy reliance on climate change science education within CCE has limited the scope of societal response. More broadly, CCE has often undermined the agency of communities within the Global South due to the expansionist, Eurocentric orientation that unpins its reductive, science-based stance. Indeed, "colonially induced environmental changes (have) altered the ecological conditions that supported Indigenous peoples' cultures, health, economies, and political self-determination" (Whyte, 2017 p. 154). Recent international resolutions at COP meetings (COP 26, 27, 28) has renewed a sense of determination to democratise CCE for a global community. However, in Africa, the roll out of CCA and CCM strategies remains painfully slow. This brings us to an important point.

In common discourse, climate change mitigation and climate change adaptation are often misunderstood as being mutually exclusive routes to climate solutions. This misconception is problematic since it presupposes a false dichotomy. It is important

to understand that effective climate solutions can serve both mitigation and adaptation goals simultaneously. So, while CCA strategies in Africa may aim to help indigenes adapt to climate change, they may also act as climate mitigation strategies that help to reduce carbon emissions. For example, using solar panels as a power source to refrigerate food satisfies both climate adaptation and climate mitigation goals. Refrigeration allows people to store food thereby making them more adaptable and resilient to climate change. Crucially though, this particular CCA strategy supports climate change mitigation goals by leveraging clean, renewable solar power. In doing so, this CCA strategy cuts carbon emissions while also reducing the potential for food waste (another major contributor of greenhouse gases). This example demonstrates the interconnected nature of climate change solutions and the importance of adopting a holistic approach to problem solving. When evaluating competing CCA strategies, it is therefore important to consider the complimentary climate mitigation potential of these interventions. For example, planting trees can represent an adaptive response to extreme heat (i.e. provides shade and cooling effects) while also supporting climate change mitigation (by converting carbon dioxide into oxygen). Alternative CCA strategies to deal with extreme heat (e.g. the construction of concrete shelters) are suboptimal since the embedded carbon in the construction of the shelters undermines, rather than supports climate mitigation goals. Where possible, CCA strategies should be evaluated holistically to assess their overall impact as a climate solution. In this light, CCE can play an important role in helping communities design climate solutions that best address their needs. In the ensuing sections, we consider the climate change context in Africa and the role of the university in reshaping the status-quo. Central to the role of any progressive university is the widespread operationalisation of CCE. However, for African universities in particular, the onerous task of achieving widespread CCE is complicated further by historical and societal factors. In this chapter, we argue for the decolonisation of CCE and for a recognition of Indigenous knowledge systems (IKS) as a vehicle for promoting knowledge co-creation through transformative social learning. We do so in the pursuit of epistemological plurality and polycentrism for climate solutions.

Climate Change in Africa and the Role of the University

Climate change results in extreme weather events that expose and exacerbate Africa's longstanding vulnerabilities in key areas relating to food security, water resources, human health and biodiversity (Apollo & Mbah, 2021). Indeed, Africa is at the forefront of the climate emergency and is predicted to suffer some of the worst effects of climate change (IPCC, 2018). Despite contributing less than 10% of global greenhouse gases, Africa is especially vulnerable to the effects of climate change. In 2022, climate change cost the continent over US$ 8.5 billion in economic damages and directly affected the lives of over 110 million Africans (Reliefweb, 2023).

It seems reasonable to assume that the deleterious effect of climate change in Africa can be reduced if climate literacy is improved. Climate literacy can be

defined as "an awareness of climate change and its anthropogenic causes" (Simpson et al., 2021 p. 937). Note, awareness of climate change alone (perhaps by observing changing weather patterns) may simply engender passivity or maladaptive responses (Eriksen et al., 2012). It is only when a person understands the anthropogenic causes of climate change that remedial and combative action can take place. Simply put, climate literacy "underpins informed mitigation and adaptation responses" that promote climate action (Simpson et al., 2021 p. 937). Sadly, climate literacy rates in Africa vary widely among different states and between different regions. Simpson et al. (2021) found that climate literacy rates ranged from 23–66% across the 33 African countries surveyed. What's more, even larger variances in climate literacy rates were witnessed in states within these African countries (e.g. 5–71% in Nigeria).

Research suggests that African communities are often misinformed about the causes of climate change (Silvestri et al., 2012). Thus, there is a compelling case to be made for striving towards greater climate literacy in Africa since a basic understanding of climate change is required before climate change adaptation and climate change mitigation strategies can be pursued. In addition to promoting adaptive climate change solutions, CCE can also be used to highlight the dangers of maladaptive, carbon producing activities (e.g. mining) that accelerate climate change. In the coming years, fossil fuel extraction in Africa is set to quadruple (Earth Insight, 2022). This is especially worrisome when we consider that 90% of the land earmarked for mining, oil, and gas reserves lies within tropical rainforests (Earth Insight, 2022). Future fossil fuel extraction in Africa is therefore doubly destructive since it fuels further carbon emissions while irreparably damaging the much-needed carbon sinks (forests) that absorb carbon emissions. It is imperative that local communities understand not only the benefits of climate adaptation but also the costs associated with environmental degradation. It is to this end that universities must apply themselves.

Universities serve as "knowledge hubs" and "training centres" (Ssekamatte, 2022) that promote sustainable development within local communities (Blum et al., 2013). In addition to striving towards carbon neutrality themselves (see Udas et al., 2018), many universities are extending this ethos outwards to promote climate adaptation and mitigation measures within their broader communities (Filho et al. 2021). In doing so they are expanding the "societal carbon brainprint by teaching knowledge and skills in the area of carbon neutral practices" (Filho et al. 2021 p. 2). This outward looking, forward-facing perspective chimes with past calls for universities to take up leadership roles within society. Universities should actively shape society by being "proactive leaders in promoting societal change" rather than simply be "indicators of (societal) change" that reflect the zeitgeist (Virtenen, 2010 p. 232). To proactively lead climate action, universities must adopt different climate related roles and goals within society. Specifically, universities must be instrumental in "generating scientific knowledge through scientific research; providing training and capacity building; carrying out sensitizations and providing guidance to communities and policy makers" (Ssekamatte, 2022 p. 12). Their role must also extend to engaging with local communities to create place-based climate change mitigation and climate change adaptation solutions (Ssekamatte, 2022 p. 12). Indeed, recent research has outlined how CCE can be integrated into all university courses (Molthan-Hill et al.,

2022). This mainstreaming and integration of CCE across all university courses is an important step in addressing climate change (see Boateng & Boateng, 2015; Buckland et al., 2018; Reza, 2016).

