Chapter

Deciphering the Climate Change Conundrum in Zimbabwe: An Exposition

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Abstract

The notion that climate change has created development opportunities largely remains poorly understood despite phenomenal evidence that points toward positive gains across the broad socio-economic spectrum. Current understanding has largely concentrated on the negative effects of climate change, with limited exposition on the benefits associated with climatic responses. This article collates and reviews evidence that interventions to curtail climate change impacts have unlocked several development opportunities and potentially contribute in improving the living standards of many communities in Zimbabwe. It argues that although climate change effects permeate all the socio-economic development sectors of the country, the collective interventions by government, development partners and individuals on mitigation and adaptation actions could lead to a development trajectory that is evident in a number of indicators toward poverty alleviation, particularly through improved food, energy, water, and health access. The article, however, questions the sustainability of these unfolding benefits and advises on the need to enhance mechanisms for climatic programming in the country's development plans, policies and strategies.

Keywords: adaptation, climate change, clean energy, food security, health, mitigation, poverty, water access

1. Introduction

The phenomenon of climate change has been nothing short of spectacular. Recent scholarship confirms earlier evidence that change and variability in the climate system, primarily triggered by anthropogenic greenhouse gas (GHG) emissions, will have far reaching global consequences [1–5]. The events associated with climatic phenomena, largely noticeably as extreme temperatures, storms, droughts and floods, are said to be more frequent and severe in developing countries [1, 3]. The reasons for such a regional risk divide in exposure to climate change are beyond climatic. The Intergovernmental Panel on Climate Change (IPCC) captures them as non-climatic drivers of vulnerability, which summarily include poor governance, conflicts and instabilities, inequalities, hunger, poverty and disease [2, 6, 7]. Zimbabwe is not an exception to the climatic disturbances. The major climatic issues are evidenced by declining water resources, fall in agricultural productivity, biodiversity decline, geographical spread of vector-borne diseases and pestiferous nature of problem pests, and volatile weather and climatic disasters [8–10].

In its Fifth Assessment Report (AR5), the IPCC identifies challenges and opportunities in both mitigation and adaptation responses [6]. Generically understood as a proactive measure to prevent or minimise harm, mitigation in climate science and practice carries a dual meaning. From the distinction given by the IPCC as mitigation of disaster risk and disaster and mitigation of climate change through reducing GHG emissions and enhancing carbon sinks, both definitional strands are beneficial to societies practising climatic interventions, albeit with some challenges. Drawing from the conceptual scheme adopted by Wilbanks and Sathaye [11], which classifies mitigation as structural (technological) and unstructural (economic structure, societal organisation and individual behaviour), a number of opportunities could be unlocked, particularly in addressing the negative effects of climate change. On the other hand, the definitional scope of adaptation extends from the mitigation of disaster risk and disaster strand, primarily focusing on actions taken to respond to climatic events. As such, it is critical to evaluate what climatic responses can do to communities intended to benefit from those policy or strategy systems. The purpose of climate mitigation, therefore, is to stabilise the climatic system and lessen pressure on adaptation. Several scholars (for example, see [11, 12]) have pointed out the complementary roles of mitigation and adaptation, arguing that adaptation is difficult or even a futile if mitigation fails to minimise the magnitude of the costs to be handled. This argument tends to shape current climate policy regimes, the recent one being the Paris Agreement, which aims to "Strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty..." [13].

The dividends of such a global policy framework, where they exist, remain largely obscured by the attention to the magnitude of observed and anticipated climatic threats and, therefore, become poorly understood. Africa is one of the regions seriously affected by climate change. The reasons for this are reported by Boko et al. [14] and later reinforced by Niang et al. [15] as relating to other factors as unequal access to resources, enhanced food insecurity and poor health management systems, which exacerbate the vulnerabilities of many communities in the region. Despite low levels of adaptive capacity reported by Klein et al. [16], adaptation success stories associated with higher adaptive capacities have been noticed in some countries mainly in North Africa [17]. Overall, within the continent, individual, household or micro level adaptive capacities are shaped by functional institutions, access to assets and collective action [15, 18]. These opportunities enhance the ability of people to make informed decisions in exploiting the beneficial aspects of responding to climate change.

Realising the effects that climate change poses to its broad socio-economic development sectors, Zimbabwe has not been complacent in responding to climate change, albeit experiencing challenges. Current evidence of climate change in Zimbabwe portrays a predominantly challenging situation. Existing knowledge on the sectoral impacts of climate change in the agriculture, water, energy, industry and health sector point to a negative state (for example, see [8, 9, 19]). This article challenges this confinement by broadening the focus to examine opportunities associated with the phenomena of climate change. In this article, the effects of climate change are deciphered. To do this, the article adopts a sector-based analysis to show how the various socio-economic development sectors are experiencing climate change. The policy and institutional field is also evaluated to understand the supporting system for climate change responses. This background forms the basis for understanding the climatic interventions that have been made or planned for each sector identified. Within this exposition, it is shown that both challenges and opportunities exist. Given the limited scholarship treatment on the latter, the article draws from empirical evidence which shows that several opportunities have been

unlocked and/or remain open for beneficial exploitation by individuals, communities and institutions as they take advantage of the climate change response agenda. The article underscores the need to take continuous stock of achievements made in the country's development sectors as mitigation and adaptation interventions gather momentum. The sustainability question of these observed and anticipated benefits is given considerable examination throughout the article.

2. Research methodology

The article largely adopts an empirical methodological approach, which is inarguably more appropriate to exposit the climatic experiences in Zimbabwe. This has been complemented by case study reviews to deepen the empirical analysis on local evidence of climatic interventions and to draw from experiences of similar climate change-induced responses from other countries mainly drawn from Africa. Within this approach, the study utilised a combination of sector-based and policy and institutional analytic frameworks to evaluate existing climatic practices that the country has embraced since 1992, when the country started to participate in global climate change regimes. Essentially, climate change responses in Zimbabwe can be traced since 1992, the period that recorded a major milestone in embracing climatic responses following the signing and ratification of the United Nations Framework Convention on Climate Change (UNFCCC). Given the evident influence of non-climatic factors of vulnerability that are reported by the IPCC [1], the analysis is broadened to incorporate the development policies that govern the broad socio-economic sectors in Zimbabwe. Thus, the empirical evidence presented in this discussion is largely drawn from existing official government reports, including other documents such as national budget statements. The utilisation of official documents might have marginalised some climatic activities and statistics outside the mainstream government records, particularly those not captured by the Climate Change Management Department (CCMD). However, given the coordinating role of climate change responses by the CCMD, the study was able to capture the official facts and statistics about climatic phenomena and response interventions in Zimbabwe. Where some figures required to be updated, particularly on funds that were received to implement climate change projects, officials from the CCMD were engaged to verify the recorded statistics.

