Unpacking the nexus between policy field, risk management and environmental externalities in adaptation planning: The case of smallholder dairy farmer production systems, western Kenya

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Abstract

The urgency to address the adverse impacts of climate change on livelihoods and ecosystems has seen an increase in global driven initiatives. However, shifting vulnerabilities associated with land use resource based adaptation and maladaptive feedback loops they create have been given low attention. Policy discourses that frame adaptation as a local responsibility and bias towards reducing industrial Greenhouse gas (GHG) emissions at the expense of agricultural emissions across scale are thought to account for the undesirable situation. This calls for a reflective policy framework and climate policy innovation. We provide counter arguments using Drivers, Pressure, State, Impact, Response (DPSIR) model and telecoupling principles to suggest use of resilience as an integrative lens in visualising the proposal. Using a case study on resource constrained smallholder dairy production systems, western Kenya, we analyse the critical issues in the context of decision making and environmental externalities. The effect of price risks on dairy cattle feeding strategies and ultimately carbon footprints and ecoefficiencies were examined through methane simulation and gross margin analysis (GM). The lowest ecoefficiency was associated with exclusively local coping strategies i.e. Maize Stover (Ms), while the highest ecoefficiency was observed in feeding strategies that utilise external resources and/or legume fodders. We conclude that management of externalities need to capture institutional, economic processes and incentive systems, as well as organizational and policy coherence to shape the interests and behaviour of individual land user. In particular, policy innovation should focus on price and market risks as critical factors that mediate actor decision making at implementation level as they impact GHG emissions which transcend individual decision boundaries.

Key words: Climate Action, Climate Policy Innovation(CPI), Effectiveness, Shifting vulnerabilities, Green House Gases(GHGs), Sustainable Development Goals, Telecoupling, Transformation, Resilience, Policy field

1.0 INTRODUCTION

Climate change and its mitigation is one of the urgent challenges facing humanity (Burch et al., 2019; Steffen et al., 2018). In context of large scale processes, climate change risks provide a good example of common pool problems whose effects transcend social and spatial boundaries (Burch et al., 2019, Smith and Mayer , 2018). In agriculture spatial externalities, such as Greenhouse gas emissions (Liu et al., 2015), have the potential to amplify the adverse climate change impacts (Parish et.al., 2018). The cross scale challenges engendered in GHG (Greenhouse gases) emissions threaten to undermine the ability of individuals and communities to effectively cope and respond to disaster risks (Burch et al., 2019; Cash et al., 2006), including the attainment of Sustainable Development Goals (SDGs). As externalities transcend spatial territories, jurisdictions and agents, effective governance and accounting systems are necessary (Liu et al., 2018). Accordingly, GHG emissions mitigation initiatives have emerged as critical in the analysis of Human-Environment (H-E) systems (IPCC, 2019). Focus on effectiveness thus has emerged as critical to adaptation planning (Nalau et al., 2015; Folke, Hahn, Olsson, & Norberg, 2005). The paradigm

shift is a dominant theme post Paris agreement hereafter referred to as COP 21. The shift is largely informed by need for impactful climate change mitigation pathways (UN, 2015a, UNFCC, 2018; UN, 2019), the need to mitigate humanitarian and economic losses and disruptions associated with increasing frequency and intensity of climate related disasters such as droughts, as well as political uncertainty over intended withdrawal from conference of Parties (COP) by United States of America (UNFCC, 2018).

Land use is one of the critical sectors in decarbonisation efforts (Otto, Donges, Cremades, Bhowmik, & Hewitt, 2020; IPCC, 2019). This could be realised in smallholder production systems whose impact on global resource use and environmental services, food and externalities and sustainability in general is potentially huge (Niles et al.,2018; Zimmerer et al., 2018). Attention to maladaptive practices that exercabate GHG effect, more so in Agriculture, Forest and land use (AFOLU) is critical as they account for at least 23% of the global emissions (UNEP, 2019; IPCC , 2019; FAO, 2016). Importantly, existing analytical lenses and perspectives, such as telecoupling, as well as climate research and policy discourses have tended to underestimate the contribution of small-scale farmers in closing global GHG mitigation gaps (Zimmerer et al., 2018). This increases the need for assessment of full mitigation potential and mainstreaming of agricultural emissions into global climate policy agenda (IPCC, 2019; FAO, 2016; Wise et al., 2014).