Climate Change Education in Africa

CCE provides the means to address the current knowledge deficits that exist within rural African communities. As thought leaders within their communities, African universities are uniquely placed to deliver the CCAE and climate change mitigation education (CCME) that Africa so desperately needs. Since climate change will influence all aspects of daily life, it stands to reason that CCE should be a cornerstone of a university student's education. Indeed, since universities are beneficiaries of taxpayer money, it seems wholly appropriate that they should serve the communities in which they reside. Indeed, some would argue that universities are morally obliged to cascade down important information that is relevant to the future lives of their students (Nussbaum et al. 2015).

This renewed focus on CCE has prompted some to assert that "the way forward for universities is to dynamically reposition" (Filho et al., 2021 p. 2). CCE can be incorporated into a wide variety of (in)formal learning scenarios and contexts if operational and regulatory inertia can be overcome within the university sector (Molthan-Hill, 2019). Indeed, CCE provides new opportunities for universities to transcend traditional barriers and mobilise transformative change within society (Apollo & Mbah, 2021; Ssekamatte, 2020). However, research suggests that a lack of commitment among university officials, shortsighted priorities, knowledge silos and a general ignorance of sustainability agendas all act as barriers to CCE within universities (see Larrán et al., 2016; Tilbury, 2011; Lotz-Sisitka, 2011). It must also be acknowledged that the transdisciplinary nature of CCE poses challenges for educators who must grapple with their own knowledge deficits when navigating the complex, interdisciplinary climate change literature (Berger et al., 2015; Pruneau et al., 2010). However, research suggests that educators are keen to embrace this challenge if given training opportunities to address their knowledge deficits (Apollo & Mbah, 2021). While CCE is taking root within at least some Africa universities (see Apollo & Mbah, 2021; Mbah & Ezegwu, 2024) serious consideration still needs to be given to the factors that help and hinder its further expansion. The green shoots of this greener education system will only grow if CCAE strategies are supported by decolonisation efforts (Mbah & Ezegwu, 2024) that undermine the prevailing Eurocentric perspective on climate change.

Decolonising Climate Change Education

"The colonial invasion that began centuries ago caused anthropogenic environmental changes that rapidly disrupted many Indigenous peoples," (Whyte, 2017 p. 155). The aftermath of this invasion has been pollution, deforestation and soil degradation. Today, the exportation of CCE from first world nations to the global south represents "climate colonialism" (Sultana, 2022). Eurocentric education systems have sought to inculcate colonised people with value systems and perspectives that are not in alignment with their own traditional practices (Ajaps & Mbah, 2022). By delegitimizing the value of Indigenous knowledge, exported education systems have marginalised communities by robbing them of important cultural components (e.g. language, religion, myth, traditions, rituals, songs etc.). The marginalising effects of occupation and subsequent indoctrination undermine community efforts to seek local solutions to local problems (Asante, 2008). Indeed, the "epistemic violence" perpetrated by colonial forces has incarcerated the minds of indigenes within "cognitive prisons" (Cajete, 2005). The devaluation of Indigenous Knowledge Systems (IKS) reinforces the prison bars of these cognitive prisons through a process of marginalisation. To stem this tide of marginalisation, curricular reform is required. According to Adebisi (2016), the decolonisation of curriculums can be viewed as an evolving process that shrugs off past colonial influence through the restoration of IKS. "The foundational intent of decolonisation is to equip students with "diverse academic learning environments, curricula and approaches to research within which Indigenous cultures, histories, and knowledge are embedded" (Waghid & Hibbert, 2018 as cited by Lumadi, 2021, p. 2). Decolonising education is an issue that has risen to prominence in recent years (Zembylas, 2018). Decolonising CCE calls for the widespread adoption of transdisciplinary teaching approaches. "Transdisciplinary education goes beyond interdisciplinary content" (Newberry & Trujillo, 2018 p. 205) and fosters knowledge exchange, and problem solving between academics and practitioners (Williams et al., 2016). The expansionist perspective afforded by transdisciplinary education permits input from those within and those outside the different scientific communities. While structural fragmentation and ever-increasing specialisation characterise the traditional sciences, transdisciplinary education seeks to withdraw the lines of demarcation between disciplines and domains. In doing so, it provides a remedy to the shortcomings of western science (Aldunce et al, 2016) that can be exclusive rather than inclusive in its outlook. Accordingly, Chao and Enari (2021 p. 32) call for transdisciplinary, experimental and decolonial imaginations" grounded in an ethos of inclusivity, participation and humility" to "destabilise the prevailing hegemony of secular science". In doing so, they invoke different types of imagination to combat climate change; relational imagination, storied imagination, beyond-human imagination, multi-sensory imagination, reflective imagination, emplaced imagination and transdisciplinary imagination. While climate change has been conceptualised as "an incredible failure of imagination" (Wallace-Wells, 2019), the authors assert that utilising these complementary imaginations will lead to a "decolonised imagination". The reductionist perspective of westernised climate science fails to capture the web

of social complexity that underpins the climate emergency. African climate change adaptation education must therefore be customised to conform to the lived experiences of those within the community (Shava & Nkopodi, 2020). To achieve this goal, CCAE strategies must leverage the Indigenous knowledge (IK) of the local community. This view appears to be shared by university students. Mampane, Omidir and Aluko (2018) found that postgraduate students perceived glocal initiatives to be an essential component of decolonisation efforts. These students also maintained that technology did not have to be relinquished to achieve decolonisation. However, the students did believe that a decolonised education system should be "foregrounded in Indigenous knowledge" (Mampanne et al. 2018 p. 1).

The Importance of Indigenous Knowledge Systems (IKS)

Indigenous Knowledge Systems (IKS) encapsulate the local skills, knowledge, cultural components and inter-generational traditions that allow indigenes to work in concert with nature (Ubisi, Kolanisi, & Jiri, 2019). IKS's are especially relevant to communities in the Global South where the intergenerational transmission of knowledge is commonplace (Greenwood, and Lindsay, 2019). IKS provide "ground truth" (Praskievicz, 2022) and may be considered integral to securing sustainable development in rural communities (Thaman, 2002). IK is "holistic, synthetic and multi-contextual" (Newberry & Trujillo, 2018 p. 204). These properties of IK make it particularly responsive to finding consensus among the republic of stakeholders that are invested in finding local climate solutions. Thus, by fortifying CCAE strategies with IK, the needs for communal inclusivity and individual self-determination are addressed. In contrast, misguided climate policies based solely on reductionist climate change science are unlikely to gain traction within rural communities. CCAE strategies must therefore embrace resident cultures and speak to the lived experiences of those within the community. To achieve their goals, CCAE strategies will require the decolonisation and indigenisation of university curriculums. Research suggests that the adoption of IKS's within CCE is linked to successful CCE programmes within the Global South (Johnson et al., 2022). However, little research has addressed the need to integrate IKS within university based CCE interventions (Ulmer & Wydra, 2020). Indeed, "western conceptions of the sustainability discourse alienate and remove the socio-cultural specificities in sustainability" (Kumalo, 2017, p.19). Past research has demonstrated that Indigenous students are more likely to suffer from alienation and a loss of identity if their curriculum undermines the Indigenous knowledge that has been passed down to them. As Newberry and Trujillo (2018) note, higher education is largely designed for 'low' context learners (also see Ibarra, 2001). 'Low' context learners are comfortable with procedural learning and can easily compartmentalise and assimilate information devoid of a social context. In contrast, 'high' context learners require information to be socially constructed and situated within their lived experience. Here, "demonstration, application, and experience" are required for learners to fully assimilate the information being