The reports and documents reviewed were also mainly sector-specific, although at the level of analysis, some overlaps exist among the agriculture, water, energy and health sectors that are discussed. Sectoral analysis was used both to deepen the analysis of climatic impacts in each sector and to examine the adequacy of the current climatic practices. The policy and institutional review also informed the state of the support systems in place to tackle the climate change challenge. It was necessary to assess if the available institutions are adequately capacitated to drive the climate change response agenda, particularly in a context where the sustainability of climatic interventions is increasingly getting some attention in global policy regimes of climate change and disaster risk management [13, 20].

3. Sectoral impacts of climate change in Zimbabwe

The evidence of climate change in Zimbabwe can best be presented by adopting a sector-based analysis, as noted earlier. This section presents observed and anticipated impacts of climate change in the agriculture, water, energy and health sectors, which are the most representative and highly vulnerable to climate change.

3.1 The agriculture sector

With reference to climate change impacts, one of the sectors that has drawn research, policy and practical attention is the agricultural sector. Climatic events such as extreme temperatures, increase in frequency of extreme weather events, and rainfall variability are projected to affect agriculture in many ways. Noticeable impacts are already being felt in increased crop failures, pests, crop disease, and the degradation of land and water resources [8, 9]. The role of agriculture as an economic enabler deserves emphasis. Agriculture promotes value chain systems and contributes about 60% to manufacturing, while consuming almost 40% of the industrial output. The sector also has a share of around 30% of export earnings, constitutes 60–70% of employment, and about 19% of GDP [21]. In this way, the sector provides a major source of livelihood for over 70% of the country's population [21]. Owing to its deep intermesh with the rest of the economy, disruption in agriculture from climatic shocks could lead to overall economic decline. Clearly, this is a de-coupling challenge that needs appropriate interventions by taking advantage of the climate change situation.

More than 70% of crop farming practice is rain fed [22]. This suggests that agriculture, food security, and nutrition are all highly sensitive to changes in rainfall associated with climate change. Specifically, climate change has been observed to trigger shifts in agricultural farming regions, with consequential loss in productivity [23, 24]. Given the regional differentiation of the climate system, where productivity follows the agro-ecological zones, climate change is believed to cause shrinkage in the highly productive regions. Agricultural performance productivity generally shows an east-west productivity gradient mainly influenced by the rainfall and temperature. This scheme, however, has been dismissed as obsolete and largely misleading in representing the current farming and ecological regions [23]. The main documented reasons for threats in farming production are high temperatures and precipitation irregularities reported by Mutasa [25] and Unganai [26]. The situation is blamed for causing arid environments that make it difficult for most food and cash crops to grow. The crops that are highly sensitive to heat include maize (a staple crop), tobacco (the major cash crop), wheat, soya beans, among others. Studies have shown a suitability gradient of different crops under different climatic scenarios. The areas suitable for maize production are projected to decrease by 2080, while spatial suitability of crops such as cotton and wheat is expected to increase by the same year [9]. However, it is believed that the north central and eastern areas of the country will likely to be less vulnerable to support production of common crops such as maize, sorghum and cotton [9, 27].

In Zimbabwe, climate change also impacts heavily on livestock. Generally, evidence of climate adaptation in the agriculture sector is moving towards livestock production as a drought tolerant practice [10]. However, as shall be discussed in the next section, there are indications of limits to using livestock as a strategy to adapt to climate change that are pointed out by Tubiello et al. [28] and Chanza [10]. This is because the decline in plant productivity associated with arid environments will likely affect rangelands and feed. The direct impacts of changes in temperature and water scarcity on animals are expected to constrain adaptation efforts. Though not well documented and understood, the indirect effects are likely to be through increased pests and diseases of livestock and decline in pasture yield. The cattle population is estimated to be about 5.5 million. Instead of increasing by over 2% per annum, the national cattle herd has been facing climatic threats. For example, the drought experienced in 2014/2015 and 2015/2016 seasons is believed to have aggravated the foot and mouth disease. The disease rapidly spread as cattle moved wider in search of water and forage and was reported in six of the country's ten provinces [21]. This affected commercial activities involving cattle and other livestock products.

It is also important to point out that the climatic impacts explained here are not uniformly experienced across the country's tenure systems. Communal and small-scale farmers are more likely to be negatively affected by the warming temperature and variability in rainfall [8, 27]. As detailed in the next subsection, the situation also impacts heavily on food security particularly to small-scale subsistence farmers whose operations are not covered by irrigation schemes.

3.2 The water sector

The total amount of water available for the country is estimated to be about 20 million megaliters of freshwater [9]. It is critical to point out that the availability of this water is largely climatic [29]. Replenishment of the water is through rainfall leading to runoff into streams, rivers, dams and lakes. Some of it collects into vleis and surface depressions or ends up as ground water stores in the form of aquifers. The country has an estimated dam population of over 8000 [8]. Zimbabwe also has seven river catchment areas, namely Mazowe, Manyame, Save, Runde, Sanyati, Gwayi and Umzingwane. The sensitivity of these catchments to climate change varies with their location and with the type of land use practices in the catchments. The 2080 model predictions generally show a significant reduction in surface water resources. The areas to the north eastern and the eastern of Zimbabwe are projected to have a surplus in surface water. However, the western and southern parts of Zimbabwe, where Umzingwane, Runde, Gwayi and Save are located, are projected to experience significant decrease in runoff and desiccation of the catchments [9, 30].

Increased water scarcity associated with climate change can also be seen in depreciation in ground water levels. The common understanding is that water tables are becoming deeper. Where communities used to easily access water through shallow wells, they now need to dig deeper to tap up the water [10]. This is clear evidence that the groundwater is getting depleted owing to a drier climate. A report by the IPCC [31] confirms that rural communities relying on low-cost dug wells and boreholes are now exposed to serious water stress owing to interruptions in recharges resulting from drought.