Ideally, adaptation should encompass changes in processes, practices, structures and institutions (Nalau, Preston, & Maloney, 2015;Adger, Arnell, & Tompkins, 2005). The adjustment to the adverse impacts and taking advantage of the opportunities presented in climate change is thus influenced both by internal and external drivers (Massey et.al., 2014), with adaptation pathways having untapped potential to reduce global GHG emissions and future climate change risks (Niles et al; 2018; IPCC, 2019). The contribution of local action to GHG mitigation is critical in global sustainable development initiatives and climate action (Jiménez et.al., 2020), especially with emergence of adaptation emissions or footprints in smallholder farmer production systems where maladaptive actions (i.e. those associated with dairy feeding strategies) could increase GHG emissions and exacerbate climate change challenges (Hopkins, 2014).

Novel framing in which policy innovation play a critical role in the design, diffusion and uptake of policies (Massey et.al., 2014), suggest adoption of integrated frameworks to visualise multilevel coupling between social and environmental interactions at local, regional and global levels (Hull & Liu, 2018; Liu et al., 2013). Key among the broad agenda in policy innovation is system and integrative frameworks that consider decision making (Otto et al., 2020; Weitz et.al., 2017; Gorddard et.al., 2016). Accordingly, several approaches, such as the transformative, environmental justice and business as usual (BAU) models have been advanced in the decarbonation and climate stabilization initiatives (Steffen et al., 2018). A focus on incentives which embodies actor interests are critical in assessing policy integration and effectiveness (Swart et al 2013), more so in the resolution of scope challenges, such as the negative environmental externalities, as well as the free rider and isolation dilemmas, all of which are underpinned by the question around who bears the costs and accrues benefits (Ingram et al., 2007). Since management solutions are critical in climate policy integration (Weitz et al., 2017), focus on farmer management actions becomes an urgent need (Lockwood et.al., 2010).

Intuitively, values are critical in policy problematisation, coherence and effectiveness (Weitz et al., 2017). Decision making and transformative agenda are particularly critical for land use based adaptation planning in developing countries where agriculture is the main economic and livelihood activity (Loboguerrero et al., 2019). Decision making process, such as the choice of dairy cattle feeding strategies is critical in the type and magnitude of environmental impacts, with dairy-agroforestry integration representing a good case study on the interplay of land use, risk and environmental externalities. To this end, we draw from two approaches, Drivers, State, Pressure, Impact, Response (DPSIR) and telecoupling to concretise how integrated risk management can be operationalised to contexts in climate policy discourses. We assess and adopt the interplay between price risks and methane emissions in dairy cattle

feeding as an opportunity for climate policy innovation (CPI). We illustrate this with a case study from western Kenya where the interlay of price risks, GHG emissions and management decisions captures the convergence on decision making processes. In exploring this relationship, we sought to answer the following questions;

1. Does adaptive capacity influence environmental footprints such as methane emissions?
2. Can individual risk disposition and decision making at micro landscape impact global climate?

We define effectiveness as the extent to which a policy instrument inter alia regulations, standards and voluntary mechanisms aid the pursuit of an environmental objective, such as GHG emission reduction or zero carbon growth initiatives. In Environmental management and sustainability discourses, effectiveness is primarily assessed in terms of a minimum number of primary agents .i.e. critical mass, required to reach thresholds that tip the state of an environmental system from undesirable to desirable state i.e. GHG neutral state or net carbon sink. We thus vouch for resilience as a framing and analytical lens in CPI and resolving the dilemma of adaptation-mitigation dualism among climate policy analysts. As the integration of broader development goals and climate-risk management objectives (Barreteau et al., 2020; Thapa, Scott, Wester, & Varady, 2016) is critical in adaptation and mitigation policies, local contexts could provide opportunity to promote adaptive management, learning, innovation and transformation (Nunan et al., 2012). This article contributes towards the development of a reflective framework for assessing policy blind spots around local-global partnership building, inclusivity of agricultural emissions in global climate agenda, resilience programming and optimization of adaptation-mitigation synergies for effective climate action.