prescribed. To service both sets of learners Cajete (2005) suggests that learners should be exposed to "engaged civic learning" that involves authentic problem-solving scenarios. University CCE programmes should therefore be relatable and relevant to indigenes. Accordingly, CCE programmes should be characterised by localised curriculums and tailored outreach programmes that are both malleable and sensitive to local concerns (Mignolo, 2011). This simple logic underpins the arguments for the customisation, decolonisation and indigenisation of higher education within the Global South. However, achieving these aims requires active and continual collaboration between the university and the local population (Mbah, 2019).

Indigenous knowledge has stood the test of time and increases a community's potential for resiliency. Its longevity is testament to the depth of knowledge that can exist between people and place. Furthermore, a recent systematic review finds that IKS can shape influential CCAE strategies that are transferable across regions (Schlingmann et al., 2021). However, scientists need to exercise restraint and ensure these IKS are not exploited, monetised, or misused (Latulippe & Klenk, 2020). The exploitation of IKS by non-Indigenous scientists simply reinstates a new brand of colonialism (Chavez & Gavin, 2018).

Research suggests that embedding IKS within CCAE strategies presents exciting opportunities for impactful knowledge co-creation (Mbah, 2019). What's more, universities have an important and expanding role in progressing sustainability goals through co-creation activities (Stein, 2023). By opening the channels of communication among stakeholders this participative approach allows for the co-creation of shared solutions through the distillation of a negotiated wisdom. However, this is contingent upon affording an equal weighting to formal (scientific) knowledge and informal (Indigenous) knowledge systems. Indeed, community based, knowledge creation within universities appears to be the exception rather than the rule. Ulmer and Wydra (2020) argue that the longstanding absence of co-creation activities between universities and local communities may be due to language barriers and cultural differences. To surmount these barriers, universities need to embrace the principles of transformative social learning if co-created, glocal solutions are to be realised (Mampanne et al. 2018).

Co-Creation of Climate Change Adaptation Education (CCAE) via Transformative Social Learning

Ensor and Harvey (2015) define social learning as a process "emerging through practices that facilitate knowledge sharing, joint learning, and co-creation of experiences between stakeholders around a shared purpose in ways that: 1) take learning and change beyond the individual to communities, networks, or systems; and 2) enable new shared ways of knowing to emerge that lead to changes in practice" (p. 510). Indeed, CCAE has been reformulated as a form of social learning that has

transformative properties (Collins & Ison, 2009). Transformation learning is characterised by an "emancipatory, participatory, value laden, transgressive co-engagement with complex matters of concern" (Macintyre et al., 2018 p.85). As such, it allows different actors to "co-define" the "matters of concern". This flexible approach facilitates cooperation and inclusivity among a broad "republic of stakeholders" by abandoning the hegemony of a purely science approach. As such, transformative social learning leaves space to develop emerging solutions through reflexive means and dialogical processes. Arguably, this approach lends itself well to addressing complex problems such as climate change. Interestingly, transformative learning has also been used in tandem with decolonizing pedagogy to progress climate change solutions (Mackinlay & Barney, 2014; Zembylas, 2018). Zembylas (2018) suggests that applying a humanist lens to "decolonial thinking" (Mignolo, 2011) provides solutions to the questions surrounding the future format of CCE. These complementary approaches lead to greater cooperation and knowledge sharing among stakeholders. Indeed, research suggests that cooperation and knowledge sharing between different cohorts permits the "co-creation" of knowledge that forms the bedrock of effective CCA strategies (Utter et al., 2021).

The co-creation of knowledge is "a collaborative process involving two or more actors, who are intentionally integrating their knowledge and learning, resulting in the development of insights and solutions that would not otherwise be reached independently" (Utter et al., 2021 p. 1). Co-creation within agroecology is characterised by bottom-up, participatory action research that focuses on the creation of novel knowledge. Interestingly, Utter et al. (2021) suggests that this novel knowledge is often "appropriated and co-opted by academics and relabelled as "new knowledge". Herein lies a problem. Undertaking research on IK can become an extractive process whereby academics assimilate and classify this wisdom through a scientific lens (Latulippe & Klenk, 2020). In short, researchers must appreciate the "epistemology of the south". Renouncing the binary classifications of Indigenous knowledge and scientific knowledge allows scholars to discern the similarities and shared ground between both these knowledge systems (Agrawal, 1995). Going forward, academics must be willing to embrace a "pluralistic" approach to CCE and climb down from their westernised ivory towers. They must move beyond the cosseted environs of the university and seek knowledge within their local communities. By relocating to the broad church of pluralism, universities and their staff will be able to fulfil their new mandate of co-creating a relatable, CCAE knowledgebase with Indigenous knowledge holders.

Reorienting Knowledge Creation to Capture Epistemological Plurality

The unwanted legacy of a colonial past is today being dismantled through indigenisation and decolonisation initiatives within higher education (Adebisi, 2016). To this end, Ajaps and Mbah (2022) advocate applying "epistemological plurality" to CCE. The plurality of knowledge finds itself occupying the middle ground between competing schools of thought, such as Afrocentrism and cosmopolitanism. Advocates of Afrocentrism hold that education within Africa must be uniquely tailored to the continental context (Royster, 2020). Furthermore, Afrocentrism asserts that education should use African concerns as the focal point for education. As the name suggests, this perspective endorses an "Africa" centric perspective whereby all ancillary concerns are pushed to the periphery. Such a perspective assumes that Africa can be both self-sufficient and self-sustaining on its own terms. This insular perspective shuns the notion of global input and seeks to ignore the unyielding power of globalism. While some might view Afrocentrism as a path to reinvigorating Indigenous knowledge systems it may also be viewed as a path to isolationism. The alienation and marginalisation suffered by Indigenous populations of the past may well be perpetuated again if they are cut off from the outside world. Afrocentrism also assumes a concept of Africa as a unity of measure which seems highly problematic given the scale and complexity that characterise the continent. Such generalisations are unhelpful and likely to be regressive.