3.3 The energy sector

Climatic concerns in the energy sector are twofold. The sector is not only a driver of climate change due to GHG emissions, but is also affected by its impacts [32]. Given that the sector drives other socio-economic factors, such impacts need to be carefully examined. Currently, the country is not producing enough energy to meet demand and it covers the deficit through electricity imports. In rural areas, there are immense challenges facing attempts to extend the national grid. Energy deficits are high in the rural areas with an estimated 19% of the rural people only having access to reliable electricity. Without electricity, farmers cannot process their crops, add value or diversify their livelihoods thereby affecting agricultural productivity. In schools and homes, children struggle to study without light and are cut off from modern technology thus affecting education performance. Health institutions are also not spared from intermittent power cuts and this affect the national health delivery system [33].

Hydro-power contributes a significant proportion to the country's electricity generation. Recurrent drought in the past few years coupled with changing rainfall patterns within the southern African region have led to the decrease in water levels of major reservoirs [34]. A conspicuous impact of climate change affecting the energy sector has been isolated in the 2015/2016 season. The water levels in Zimbabwe's main lake, Lake Kariba, dropped to below 30%. This situation seriously affected power generation in the country. Similarly, in Kenya, droughts that occurred between 1999 and 2002 drastically affected hydro-power generation,

falling by 25% in 2000. The resultant cumulative loss in generation was variously estimated at between 1.0 and 1.5% of total GDP. These negative climate impacts have affected other sectors of freshwater distribution and food production [35].

Zimbabwe uses a mix of energy sources. These include fossil fuels (coal, coal bed methane and imported petroleum) and clean energy sources (hydropower, biofuel and solar). The sector faces challenges from rising population and economic demands. Climate change is also expected to exacerbate the energy supply situation. The energy sector constitutes about 49% share of total GHG emissions in CO_2 equivalent [36]. However, as shall be discussed later, there are also opportunities created by climate change in the sector.

3.4 The health sector

Evidence suggests that climate change will affect human health in various ways. Africa is already experiencing high burdens of health outcomes whose frequency, magnitude and spatial range is anticipated to grow [15]. These challenges, largely triggered by temperature and precipitation extremes, manifest in malnutrition, diarrheal diseases, and malaria and other vector-borne diseases. Climate change is also expected to exacerbate the human exposure to heat waves and direct exposure to ozone owing to elevation of ozone in the troposphere [37, 38]. There is a gender dimension to these problems, with evident disproportionate impacts on women, children and people living with disabilities [39, 40].

In Zimbabwe, observed health burdens of climate disturbances largely emanate from high frequencies and severity of floods, storms and droughts, including geographic spread of infectious disease vectors. The geographical range of malaria and other mosquito-borne diseases, such as dengue; increases in the problem of diarrheal diseases, and of water-borne pathogens such as cholera and typhoid, are worrisome [22, 41]. Hartmann et al. [41], using sixteen climate change scenarios, reveal that the geographical distribution of malaria could change, with previously unsuitable areas becoming suitable for transmission as the ecology of vectors and pathogens is altered. Matawa and Murwira [42] also projected expansion in habitats of certain disease vectors owing to changes in temperature and rainfall in some parts of the country. There are also fears that disease epidemics in addition to other stressors such as food insecurity, chronic malnutrition, and HIV and AIDS are eroding the resilience of households, rendering them less resilient and more vulnerable to health problems. Although mainly attributed to water contamination, the recent outbreaks in cholera and typhoid could also be partly blamed on climate change. A case in point is the repeated outbreaks of cholera that recorded over 98,000 cases and more than 4000 deaths between August 2008 and June 2009 [43] and over 6500 cases and 31 deaths reported by 20 September 2018 [44]. The Cyclone Idai, which was downgraded to a tropical depression on the 16th of March 2019 caused high winds and heavy precipitation in Manicaland Province, riverine and flash flooding and subsequent deaths, destruction of livelihoods and properties, with Chimanimani and Chipinge districts being the most affected. The Ministry of Health and Child Care (MoHCC), with support from development partners, had to urgently move in to lead the health response, including preventing outbreaks of epidemic diseases such as cholera [45].

4. Policy and institutional responses to climate change

In line with the climate mitigation and adaptation agenda articulated in multilateral environment agreements (MEAs), Zimbabwe's policy space has largely been characterised by active participation in international environmental laws and

subsequent ratification of the MEAs. Reviewing this policy space is necessary to show the main activities in the national policy regime and the reapable benefits thereof. Thus, the country's response to the three main climate based MEAs, namely the UNFCCC, the Kyoto Protocol and the Paris Agreement is assessed in this section. These instruments unlock opportunities in the form of knowledge and skills acquisition through training, technical assistance, technology transfer, funds received, materials or equipment accessible to the country.

Zimbabwe signed and ratified the UNFCCC in 1992. The coordination for the implementation of this Convention is done by the Climate Change Management Department (CCMD) in the Ministry of Lands, Agriculture Water, Climate and Rural Resettlement. The UNFCCC is supported by other important instruments namely, the Kyoto Protocol and the Paris Agreement. The purpose of the UNFCCC is to prevent dangerous human interference with the climate system. It covers climate change assessments, mitigation and adaptation. Focus of the Convention is on stabilising GHGs at a level to be achieved "... within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner." The Kyoto Protocol is an international agreement linked to the UNFCCC, which commits its Parties by setting internationally binding emission reduction targets. Although drawing much attention to the developed countries as principally responsible for the current high levels of GHG emissions in the atmosphere as a result of industrial activity, Zimbabwe also ratified the Protocol in 2009 [9].

The Paris Agreement builds upon the UNFCCC and has managed, for the first time, to bring all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. Zimbabwe signed the Agreement on 22 April 2016, ratified it on 7 August 2017 and was entered into force on 6 September 2017. The Agreement's central aim is to strengthen the global response to the threat of climate change by keeping global temperature rise below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a proposed technology framework and an enhanced capacity building framework will support action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework. It requires all Parties to put forward their best efforts through nationally determined contributions (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts [13, 46].

Under these instruments, Zimbabwe has developed the National Climate Change Response Strategy (NCCRS) in 2014; Intended Nationally Determined Contribution (INDC) in 2015; National Climate Policy (NCP) of 2017; the First, Second and Third National Communication to the UNFCCC. The country also conducted United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation (UN REDD+) Capacity Needs Assessment. **Table 1** summarises the interventions made so far and the benefits that accrue to the country.