2.0 Role of policy in climate change adaptation

In decarbonisation of economies critical reflexivity to manage internal processes of change at individual, organisational and technological level is key in addressing the transformative agenda (Otto et al., 2020; UN, 2019; Tvinnereim & Mehling, 2018; Pelling et al., 2015). The role of policy and institutions in thus very critical (UNEP, 2011). Policy is deliberate effort to influence the behaviour and decision making of various agents via various means interlia, regulatory, communicative, information and economic instruments (Mees et al., 2014; Massey & Huitema, 2013). It infers the statement of intent backed by governance, such as regulatory tools, as well as requisite financial and human resources to address a given issue (Massey & Huitema, 2013). It includes use of holistic framing and innovative instruments to generate fundamental change in approaches and steering mechanisms that address a given policy problem (Hall, 1993). In land use, the choice and implementation of policy instruments influence future climate risks and sustainability outcomes (IPCC, 2019). Policy is especially critical in fostering collective action and ultimately effectiveness in many of the sustainability problem areas (Mees et al., 2014; Adger, Arnell, & Tompkins, 2005).

Norms, rules, policies and laws collectively defined as institutions are critical drivers, constraints or enablers of human economic (in)action (North, 1991). At local level institutions in form of policy instruments, such as subsidies and taxes influence farmer responses (Lewis, Barham, & Zimmerer, 2008). In relation to climate change adaptation, policy can be defined as decisions and actions that mediate adjustment to and minimise adverse impacts while taking advantage of opportunities presented therein (Dupuis & Knoepfel, 2013). Policies not only provide a supportive environment but also guide stakeholders in planning and executing adaptation interventions which enables farming communities to adjust to changing climate while taking advantage of any presented opportunity (urwin & jordan, 2008). Policy is especially critical in in fostering collective action and ultimately effectiveness (Mees et al., 2014; Paavola & Adger, 2006), .i.e. resolution of functional misfit (Adger, Arnell, & Tompkins, 2005).

To a great extent, policy field refers to the highest unit of governing in terms of institutions, policy products/inputs i.e. programs, legislation and rules and expertise evidenced through

knowledgeable persons, coalitions and thinktanks (Massey & Huitema, 2013). Working in tandem or policy field is critical in the management of a public issue or set of issues a cross steering mechanisms such as the state, nonstate actors and the primary agents or citizens with potential to deal with problems or issues in a particular field in a systematic manner (Massey et al., 2014). The minimum requisite for a policy field are institution order, substantive expertise and substantive authority. Table (1) summarises an ideal description of a policy field. Ideally policy fosters new policy fields in environmental management i.e. innovative instruments, such as voluntary action, emission trading and PES, instruments and institutions that can be used to enhance ownership and participation or legitimacy (Jordan et al., 2013). These include equity considerations, which in policy and practice, can be balanced by a mix of both market i.e. use of carbon taxes and non-market mechanisms to address emissions leakages (IPCC, 2019). In our framing, effective policy requires an understanding on the interplay between primary actors' production, market and price risk constraints and potential outcomes at local and extra local levels.

The matching or confluence of key Human-Environment (H-E) interaction attributes, and the institutions designed to steer them, define fit (Young, 2006; Ostrom, 1990). Fit is reflected in the extent to which policy captures and addresses scope issues, such as externalities, as well as temporal dimensions i.e. preferences and motivations of the agents (Young, 2006; Rijke et al., 2012). The interplay of fit and scale are thus key governance challenges in the management of externalities. This is particularly critical in in the reduction of GHG mitigation gaps under the climate action goal of the SDGs (UNEP, 2019). Process dimensions i.e. the establishment of standard operating procedures, such as Environmental Impact Assessment(E.I.A), Strategic Environmental Assessment (SEA), Regulatory Impact Assessment (Weitz et al., 2017; Vammen et al., 2012), are some of the critical elements in attainment of fit. Given that policy design coherence and integration minimises trade-offs and leverages on synergies, effective CPI in land use is judged on the extent to which mitigation and adaptation objectives are mainstreamed into sectoral policies (Di Gregorio et al., 2017), as well as the extent to which climate change and overall development goals are integrated. The enactment of National Adaptation plans (Napas) is one such indicator in CPI. However, Napas in themselves may fail to elaborate the implementation, monitoring and evaluation mechanisms for assessing effectiveness even if they increase the visibility of climate change challenges into national policy discourses (Biesbroek et al., 2010).