In contrast, cosmopolitanism asserts that Africa is part of a global community and should therefore tailor its education system to embrace pluralistic and globalist ideals. Cosmopolitism holds that Africa is part of a global community and, as such, must remain fully open to outside influences. Arguably, influences from the west and more recently, influences from the east, allow Africa to find its place in the world. This perspective seeks to centralise a global perspective and pushes this agenda to the fore at the expense of local and regional concerns.

Negotiating a more conciliatory and centrist position, pluralism seeks to reconcile these binary propositions by endorsing the use of both local and glocal responses to CCE. By weighting all knowledge systems equally, pluralism advocates utilising both IKS and western sciences to arrive at equitable, localised, co-created, climate solutions. Importantly, the inclusion of localised knowledge and IKS serves to undermine the Eurocentric hegemony that currently characterises African education. Pluralism therefore champions both place-based pedagogy (Sobel, 2005) and critical pedagogy (De Sousa Santos, 2014) in its aim to renounce colonial narratives and progress social justice. Critical pedagogy renounces imported doctrine and embraces the social situations of the local people. This teaching approach champions a social justice agenda which may be viewed as a recurring theme within pedological research. Indeed, this theme has been repackaged under various guises and could hardly be considered contentious. For example, while Banks and Banks (1995) speak of multicultural education and Kumashiro (2002) of anti-oppressive education, the roots of this school of thought can be traced back to transformative learning (Mezirow, 1978) and the

democratic pedagogy espoused by Freire (1996). By restoring the inextricable link between people and place, pluralism ensures that the full "ecology of knowledges" are represented in problem solving and co-creation activities (Ajaps & Mbah, 2022). The aim of pluralism is therefore to achieve parity between different knowledge systems in an effort to deconstruct the prevailing Eurocentric hegemony that is both persistent and frequently pernicious. As depicted in Fig. 4.1, the ecology of knowledges should be evident in different areas of a university's mission, namely teaching, research and outreach activities.

In real terms, the ecology of knowledges involves an emancipatory engagement with all stakeholders. Solutions are therefore derived through a process of thoughtful consultation and co-creation between all vested interests. Learners within the education system can therefore be viewed as active contributors. As such, these learners should have the power to bend a malleable curriculum to their will in order to address and redress the historical repressions of thought and action.

Hegger et al (2012) suggests that seven conditions need to be met to facilitate co-creation. Co-creation activities require a "broad church" where all actors find a voice in the problem definition and goal setting stages. The differing perspectives and competencies of stakeholders must be acknowledged, and the resources

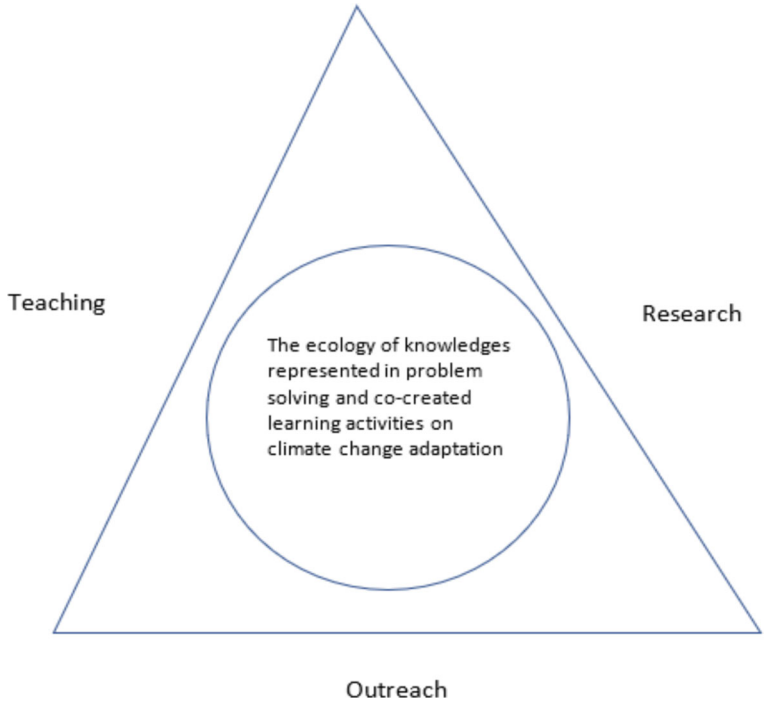

Fig. 4.1 The relationship between the ecology of knowledges and different missions of the university

and facilities required to support co-creation activities, carefully considered. Meaningful incentives and rewards need to be put in place to overcome inertia and help promote innovation. Sadly, a recent systematic review of co-creation activities within agroecology finds that only 6% (of the 69 cases reviewed) resulted in positive outcomes (Cartagena, 2019). The review concluded that co-creation activities that yielded successful impacts were those that solicited a sense of attachment to the project and those that were personally relevant to the farmers. External factors such as resource limitations, power asymmetries and obstructive regulation were found to hinder co-creation efforts. Past research on agroecology co-production also finds that shifting power dynamics between stakeholders greatly affects engagement and interaction levels (Carolan, 2006). This is an important consideration for future university outreach programmes. Outreach programmes that aim to co-create knowledge between academics and farmers must foster a mutual respect for both people and place (Scannell & Gifford, 2010). Relationship building is therefore fundamental to the success of outreach programmes (White & Utter, 2021). Humility, active listening, and empathy are required to gain the trust of farmers who may feel wary of imported doctrines that are incompatible with their local culture (De Sousa Santos, 2014). Differences in perspective, interests and goals can also drive a wedge between stakeholders unless they are properly managed (Ayala-Orozco, et al., 2018). Indeed, the importing of solutions from the Global North represents a form of techno-solutionism that arises from climate colonialism (Stein, 2023). Nevertheless, transdisciplinary outreach activities focused on co-creation have the potential to support transformational social learning within communities (Macintyre et al., 2018).

The inclusivity of transdisciplinary teaching approaches holds the promise of meaningful dialogue between local communities and scientists. This participative approach allows for the co-creation of optimised and localised climate solutions. Couched within the resident culture and nested within nuance, transdisciplinary approaches have yet to be fully realised. Parity between science and non-science inputs appears difficult to achieve. However, scientists need to realise that effective climate solutions all inherently require a polycentric approach and understanding of the behavioural complexities that contribute to the problem. In this regard, western science alone comes up short.