Through the Adaptation Fund that is established to finance concrete adaptation projects and programmes in developing countries that are vulnerable to the adverse effects of climate change, Zimbabwe is likely to benefit from this funding window. There is an on-going process for the Environmental Management Agency (EMA) to be accredited as a National Implementing Entity (NIE), to access the funds. The country also got support from the Common Market for East and Southern Africa (COMESA), UNDP, Global Water Partnership Southern Africa, UNECA, Climate

MEA	Focal point	National action plans/strategies	Source of funds	Funds received (US$)
UNFCCC	CCMD	NCCRS, 2014	COMESA, UNDP, Global Water Partnership Southern Africa, UNECA, Climate Technology Centre and Network (CTCN) & Environment Africa	100,000
UNFCCC	CCMD	Energy and Water Efficiency Audit for 10 selected pilot companies	Climate Technology Centre and Network (CTCN)	250,000
UNFCCC	CCMD	Climate Smart Agriculture Manual development	Climate Technology Centre and Network (CTCN)	100,000
UNFCCC	CCMD/EMA	Coping with Drought Project	Special Climate Change Fund (SCCF)	1,000,000
		Scaling Up Adaptation	Special Climate Change Fund (SCCF)	3,980,000
UNFCCC	CCMD	National Climate Policy (NCP)	Government of Zimbabwe, UNDP, Global Water Partnership Southern Africa, UNECA, Climate Technology Centre and Network (CTCN) & Environment Africa	130,000
UNFCCC	CCMD	Third National Communication to UNFCCC	UNEP	400,000
UNFCCC/Kyoto Protocol	CCMD/Forestry Commission	UN REDD+ Capacity Needs Assessment	UN-REDD	50,000
Paris Agreement	CCMD	Intended Nationally Determined Contribution (INDC), 2015	UNEP from Zimbabwe's GEF STAR Allocation and French Embassy in Zimbabwe	200,000
Paris Agreement	CCMD	Climate Change Technical Assistance-NDC MRV Framework development	World Bank	1,500,000
UNFCCC	CCMD/EMA	NIE Accreditation	Adaptation Fund/ South-South Cooperation	50,000
UNFCCC	CCMD	GCF Readiness Programme	Green Climate Fund	300,000

MEA	Focal point	National action plans/strategies	Source of funds	Funds received (US$)
UNFCCC	CCMD/EMA	National Adaptation Plan	Green Climate Fund	3,000,000

Table 1.
Interventions for climate related MEAs implementation (source: [47]).

Technology Centre and Network (CTCN) and Environment Africa. These provided support towards the development of the NCCRS, NCP, UNFCCC COP participation and other capacity building on climate change issues negotiations, including development of a Climate-Smart Agriculture (CSA) Manual, Technical Assistance on Climate Change readiness, and NDC MRV Framework development. So far, Zimbabwe has one Clean Development Mechanism (CDM) registered project known as the Sable Chemicals Tertiary N_20 Abatement Project, which is supported by the United Kingdom. This large-scale project has potential to reduce an estimated 473,759 metric tonnes of CO_2 equivalent per annum. Limited understanding of the opportunities associated with CDM projects, high upfront costs for baseline evaluation, and capacity to develop CDM project proposals, among other policy and institutional implementation challenges, have been cited as the main impediments to adoption of CDM interventions in the country [48].

The broad national climate policy regime has also enabled the engendering of climate change in national budgets. **Figure 1** indicates the budgetary allocations given to the CCMD from 2016 to 2019. There has been a significant increase in funds allocated to support the climate change coordination activities of the CCMD since 2016. This increased attention to climate change can be attributed largely to the recognition of the climatic challenge in the recent national economic blueprints, in particular, the Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZimASSET) (2013–2018) and the Transitional Stabilisation Programme (TSP) (2018–2020). While ZimASSET did not articulate clear guidance on climate change interventions, there has been increased consideration and guidance on climate change in the TSP.

The sustainability of these policy interventions deserves critical analysis. The next section uses the sustainability lens in examining the challenges and opportunities associated with sectoral climate change interventions in Zimbabwe. The policy

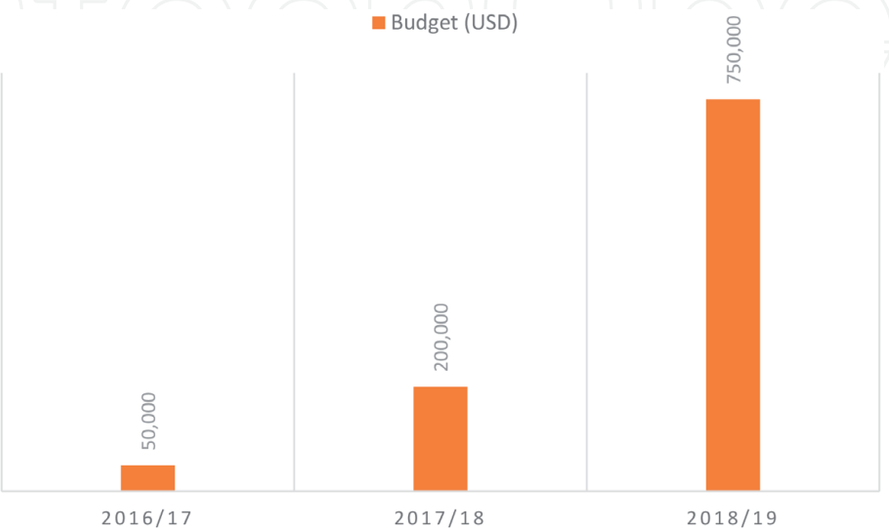

Figure 1.
Treasury allocations to the Climate Change Management Department, 2016–2019 (source: CCMD Official).

environment and the capacity of multi-sectoral institutions responsible for addressing climate change is also discussed.

5. Sectoral interventions, challenges and opportunities

Acknowledging the effects of climate change and guided by the policy and institutional framework presented above, the country, institutions and individuals have not been complacent. The responses, depending on the nature of the climatic event and the persons involved, have either been well-planned or spontaneously executed. This section discusses the sectoral responses to climate change by various stakeholders. Aside from sectoral analysis of the mitigation and adaptation practices in place, the discussion attempts, where possible, to disaggregate the analysis at the level of government, institutions and individuals. The interventions discussed here are intended primarily to identify opportunities that have been unlocked or that are potentially available within the sectors in question. It also ingrains the sustainability question in the analysis.

5.1 Climate change responses in the agriculture sector

There is growing evidence that farmers in Zimbabwe are adapting to observed climate changes. This is through altering cultivation and sowing times and crop cultivars and species that can withstand climatic irregularities. Notable progress in the agriculture sector relates to the development of irrigation infrastructure. In 2001, about 152,000 hectares of land were under formal irrigation with a total of 5000–20,000 under informal irrigation. A further 600,000 ha of land nationwide was to be availed for irrigation development. In 2015, government availed a total of US$2.6 million towards completion of 13 irrigation schemes covering about 635 ha [21]. Since then, government with support from development partners has upscaled the irrigation programme as illustrated in **Table 2**. It is clear from the table that the adaptation agenda has got support largely from international players who have injected funds and equipment to increase the area that can be put under irrigation. The objective is to depart from a practice that has largely relied on rain-fed agriculture to subsequently harness the available water resources for irrigated farming. Within the irrigation policy drive, a number of projects on resilience capacity building in agriculture for communities to better cope with the negative impact of climate change have been implemented. These interventions have also strengthened the Agriculture Extension Services Department (Agritex) to be able to give advisory warnings on planting, crop maturing varieties, including varying of planting dates to spread risks.

Climate change has also led to innovative ways of adaptation in the agriculture sector. These range from isolated practices such as moisture conservation practices by farmers to well-developed responses of CSA such as precise fertiliser application, manure application, agroforestry, crop rotations and intercropping and soil conservation [49]. Adoption of moisture conservation farming practices for example, enable farmers to extend the growing season and to do dual season cropping. In places such as Muzarabani, where climate change has increased the frequency and severity of floods, the practice of dual season cropping has been observed. This strategy enables the locals to harness opportunities associated with flooding [50]. However, floods bring mixed fortunes to the communities experiencing them such as improved soil fertility and ground water recharge [10, 51], but adaptation interventions being practiced in such areas may not be sustainable.

Climate-smart agriculture is farming that embraces the twin goals of mitigation and adaptation at the farm level. The Food and Agriculture Organisation (FAO) describes it as a sustainable climate sensitive response in the agriculture sector with

Responsible authority	Funds (US$)	Target (ha)	Description
European Union (EU)	7.8 million	1206	Technical support for 20 irrigation schemes in Chimanimani, Makoni, Chipinge, Beitbridge, Gwanda and Mangwe districts
Swiss Development Cooperation	1.3 million	656	Rehabilitation of 14 irrigation schemes, benefiting 1425 households in Bikita, Gutu, Masvingo and Zaka districts
Japanese International Cooperation Agency (JICA)	15 million	674	Rehabilitation and development of Nyakomba irrigation scheme in Nyanga District along Gairezi River
International Fund for Agricultural Development (IFAD)	60 million	—	Smallholder Irrigation Revitalisation Programme commencing in 2017
Kuwait and Abu Dhabi funds supported projects	28.7 million	11,290	Maintenance of irrigation schemes for over 2000 households' beneficiaries across the country. This was to be complemented by US$8,6 million of support from development partners. Co-financing of Zhove Irrigation Scheme with government contributing US$7 million
Department for International Development (DFID)	48 million	—	Rehabilitating irrigation schemes for smallholder farmers and supporting training and extension services

Table 2.
Irrigation support projects in Zimbabwe (source: [21]).

co-benefits of increasing productivity and building the resilience of agricultural-based livelihoods communities while reducing GHG emissions. It is a planned intervention strategy encompassing agricultural practices, policies, institutions and financing to bring tangible benefits particularly to smallholder farmers and to enable them to be stewards of the environment that support them [49, 52]. With support from development partners, Zimbabwe has started implementing the CSA programme. The programme targets small-scale farmers, particularly women and poor households that are vulnerable to food insecurity under a changing climate. Elsewhere, successful results have been noted in Kenya and Tanzania as detailed in **Box 1**.

The CSA pilot projects (2011–2014), implemented jointly with partners in Kenya and Tanzania, promoted integrated and diversified farming systems and agro-ecological principles. The programme was established to demonstrate that ongoing agricultural development programmes could bring co-benefits in terms of climate change adaptation and mitigation thereby increase the uptake of CSA at significantly larger scale. The pilot projects linked research activities, practical work in farmers' fields and policy making at different levels to enhance the effectiveness of planning and programming for CSA on farms, throughout the landscape and at the national level. Results showed that: The main benefits of following the CSA approach resulted in higher yields, raised farm income and increased food availability. This is an indication that CSA can be an effective approach for improving food security, alleviating poverty and building more resilient livelihoods. It also indicates that smallholder farmers can be an effective part of the response to climate change and make a meaningful contribution to reducing GHG emissions. Scenarios, modelling and measurements serve an important role in evaluating and prioritising CSA practices for implementation and scaling up. By building research into ongoing development activities, the assessment of CSA practices can be undertaken more quickly, and the findings can be used to prioritise efforts in projects and programmes. Bringing sound, up-to-date evidence into decision-making processes can help shape policy making that effectively supports CSA. The findings from the pilot activities were presented in national workshops, which allowed decision makers to become familiar with the benefits of CSA practices and develop or adjust policies, plans and programmes to better foster CSA.

Box 1.
Successful climate smart agriculture practices in Kenya and Tanzania (source: [49]: xii-xiii).

It is clear from the cited Kenyan and Tanzanian cases that for climatic interventions to be successful, they need to be driven by evidence-based policy formulation and trialled in participatory learning experiences with the concerned communities. Similar CSA approaches, though existing at small isolated scales, are also practiced in Zimbabwe. Many studies carried out in Zimbabwe identify the development of irrigation facilities, growing of small grains and short to medium term crops which mature early and are drought tolerant, and introduction of new agricultural techniques and practices as opportunities farmers were harnessing in adapting to drought [24, 26, 53, 54]. Chanza [53] collaborated with earlier views by Mararike [55] and Kaseke [56] that revival of indigenous food security strategies at village level is an important direction to adapt to climate change disturbances that lead to food insecurity.

The major concern, however, is that most of the climatic support to the farmers has largely been driven by the donor community and the direct support by government is insufficient to meet the assortment of farmers described earlier. As such, farmers who take long to be independent may not be able to continue with the new agricultural techniques without external support.