Pursuing Polycentricity within the University to Address Climate Solution

Changes in perceptual and behavioural patterns are required across different facets of a university's mission to facilitate climate solutions. Solutions that fail to leverage the generational wisdom embedded with communities are likely to fail. While western science has served society well, it must adopt a more conciliatory stance with regard to Indigenous knowledge. Scientists within the hard sciences must listen to their

colleagues within the softer social sciences who are more receptive to the wisdoms contained within culture. The epistemological implications may be uncomfortable for some who have spent their lives asserting the supremacy of western sciences. Since the age of the enlightenment (Pinker, 2018), reason and logic have become the mainstays of this domain. The unbounded success of the scientific method as a means of progressing development has led to an epistemology that reinforces the narrative that science in isolation can overcome all challenges. However, now science faces its most pressing challenge, one that cannot arguably be overcome without transdisciplinary input. Science must extend an olive branch to those who seek to contribute to climate solutions from outside academia and outside the traditional sciences (Newberry & Trujillo, 2018). It is worth considering that academics have been indoctrinated with the scientific method. Thus, training and resources may be needed to help facilitate their transition to a more inclusive modus operandi that considers the ecology of knowledges. The vaulted position that academics occupy within society furnishes them with the power to influence vast swathes of people. However, perhaps the issue is that the self-sustaining culture within academia is at loggerheads with the culture that exists outside of the university gates. Typically, it is environmental evangelists and politicians who extoll the virtues of a data driven approach to climate change solutions. These prominent thought leaders often set the agenda and frame the messaging on climate change solutions. In stark contrast, the voices of those who are most affected by climate change are often muted or unheard. Going forward, universities have an important role to play in giving voice to these underrepresented communities. Since universities should serve their communities, they must consider how the Indigenous knowledge of the region can be incorporated into their curricula to comunially transform local and national responses to climate change (Mbah et al., 2021).

We assert that the African university of tomorrow should embrace a placed-based focus when delivering CCE. Such a university would aim to capture the full ecology of knowledges through its teaching, research, and outreach programmes (see Fig. 4.1). In short, African universities should adopt a polycentric approach to CCE (Ajaps & Mbah, 2022). This approach should be characterised by a tripartite mission focus that embeds IK within all teaching, research and outreach activities within the university. The role of academics within this approach is to actively raise the profile of IK among students, the private sector and the government. Table 4.1 summarises how research, teaching, and outreach/fieldwork can be used to pursue polycentricity among these different cohorts. Below, we provide an example of how a polycentric approach might be used as a framework for operationalising a climate solution (clean cooking).

Rigorous research by an international team of scientists has identified 93 of the most impactful technologies and practices that can be employed to reduce concentrations of greenhouse gases (Project Drawdown, 2022a). Highly ranked in this list of climate solutions is the practice of “clean cooking”. Indeed, “clean cooking is one of the most potent solutions to reducing global greenhouse gases” (Project Drawdown, 2022a). Unlike traditional means of cooking, clean cooking does not involve burning materials that significantly contribute to greenhouse gases. Instead, clean cooking uses renewable fuel (e.g. solar power) or low impact fuels (e.g. liquid petroleum

Table 4.1 A tripartite approach to pursuing polycentricity within the university

Research	As intermediaries between government and local communities, universities should engage in research that seeks to build bridges between rural communities and national government. Transdisciplinary and interdisciplinary research should be employed to promote curriculum decolonisation (Newberry & Trujillo, 2018). The findings of the research should inform future government policy on climate action
	More funding should be provided to support local outreach programmes aimed at achieving glocal solutions (Mampane et al., 2018). Government policies should seek to nurture farmers' links with the land (Ajaps & Mbah, 2022) by encouraging cross pollination between academia and agrarian practice
Teaching	Universities should employ place-based pedagogy and outreach work to prioritise and normalise transformative social learning. These activities should foster continuous engagement with the local community to create stronger links between the university and the community (Mbah, 2019)
	A flexible, interactive and innovative approach to curriculum design should be adopted. Students should be actively involved in problematising and problem solving local issues through the lens of a polycentric approach (Ajaps & Mbah, 2022; Mignolo, 2011). Mainstreaming CCE within all levels of higher education is critical to achieving a sustainable future. However, future CCE efforts need to focus on teaching tailored climate solutions that simultaneously serve both climate mitigation and climate adaptation goals (Molthan-Hill et al., 2022). The route to achieving this goal is through co-created, glocal solutions that combine the full ecology of knowledges
Outreach and fieldwork	Best practices need to be adopted when undertaking fieldwork to avoid conflict (Chavez & Gavin, 2018) and to ensure that the research being undertaken is directly applicable to the indigenes (Olesen & Nordentoft, 2018). Students and academics who undertake outreach work should take a collaborative approach to fieldwork. In the spirit of restorative justice, researchers should adopt a humble, open-minded outlook that seeks to redress traditional power asymmetries
	Relinquishing incompatible goals and the allure of techno-solutionism (Stein, 2023) will ameliorate relations with the indigenes. Lecturers and other stakeholders who enjoy privileged positions of power need to remain open-minded and magnanimous during co-creation activities. Knowledge systems should be afforded equal weight if the stereotypes of ill-fated past encounters are to be avoided (Briley et al., 2015)

gas) that create much less greenhouse gases than traditional solid fuel stoves. Clean cooking may also be viewed as a CCM strategy but also as a CCA strategy since it potentially allows people to cook food in the absence of dwindling resources such as firewood. The potential impact of educating people on the benefits of clean cooking are huge when we consider that "worldwide, billions of people mainly cook with polluting fuels and technologies" (Project Drawdown, 2022b).

."As of 2020, an estimated 43% of families in low and middle-income countries were mainly using cookstoves fuelled by traditional wood or coal stoves for cooking" (Project Drawdown, 2022b). What's more, research suggests that 31% of the global population will still be using solid fuel stoves by 2030 (Stoner et al., 2021). While

clean cooking is an important climate solution it nevertheless represents an externally sourced, technocratic intervention to reduce carbon emissions. If widespread behaviour change is to be adopted by Indigenous communities then this departure from traditional cooking methods must be sympathetic to the existing Indigenous knowledge base.

Similarly, universities can adopt a polycentric approach to CCE as itemised in Table 4.1, touching on their missions: (1) Research, (2) Teaching, and (3) Outreach and fieldwork.

Specifically, for clean cooking to be widely adopted, significant research is first required to ascertain the type of stove that would work best in each region. Weather conditions, infrastructure and the availability of renewable materials are key determinants. University researchers could assess the viability and suitability of the different options available in the area. Importantly, researchers would also need to work with local communities to understand the barriers and constraints that might hinder the adoption of this new practice. This information could then be fed back to government bodies to inform future public policy. In doing so, researchers could act as intermediaries between local communities and legislative bodies to help create the social conditions conducive to the adoption of clean cooking practices.

After the research has established the best stove, it could then fall to educators to disseminate this knowledge widely within their communities. Here, the role of the educator is to cascade the information down to the grassroot level within communities. As respected thought leaders within their communities, academics also have the power to sway industry leaders and local influencers within the community.