5.2 Climate change responses in the water sector

The unpredictable and potentially devastating effects of climate change puts a strain on the management of water resources. Zimbabwe's water sector faces mixed challenges such as satisfying increasing competing and conflicting uses owing to climate change effects and increased water demand by other sectors and underutilisation of water resources in some areas. Degradation of water quality worsens the urban water supply situation in the country. This also creates potential for conflict among the different sectors and water users. With proper decisions however, climate change can guide society and water users to be water sensitive and adopt water conservation practices. The challenges related to unpredictable rainfall patterns have seen government, with support from development agencies, investing in irrigation development and maximising on use of existing water and irrigation facilities. Despite the capacity to irrigate more than 330,000 ha, only 80,000 ha were under irrigation in 2016 [21]. There are many ways in which investment in irrigation can bring benefits to the country and farmers involved. For instance, irrigation enables expansion of agriculture activities by turning dry areas into highly productive lands. Development of irrigation infrastructure allows continuous crop production and can facilitate increased productivity where farmers supplement rain fed agriculture. However, under the changing climate, irrigation cannot be business as usual since it is also likely to be affected by the increasing frequency of droughts. The government has moved in to promote centre pivot irrigation to save the water resources and address the high costs associated with the more efficient drip irrigation [57].

Beginning in 2016, Government of Zimbabwe started implementing the Climate Resilient National Water Resources and Irrigation Master Plan, whose objective is to integrate climate change modelling with development and management of water resources and irrigation infrastructure. Under this scheme, the government secured a US$98 million loan facility to buy irrigation equipment, tractors and implements through Brazil's More Food for Africa programme. The programme has been extended to cover small-scale farmers. For instance, following acknowledgement that the available water bodies are being under-utilised, government mooted an integrated water use master plan beginning with Tokwe Mukosi Dam. The plan is expected to support irrigation farming, fisheries, hydropower supply and tourism. The dam reported as the largest inland reservoir in the country, has capacity to irrigate 25,000 ha and can supply 15 MW of hydropower. Clearly, this intervention

has managed to resuscitate idle irrigation infrastructure to increase food production. There are also opportunities for technology, knowledge and skills transfer. For example, through using drip and canal irrigation that use less power as compared to the overhead sprinkler methods [21].

With reference to urban areas, the threats of water scarcity associated with climate change have caused water institutions to embark on water saving practices and recycling. It is a fact that urbanisation, whether with or without climate change, imposes increased water use and consumption demands. Accordingly, through adapting water sensitive practices such as recycling, more water can be availed into the supply system. If treated to meet specific water quality standards, wastewater can still be discharged back into public river systems for ecological support and use by downstream communities [10].

The key challenge, however, is that investment in the water sector or in setting up irrigation infrastructure requires large funding. Given the predominantly external based support in irrigation projects that is presented earlier in **Table 2**, there are notable deficiencies in upscaling climatic responses in the water and agriculture sectors. Therefore, unless government allocates adequate funding for irrigation development, the current practice is not only slow in implementation but also not sustainable.

5.3 Climate change responses in the energy sector

The energy sector remains a key intervention focal area by the Government of Zimbabwe. In response to the UNFCCC's global call to cut GHG emissions, Zimbabwe set the conditional mitigation contribution of reducing emissions by 33% below a business as usual (BAU) scenario by 2030. This goal is to be accomplished by uptake of robust responses in the energy sector. Projects that are currently running include ethanol blending, solar water heaters, energy efficiency improvement, increasing hydropower generation in the energy mix, and the refurbishment and electrification of the rail infrastructure. The country is on course to meet these target reductions in carbon-dioxide (CO_2), methane (CH_4) and nitrogen oxide (N_2O) gases. Other mitigation strategies proposed include coal-bed methane power, solar powered off-grids, integrated waste management, changing thermal power station technologies, reviewing the transport system, upscaling the UN-REDD+ implementation and sustainable energy alternatives in the tobacco farming system [46, 58].

As explained earlier, responses in the energy sector are being supported by an enabling policy framework. Specific policies related to the energy sector include the National Climate Policy and the Transport Policy, alongside other climate mitigation instruments. Other policies expected to support GHG mitigation interventions include the Forest Policy, Renewable Energy Policy and Bio-fuels Policy, which are being finalised for adoption. The supportive policy framework has enabled the country to speed up the upgrading of hydro-power generation plants (the recent one being the Kariba Dam Project) and the completion of the Tokwe Mukosi Dam cited earlier. Already the country is on course in renewable energy drive although there are still some challenges to be addressed to scale up the implementation and uptake of renewable energy. Some of these challenges include un-viable tariffs and the low creditworthiness of the power utility who is the major offtaker. **Table 3** shows some of the key projects that are at various stages of implementation, notably the Batoka and the Gairezi hydro-power plants, with others already been completed. The bigger projects capable of generating at least 100 MW have largely been spearheaded by the Zimbabwe Power Company (ZPC), with independent power producers (IPP) concentrating on smaller projects. In addition to the projects indicated in **Table 3**, small hydro-power projects on run off

Project description	Proponent	Energy contribution
Expansion of the Kariba South Power Station	ZPC	300 MW
Batoka Gorge Hydropower Project	Zambezi River Authority (ZRA)	1200 MW (for Zimbabwe) and 1200 MW (for Zambia)
Gwanda Solar Power Plant	ZPC	100 MW
Insukamini Solar Power Plant	ZPC	100 MW
Munyati Solar Power Plant	ZPC	100 MW
Pungwe Hydropower Plant	Nyangani Renewable Energy (IPP)	3 MW
Kupinga Hydropower	IPP	1.4 MW
Gairezi Hydropower Project	ZPC	30 MW

Table 3.
Clean energy project interventions (source: [21]).

river in the Eastern Highlands, and on inland dams around the country are variously taking course [21, 22].

Although still lacking the appropriate supporting policy instruments, fuel blending of E10, E15 and E85 have been introduced. The major challenge is related to limited awareness and low uptake of these products by the public. Solar energy technologies are widely being adopted especially for lighting, powering phones and solar-powered geysers in some households. Most of the large urban areas such as Harare, Bulawayo and Gweru have embarked on projects to use solar-powered traffic lights in the cities although these maybe low-key initiatives compared to what countries like South Africa, Kenya and Morocco have done in the solar energy space. The Rural Electrification Agency (REA) of Zimbabwe has scaled the uptake of solar systems in schools, clinics and public facilities. REA has also supported the uptake of biogas digesters to provide alternative energy for cooking for rural households. Overall, the mitigation initiatives highlighted here present enormous opportunities for a developing country like Zimbabwe. A number of development windows have been opened for international collaboration towards low carbon development pathways and economic development. Investments in low emissions development (LED) are still limited but have potential to grow. Therefore, the country is set to fully benefit from a LED trajectory [22].