Finally, outreach and field research could be used to demonstrate the utility of the clean cooking stoves in real world conditions. This type of outreach work would extend the university's conservation ethos outwards. It would bring the message to hard-to-reach communities that traditionally lay beyond the reach of the university. By adopting a polycentric approach to CCE, researchers and educators can begin to redress the knowledge gap between the "town and the gown". In doing so, they can develop ever more impactful climate change adaptation and climate change mitigation strategies within their resident communities.

Conclusion

IK has an important role to play in adaptation practices in Africa. However, greater recognition of IKS within higher education and governmental spheres is required to co-create CCA solutions that are relevant and relatable to rural farmers. The lack of recognition of IK within governmental quarters seems to undermine the utility of IK at university level, thereby delegitimising this knowledge base. It appears that colonial narratives still shape education within Africa. We propose that future IK research should challenge scientists to find the humility to relinquish the power advantage bestowed unto them by their datasets. Similarly, we propose that outreach programmes should promote genuine co-creation opportunities rather than simply

be used as fortuitous encounters to harvest Indigenous wisdom or propagate the scientific faith. The goal of the epistemologically plural or polycentric university is not to integrate knowledge but rather to co-create it. This constructionist perspective challenges the positivist orthodoxy embedded within academia and governments. Government policy and university curriculums must strive to accommodate the place-based attachments that bind people to places. It is clear that IK must form an integral part of climate mitigation and climate adaptation strategies in Africa.

The conceptual premises advanced in this chapter are intended to support the transdisciplinary research and co-creation activities needed to deliver the climate solutions of tomorrow. Alas, if the promise of an epistemological plural or polycentric university is to be realised then the cultural barriers of climate colonisation and techno-solutionism must first be overcome. A departure from a neo-liberal, market-driven education system is required to secure transformative education (Odell et al., 2019). Furthermore, transformative education that seeks to address all the Sustainable Development Goals must "restructure power and the embedded values within society" (Odell et al., (2019 p. 3). To promote the required "third order changes" to learning, Sterling (2011) asserts that we must engage in "seeing things differently". An epistemological plural or polycentric approach to CCE in Africa will help to achieve these transformative changes by promoting core sustainability competencies that empower learners to integrate sustainability into their everyday lives (see Wiek et al., 2011). Empowering learners to tackle climate change will require them to engage in different modes of thinking; (1) Systems thinking competency, (2) anticipatory or future thinking competency, (3) normative or value thinking competency, (4) strategic thinking or action-orientated competency and (5) interpersonal or collaborative competency. Tailored CCE can induce these modes of thinking that are needed to foster meaningful and impactful changes to thinking and behaviour. As such, CCE has the potential to empower a new generation of Africans to take ownership of their own futures by facing down the threat of climate change on their own terms.

References

Adebisi, F. I. (2016). Decolonising education in Africa: Implementing the right to education by re-appropriating culture and indigeneity. *Northern Ireland Legal Quarterly., 67*, 433–451.

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and Change, 26*(3), 413–439.

Ajaps, S., & Mbah, F. M. (2022). Towards a critical pedagogy of place for environmental conservation. *Environmental Education Research, 28*(4), 508–523. https://doi.org/10.1080/13504622.2022.2050889

Aldunce, P., Bórquez, R., Adler, C., Blanco, G., & Garreaud, R. (2016). Unpacking resilience for adaptation: Incorporating practitioners' experiences through a transdisciplinary approach to the case of drought in Chile. *Sustainability, 8*(9), 905.

Apollo, A., & Mbah, M. F. (2021). Challenges and opportunities for climate change education (Cce) in East Africa: A critical review. *Climate, 9*(6), 93.

Asante, M. K. (2008). Afrocentricity: Toward a new understanding of African thought in the world. In M. Kete, Y. M. Asante, J. Yin (Eds.) *The Global Intercultural Communication Reader* (pp. 101–110). New York, USA: Routledge. ISBN 978-0-415-95812-7.

Ayala-Orozco, B., Rosell, J. A., Merçon, J., Bueno, I., Alatorre-Frenk, G., Langle-Flores, A., & Lobato, A. (2018). Challenges and strategies in place-based multi-stakeholder collaboration for sustainability: Learning from experiences in the global South. *Sustainability, 10*(9), 3217.

Banks, C. A. M., & Banks, J.A. (1995). Equity pedagogy: An essential component of multicultural education. *Theory Into Practice*, 152–158.

Berger, P., Gerum, N., & Moon, M. (2015). Roll up your sleeves and get at it! climate change education in teacher education. *Canadian Journal of Environmental Education, 20*, 154-172.

Blum, N., Nazir, J., Breiting, S., Goh, K. C., & Pedretti, E. (2013). Balancing the tensions and meeting the conceptual challenges of education for sustainable development and climate change. *Environmental Education Research, 19*(2), 206-217.

Boateng, C. A., & Boateng, S. D. (2015). Tertiary institutions in Ghana curriculum coverage on climate change; implications for climate change awareness. *Journal of Education and Practice*, *6*(12), 99–106.

Briley, L., Brown, D., & Kalafatis, S. E. (2015). Overcoming barriers during the co-production of climate information for decision-making. *Climate Risk Management, 9*, 41–49.

Buckland, P., Goodstein, E., Alexander, R., Muchnick, B., Mallia, M. E., Leary, N., et al. (2018). The challenge of coordinated civic climate change education. *Journal of Environmental Studies and Sciences, 2018*(8), 169–178.

Cajete, G. A. (2005). American Indian epistemologies. *New Directions for Student Services, 2005*(109), 69–78.

Carolan, M. S. (2006). Sustainable agriculture, science and the co-production of 'expert' knowledge: The value of interactional expertise. *Local Environment, 11*(4), 421–431.

Cartagena, B. L. (2019). Bridging the gap between theory and practice in agroecological farming: Analyzing knowledge co-creation among farmers and scientific researchers in Southern Spain [Unpublished master's thesis]. Murcia, Spain: Spain Regeneration.

Chao, S., & Enari, D. (2021). Decolonising climate change: A call for beyond-human imaginaries and knowledge generation. *ETropic, 20*(2), 32–54. https://doi.org/10.25120/etropic.20.2.2021.3796

Chavez, D. M., & Gavin, M. C. (2018). A global assessment of Indigenous community engagement in climate research. *Environmental Research Letters, 13*(12), 123005.

Collins, K., & Ison, R. (2009). Jumping off Arnstein's ladder: Social learning as a new policy paradigm for climate change adaptation. *Environmental Policy and Governance, 19*(6), 358–373.

Cross, I. D., & Congreve, A. (2021). Teaching (super) wicked problems: Authentic learning about climate change. *Journal of Geography in Higher Education, 45*(4), 491–516.