In order to respond to the twin problems of energy poverty and land degradation, the Zimbabwe government implemented energy sector reforms that aimed at substituting biomass fuels with liquefied petroleum gas (LPG). Davidson et al. [59] reported a reduction in charcoal use, in favour of LPG consumption, which grew by an annual rate of 12%. The use of LPG also stopped the production of an estimated 337,500 tonnes of charcoal that would have destroyed about 40,500 ha of forest [60]. As argued by Johnson and Lambe [61], switching from a traditional biomass fuel source, for example, charcoal to an environmentally friendly source (LPG) can often lead to adaptive response mechanisms.

A renewable energy project supported by Oxfam and Practical Action in rural areas of Masvingo and Manicaland provinces has yielded positive benefits to the communities. As detailed in **Box 2**, the project has literally energised the beneficiaries as it led to improved health outcomes, widened access to education, increased agricultural production and boosted business and enterprise, strengthened livelihoods, and enhanced quality of life. Already the intervention has shown possibilities of creating green communities that are independent of the national grid and becoming self-sustaining [33].

The Rural Sustainable Energy Development Project (RuSED) in Zimbabwe ran from August 2011 to January 2016. The project was funded by a two million euros grant from the European Union and Oxfam and was led and implemented by Oxfam in partnership with Practical Action and in association with the Ministry of Energy and Power Development and the Rural Electrification Authority of Zimbabwe. The project aims to enhance the lives and livelihoods of poor rural people by harnessing energy from the sun and running water to bring electricity to remote and isolated communities in ways that are affordable and sustainable. Over the course of the project, Oxfam has implemented a solar energy scheme in Gutu District in Masvingo province, and Practical Action a micro-hydro project in Himalaya in Mature District in Manicaland. The Himalaya scheme was commissioned on 8 April 2015. The Gutu scheme has many elements, including a solar pumping extension to the Ruti irrigation scheme which was commissioned on 10 April 2015.

Results show that access to affordable and reliable electricity from the sun or from running water is crucial to boosting enterprise and increasing production. This has improved quality of life of the beneficiaries, in particular, the quality of women's lives. Access to energy and water has also improved the social and psychological health of communities and their sense of empowerment.

Box 2.
Case study of a clean energy project in Zimbabwe (source: [33]).

The project cited above (see **Box 2**) presents numerous development opportunities for rural development in Zimbabwe. This is a clear demonstration that decentralised energy systems have a potential to contribute to a sustainable future in Zimbabwe. The sustainability of the project has been guaranteed since it enabled communities to take ownership, set their own priorities for energy use and devise payment systems such that they will be able to finance the ongoing operation and maintenance, and ultimately expansion and improvement. Notwithstanding the encouraging progress, much remains to be done in terms of activities to complement energy access that will enable enterprises to thrive [33]. The main challenge could be related to the fall in general economic development indicators that would make it difficult for poor households to access the energy resource.

5.4 Climate change responses in the health sector

Zimbabwe's commitment in the health sector is generally reflected through international, regional and national frameworks. Within these instruments, health issues associated with climate or weather-related shocks and stresses are addressed. Some of the international obligations have been domesticated into national policies and legislation, starting with its Constitution, medium term policies and sectoral strategies in the health sector and in relation to climate change. The NCP and NCCRS give specific mention of health, while the 2016–2020 National Health Strategy makes explicit reference to the need to improve climate change awareness and the need to develop a Public Health Adaptation to Climate Change Plan [22].

Through a strong epidemiological surveillance system in place, the country is capable of giving an early detection of changes in incidence, mortality and geographic range of health outcomes associated with climatic change. One of the critical national programmes to respond to the observed and anticipated spatial spread of malaria mosquitoes is the National Malaria Control Programme, spearheaded by the Department of Disease Prevention and Control in the Ministry of Health and Child Care. The programme implements many strategies, including vector control, case management, epidemic preparedness and response, intermittent preventive therapy, research, monitoring and evaluation, and information, education and advocacy for malaria treatment and prevention. The programme receives support from two major donors: The Global Fund to Fight AIDS, Tuberculosis and Malaria and the President's Malaria Initiative [22].

In some places such as Muzarabani, it can be argued that the desiccation of wetlands and ponds that previously harboured vectors and acted as breeding grounds for mosquitoes has significantly reduced disease incidences. Drought has also led to serious water scarcities prompting the government and other development partners to sink boreholes in order to improve access to portable water. This means people can now easily access portable water, which previously they could not. In this thinking therefore, climate change is arguably an opportunity for community development through interventions to improve water and sanitation [50]. The major threat to this drive emanates largely from the depletion of ground water sources described earlier. This means communities in some dry regions may only have seasonal access to the portable water as drought events worsen.

Existing policies also create adaptation opportunities that can assist in evading adaptation barriers. Worth mentioning is the National Water Policy of 2012 that provides an enabling environment for climate change response. Within it, the Zimbabwe National Water Act specifies the need to use water efficiently and applies a user pays principle that regulates water use. Alongside other development policies, the water policy aims to promote uptake of cleaner and more efficient technologies across all water consumption sectors. This has seen sectoral and institutional collaborations in funding the construction of solar powered boreholes in dry areas of the country such as Chivi District in Masvingo Province. This has been supported by construction of Blair toilets to improve the hygiene and sanitation of the communities [22]. Zimbabwe's Water, Sanitation and Hygiene (WASH) sector is managed and coordinated by an inter-ministerial committee, the National Action Committee (NAC) with the National Coordinating Unit (NCU) as the Secretariat. WASH components comprising of Hygiene Promotion, Water Supply, Excreta Disposal, Vector Control, Solid Waste Management and Drainage require protection from damage and disruption by climate change induced disasters. Should they be damaged, they urgently require restoration to avert deaths, diseases and malnutrition. The NAC has been strategic in engaging partners, mobilising resources and ensuring timeous response to WASH disasters. Undoubtedly, the sector interventions lessen the impacts of climate change as people have access to adequate water supply and sanitary facilities, which are key provisions in reducing diarrhoea and other infectious diseases.