De Sousa Santos, B. (2014). *Epistemologies of the South: Justice against Epistemicide*. Oxon, UK: Routledge.

Dupigny-Giroux, L. A. L. (2010). Exploring the challenges of climate science literacy: Lessons from students, teachers and lifelong learners. *Geography Compass, 4*(9), 1203–1217.

Earth Insight. (2022). Congo in the Crosshairs: New Oil & Gas Expansion Threats to Forests and Communities. Retrieved 08 Jan 24, from https://www.earth-insight.org/wp-content/uploads/2022/11/Congo-in-the-Crosshairs-November-2022-English-Report-small.pdf.

Ensor, J., & Harvey, B. (2015). Social learning and climate change adaptation: Evidence for international development practice. *Wiley Interdisciplinary Reviews: Climate Change, 6*(5), 509–522.

Eriksen, S., Aldunce, P., Bahinipati, C.S., Martins, R.D.A., Molefe, J.I., Nhemachena, C., O' Brien, K., Olorunfemi, F., Park, J., Sygna, L., & Ulsrud, K. (2012). When not every response to climate change is a good one: Identifying principles for sustainable adaptation. In *Sustainable Adaptation to Climate Change* (pp. 7–20). Routledge.

Filho, W. L., Sima, M., Sharifi, A., Luetz, J. M., Salvia, A. L., Mifsud, M., Olooto, F. M., Djekic, I., Anholon, R., Donkor, F. K., Dinis, M. A. P., Klavins, M., Finnveden, G., Chari, M. M., Molthan-Hill, P., Mifsud, A., Sen, S. K., & Lokupitiya, E. (2021). Handling climate change education at universities: An overview. *Environmental Sciences Europe, 33*, 1–19.

Freire, P. (1996). *Pedagogy of the Oppressed (Revised)*. Continuum.

Greenwood, M., & Lindsay, N. M. (2019). A commentary on land, health, and indigenous knowledge (s). *Global Health Promotion, 26*(3_suppl), 82–86.

Hegger, D., Lamers, M., Van Zeijl-Rozema, A., & Dieperink, C. (2012). Conceptualising joint knowledge production in regional climate change adaptation projects: Success conditions and levers for action. *Environmental Science & Policy, 18*, 52–65.

Ibarra, R. (2001). *Beyond affirmative action: Reframing the context of higher education*. The University of Wisconsin Press.

IPCC. (2018). *Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Retrieved Feburary 14, 2023, from http://www.ipcc.ch/report/sr15/.

Johnson, D. E., Parsons, M., & Fisher, K. (2022). Indigenous climate change adaptation: New directions for emerging scholarship. *Environment and Planning E: Nature and Space, 5*(3), 1541–1578.

Kumalo, S. H. (2017). Problematising development in sustainability: Epistemic justice through an African ethic. *Southern African Journal of Environmental Education, 33*, 14–24.

Kumashiro, K. K. (2002). Troubling education: Queer activism and anti-oppressive pedagogy. *Psychology press*.

Larrán Jorge, M., Herrera Madueño, J., Calzado, Y., & Andrades, J. (2016). A proposal for measuring sustainability in universities: A case study of Spain. *International Journal of Sustainability in Higher Education, 17*(5), 671–697.

Latulippe, N., & Klenk, N. (2020). Making room and moving over: Knowledge co-production, Indigenous knowledge sovereignty and the politics of global environmental change decision-making. *Current Opinion in Environmental Sustainability, 42*, 7–14.

Lotz-Sisitka, H. (2011). The "event" of modern sustainable development and universities in Africa. *Sustainable Development, 2*(1), 41–57.

Lumadi, M. W. (2021). The pursuit of decolonising and transforming curriculum in higher education. *South African Journal of Higher Education, 35*(1), 1–3.

Macintyre, T., Lotz-Sisitka, H., Wals, A., Vogel, C., & Tassone, V. (2018). Towards transformative social learning on the path to 1.5 degrees. *Current Opinion in Environmental Sustainability, 31*, 80–87.

Mackinlay, E., & Barney, K. (2014). Unknown and unknowing possibilities: Transformative learning, social justice, and decolonising pedagogy in indigenous Australian studies. *Journal of Transformative Education*, *12*(1), 54–73

Mampane, R. M., Omidire, M. F., & Aluko, F. R. (2018). Decolonising higher education in Africa: Arriving at a glocal solution. *South African Journal of Education, 38*(4). https://doi.org/10.15700/saje.v38n4a1636

Mbah, M. (2019). Can local knowledge make the difference? Rethinking universities' community engagement and prospect for sustainable community development. *The Journal of Environmental Education, 50*(1), 11–22.

Mbah, M., Ajaps, S., & Molthan-Hill, P. (2021). A systematic review of the deployment of indigenous knowledge systems towards climate change adaptation in developing world contexts: Implications for climate change education. *Sustainability, 13*(9), 4811.

Mbah, M. F., & Ezegwu, C. (2024). The Decolonisation of climate change and environmental education in Africa. *Sustainability, 16*(9), 3744.

Mignolo, W. (2011). *The darker side of western modernity: Global futures, decolonial options*. Duke University Press.

Mochizuki, Y., & Bryan, A. (2015). Climate change education in the context of education for sustainable development: Rationale and principles. *Journal of Education for Sustainable Development, 9*(1), 4–26.

Molthan-Hill, P., Blaj-Ward, L., Mbah, M. F., & Ledley, T. S. (2022). Climate change education at universities: Relevance and strategies for every discipline. *Handbook of Climate Change Mitigation and Adaptation* (pp. 3395–3457). Springer International Publishing.

Molthan-Hill, P., Worsfold, N., Nagy, G. J., Filho, W. L., & Mifsud, M. (2019). Climate change education for universities: A conceptual framework from an inter-national study. *Journal of Cleaner Production., 226*, 1092–1101. https://doi.org/10.1016/j.jclepro.2019.04.053

Mezirow, J. (1978). Perspective transformation. *Adult Education, 28*(2), 100–110.

Newberry, T., & Trujillo, O. V. (2018). Decolonizing education through transdisciplinary approaches to climate change education. In *Indigenous and decolonizing studies in education* (pp. 204–214). Routledge.

Nussbaum, E. M., Owens, M. C., Sinatra, G. M., Rehmat, A. P., Cordova, J. R., Ahmad, S., et al. (2015). Losing the Lake: Simulations to promote gains in student knowledge and interest about climate change. *International Journal of Environment & Science Education, 10*(6), 789–811.