6. Discussion

Emerging from this exposition is that if exploited well the potential benefits of climate change could be realised in all the socio-economic development sectors discussed in this article. The country needs to identify the best alternatives that do not involve lots of capital and are adaptive to local communities in Zimbabwe. With reference to the agriculture sector, there are opportunities for livelihoods diversification pointed out by Chikodzi et al. [24] and Chanza [53] where adaptation on ensuring food security under climate change could have the most direct benefits on livelihoods. There are also multiple benefits for food security, including enhancing food production, access to markets and resources, and reduced disaster risk. Effective adaptation of cropping can help ensure food production and thereby contribute to food security and sustainable livelihoods by enhancing current climate risk management. It is also important to point out that climate change has allowed climate sensitive budgeting in the broad socio-economic development sectors of the country.

The situation in benefits of climate adaptation in the water sector appears blurred. There are places, particularly in urban areas, which are expected to experience serious water supply challenges while other areas, mainly rural communities, are evidently harnessing opportunities brought about by climatic events.

From a social development perspective, water and sanitation interventions have also impacted on the gender dimension of the rural community. In a study in Muzarabani, one of the dryland rural community largely regarded as the epicentre of climatic disturbances [51, 62, 63], women and girls who used to travel long distances to access water are now travelling less distances owing to proximity and improved access of portable water from boreholes drilled in their villages [50].

Effective responses in the energy sector tend to be constrained by limited funding for project development, lack of feasibility studies for wind power generation to prove the achievable capacity, lack of financing to upgrade feasibility studies of some small hydropower sites which were carried out back in the 1990s and lake of capacity to install and maintain renewable energy systems. In addition, there are weaknesses in institutional capacity for support mechanisms. Notwithstanding the existing challenges, there are promising nuances in unlocking development benefits to the country, institutions and individuals. Specifically, Zimbabwe should strengthen the policy on energy efficiency along with supporting instruments that can be used to support energy efficiency adoption by industries. The country is challenged to fully develop the market for energy services. Apparently, decision makers lack in awareness on markets for energy services; service providers are unable to deliver the appropriate market services to unlock the market for energy services; and financiers are not appreciative of the energy efficiency business and therefore fail to deliver sustainable financial products. Elsewhere, it has been proven that putting in place mechanisms for accessing energy efficient technologies can create energy security, energy access, employment generation, cost-savings and health benefits to countries adopting such a practice [64, 65].

In order to fully realise the benefits of climate change in the health sector, the government would need to strengthen its health warning systems on climate-related disturbances. Generally, the early warning systems (EWS) are still weak as they tend to be poorly supported by early action. In other places, the health sector has employed EWS to predict disease for adaptation planning and implementation [66]. For example, studies done in some parts of Africa have assisted in predicting conditions expected to lead to an outbreak of Rift Valley fever [67] and in predicting meningitis against weather and climatic extremes [68] to facilitate early disease interventions. Confalonieri et al. [66] indicate that through public awareness, individual-level responses and adaptation to climate change can be improved. It has been established that the effectiveness of health warning systems, for extreme events such as heat waves and floods, depends on individuals taking appropriate actions [66, 69]. Hence, to achieve maximum benefit from climate response, it is imperative that the disaster affected population has the necessary information, knowledge and understanding to take appropriate action.

Health benefits of responding to climate change are well documented. Ludi et al. [17] explain that health benefits can be achieved by greener and more sustainable choices in broad sectors covering household energy, electricity generation, transport, urban planning and land use, buildings, food and agriculture. For example, the use of cleaner fuels and cooking technologies can reduce the large burden of disease from household air pollution in developing countries; greater use of renewables in electricity generation can cut ambient air pollution; behavioural shifts towards walking and cycling can reduce the burdens of both physical inactivity and air pollution [70–72]. Zimbabwe can take advantage of existing health sector interventions such as public education and awareness campaigns to reduce the risk of diarrhoeal and vector-borne diseases whose incidences may be worsened by climate change. Accordingly, adaptation strategies to climate change in the health sector can result in development of capacity building to evade barriers associated with climate change. If attention can be given to such critical institutions as the Meteorological Services Department (MSD),

rural district councils (RDCs) and health institutions, for example through funding, the health system can be strengthened to address climatic challenges.

Overall, although a range of benefits are evident in the broad socio-economic development sectors of the country, much still needs to be done to enhance the sustainability trajectory of climate change responses. Most of the interventions discussed here have mainly been spearheaded by the external driven initiatives, mainly in terms of policy direction and funding. The main reasons for an external driven orientation relate largely to the macro-economic problems that the country has been facing over the past two decades and partly to the heterogeneous acknowledgement of climate change as a development priority on the policy and institutional front.

7. Conclusion

From the analysis given in this article, Zimbabwe, like many developing countries, faces climate change in its main socio-economic development sectors. Although the article only concentrated on the agriculture, water, energy and health sectors to show climate change impacts and the country's responses to the climate agenda, it is proper to conclude that climate change brings mixed experiences that need to be carefully studied. The study challenges the current discourse that have tended to project climate change as a development hindrance. Instead, the article revealed several development opportunities that exist. If these opportunities are carefully considered, government, communities and individuals will be able to take advantage of the climate change phenomena to reshape the development trajectory. At the policy front, climate change has intensified policy formulation whose benefits go beyond environmental to cover co-benefits in the broad socio-economic development sectors. This has unlocked investment opportunities in clean energy and the associated health benefits, improved energy access, improved energy security particularly in remote and newly developed settlements, access to portable water, expansion of irrigation facilities, climate-sensitive budgeting, improved agriculture production, and improved food security. Essentially, most of the climatic interventions associated with these benefits have also managed to articulate cross-cutting issues of gender, poverty and marginalised groups. In the context of the energy sector, communities that are otherwise far from the grid could benefit as they get closely connected to the world through off-grid energy systems, modern communications and information technology. Clearly, the climate response regime that Zimbabwe embraces has opened up several avenues for addressing poverty. However, these benefits are not evenly experienced but tend to be isolated across the Zimbabwean communities.

The sustainability question on whether the current and anticipated benefits of climate change responses can be guaranteed to continue accruing to individuals, institutions and the country at large has been investigated. One way of making climatic responses sustainable would be to leverage the current predominantly external funding to get the necessary knowledge and best practices implemented to inform necessary government budgetary allocations that is supported by climate-sensitive development plans and policies. The government should depart from external funding but promote blended financing approach to allow for ownership and enhance impact investment by all players. Essentially, benefits of responding to climate change are only fully realised when the country embraces both mitigation and adaptation practices in its response decision mix. Mitigation should not only be understood as concerned with cutting carbon emissions but should be designed to take advantage of technological advances in renewable energy, for example, among other opportunities that it offers.

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