Odell, V., Molthan-Hill, P., Martin, S., and Sterling, S. (2019). Transformative Education to Address All Sustainable Development Goals. In: Leal Filho, W., Azul, A., Brandli, L., Özuyar, P., Wall, T. (eds) *Quality Education. Encyclopedia of the UN Sustainable Development Goals*. Springer, Cham. https://doi.org/10.1007/978-3-319-69902-8-106-1

Olesen, B. R., & Nordentoft, H. M. (2018). "On slippery ground"–beyond the innocence of collaborative knowledge production. *Qualitative Research in Organizations and Management: An International Journal, 13*(4), 356–367.

Paytan, A., Halversen, C., Weiss, E., Pedemonte, S., & Mescioglu, E. (2017). Education for climate change adaptation and resilience. *Limnology and Oceanography Bulletin, 26*(3), 71–73.

Pinker, S. (2018). Enlightenment now: The case for reason, science, humanism, and progress. Penguin, UK.

Praskievicz, S. (2022). Ground truth: Finding a "place" for climate change. *Progress in Environmental Geography, 1*(1–4), 137–162.

Project Drawdown. (2022a). *Table of Solutions*. Retrieved 08 Jan 2024, from https://drawdown.org/solutions/table-of-solutions.

Project Drawdown. (2022b). *Clean cooking*. Retrieved 09 Jan 2024, from https://drawdown.org/solutions/clean-cooking.

Pruneau, D., Khattabi, A., & Demers, M. (2010). Challenges and possibilities in climate change education. *Online Submission, 7*(9), 15–24.

Reliefweb, (2023). Africa suffers disproportionately from climate change. Retrieved January 8, 2024, from https://reliefweb.int/report/world/africa-suffers-disproportionately-climate-change.

Reza, M. I. (2016). Sustainability in higher education: Perspectives of Malaysian higher education system. *SAGE Open*, 1–9.

Royster, P. D. (2020). Epistemology of knowledge. In *Decolonizing Arts-Based Methodologies*, pp 150–171. Brill.

Scannell, L., & Gifford, R. (2010). Defining place attachment: A tripartite organizing framework. *Journal of Environmental Psychology, 30*(1), 1–10.

Schlingmann, A., Graham, S., Benyei, P., Corbera, E., Sanesteban, I. M., Marelle, A., & Reyes-García, V. (2021). Global patterns of adaptation to climate change by indigenous peoples and local communities: A systematic review. *Current Opinion in Environmental Sustainability, 51*, 55–64.

Shava, S., & Nkopodi, N. (2020). Indigenising the university curriculum in southern Africa. In *Indigenous studies: Breakthroughs in research and practice*, (pp. 243–254). IGI Global.

Silvestri, S., Bryan, E., Ringler, C., Herrero, M., & Okoba, B. (2012). Climate change perception and adaptation of agro-pastoral communities in Kenya. *Regional Environmental Change, 12*, 791–802.

Simpson, N. P., Andrews, T. M., Krönke, M., Lennard, C., Odoulami, R. C., Ouweneel, B., Steynor, A., & Trisos, C. H. (2021). Climate change literacy in Africa. *Nature Climate Change, 11*(11), 937–944.

Sobel, D. (2005). Place-based education: Connecting classrooms and communities. *Education for Meaning and Social Justice., 17*(3), 63–64.

Ssekamatte, D. (2022). The role of the university and institutional support for climate change education interventions at two African universities. *Higher Education*, 1–15.

Ssekamatte, D. (2020). Towards a theoretical model linking university education to climate change interventions in the African context. *Journal of African Studies and Development, 12*(1), 17–24. https://doi.org/10.5897/jasd2020.0569

Stein, S. (2023). Universities confronting climate change: beyond sustainable development and solutionism. *Higher Education*, 1–19. https://doi.org/10.1007/s10734-023-00999-w

Sterling, S. (2011). Transformative learning and sustainability: sketching the conceptual ground. *Learning and teaching in higher education, 5*(11), 17–33.

Stoner, O., Lewis, J., Martínez, I. L., Gumy, S., Economou, T., & Adair-Rohani, H. (2021). Household cooking fuel estimates at global and country level for 1990 to 2030. *Nature Communications, 12*(1), 5793.

Sultana, F. (2022). The unbearable heaviness of climate coloniality. *Political Geography*. https://doi.org/10.1016/j.polgeo.2022.102638

Thaman, K. H. (2002). Shifting sights: The cultural challenge of sustainability. *Higher Education Policy, 15*(2), 133–142.

Tilbury, D. (2011). Higher education for sustainability: A global overview of commitment and progress. *Higher Education in the World, 4*(1), 18–28.

Ubisi, N. R., Kolanisi, U., & Jiri, O. (2019). Comparative review of indigenous knowledge systems and modern climate science. *Ubuntu: Journal of Conflict and Social Transformation, 8*(2), 53–73.

Udas, E., Wölk, M., & Wilmking, M. (2018). The "carbon-neutral university"–a study from Germany. *International Journal of Sustainability in Higher Education, 19*(1), 130–145.

Ulmer, N., & Wydra, K. (2020). Sustainability in African higher education institutions (HEIs) shifting the focus from researching the gaps to existing activities. *International Journal of Sustainability in Higher Education, 21*(1), 18–33.

UNESCO. (2020). Education for sustainable development: a roadmap. Retrieved Feburary 14, 2022, from https://unesdoc.unesco.org/ark:/48223/pf0000374802.locale=en.

Utter, A., White, A., Méndez, V. E., & Morris, K. (2021). Co-creation of knowledge in agroecology. *Elementa: Science of the Anthropocene, 9*(1), 00026.

Virtenen, A. (2010). Learning for climate responsibility: Via consciousness to action. In W. L. Filho (Ed.), *Universities and climate change* (pp. 231–240). Springer.

Waghid, Z., & Hibbert, L. (2018). Advancing border thinking through defamiliarisation in uncovering the darker side of coloniality and modernity in South African higher education. *South African Journal of Higher Education, 32*(4), 263–283.

Wallace-Wells, D. (2019). The uninhabitable earth: A story of the future. Penguin UK.

White, A., & Utter, A. (2021). Essential attributes in the co-production of knowledge by farmers and agricultural outreach professionals in Vermont (*Unpublished manuscript*). University of Vermont.

Whyte, K. (2017). Indigenous climate change studies: Indigenizing futures, decolonizing the Anthropocene. *English Language Notes, 55*(1), 153–162.

Wiek, A., Withycombe, L., & Redman, C. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science, 6*(2), 203–218.

Williams, J., Roth, W.M., Swanson, D., Doig, B., Groves, S., Omuvwie, M., Borromeo Ferri, R., & Mousoulides, N. (2016). *Interdisciplinary mathematics education.* Springer Nature.

Zembylas, M. (2018). Decolonial possibilities in South African higher education: Reconfiguring humanising pedagogies as/with decolonising pedagogies. *South African Journal of Education, 38*(4), 1–11.