Table 1: Summary of policy field in climate change adaptation

Policy component	Description and operationalisation	Evidence
Institutional Order(IO)	Refer to authorised legitimate government institutions with power and/ or expertise to steer or oversight an issue .i.e. the institutions that order and structure policy responses (Massey et al., 2014).	Types and number government institutions that produce policy products/outputs and devoted to adaptation(Massey et al., 2014). This includes the presence of a lead agency that coordinates and oversees the whole adaptation process and acting as secretariat for disaster risk assessment evidenced through • Multi-stakeholder coordinating body • technical committees • legal framework
Substantive Authority(SA)	What gives meaning and legitimacy to the policy actors, moreso the coordinating agency	• It is reflected in policy products and outputs including programs, legislation and rules (Massey et al., 2014)
Substantive Expertise(SE)	Evidence of expert knowledge among state	presence/ and or absence of working/steering groups, task forces, policy networks, citizen interest groups,

	and non-state actors in adaptation planning (Massey & Huitema, 2013)	policy papers and proposals, studies, reports, issue papers

Policy coherence signals the optimisation of synergies and positive externalities (co-benefits). In climate policy, it is assessed in terms of how sectoral and broader development objectives are integrated through a central authority (Di Gregorio et al., 2017). Policy coherence is critical in mobilising private actors towards resolution of collective problem (Dupuis & Knoepfel, 2013), and mediates effectiveness in local-global policy initiatives (Otto et al., 2020), where critical mass is required to mediate adoption trajectories inter alia behavioural, social norms and structural reorganisation (Milkoreit et al., 2018), as well as provide reinforcing feedback mechanisms (Otto et al., 2020). Critical mass is especially relevant in cross scale governance of GHG spillover systems (Liu et al., 2018). Accordingly, policy coherence and integration (Lemos et al., 2013), is critical in managing maladaptive outcomes. Addressing adaptation-mitigation dualism in climate policy and research could redefine how effectiveness is assessed.

2.1 Risk, Micro level decision making and environmental externalities

The availability of resources and ability to utilise them greatly influences the adaptive capacity of an individual and communities (Nelson et al., 2007). Theoretically generic capacity is a precondition for specific capacity and risk management (Eakin et al., 2014), with their interplay being critical in policy coherence. In adaptation policy, adaptive capacity and coping mechanisms largely focuses on local resource capacity (Kuruppu & Willie, 2015). Since coping mechanisms represent specific capacity, it is critical in risk innovation and resilience building (Kuruppu & Willie, 2015; Eakin et al., 2014), moreso because they are correlated to maladaptive outcomes (Suckall et al., 2014). Maladaptation creates shifting vulnerabilities whose social costs impact beyond the primary agents' jurisdiction (Barreteau et al., 2020; Adger, Eakin, & Winkels, 2009).

Given that policy innovation is assessed by the extent to which it is responsive to felt needs (Massey & Huitema, 2013), there is need for policy coherence metrics to consider decision making and management of externalities (Weitz et al., 2017). The use of risk-based decision-making tools to address time related preferences of an individual (Nelson, Adger, & Brown, 2007), as well as the capture of institutional, economic processes and incentive systems that shape the behaviour of land users and management of externalities (Xu et al., 2015; Ostrom, 2007) is critical. We demonstrate how dairy cattle feeding adaptation strategies in climate risk management influences methane emissions and ultimately impact climate at scale. We restrict ourselves to dairy cattle (domesticated ruminants), as it is a major driver of GHG emissions and climate spillover system (Meng, Peters, & Wang, 2015; Geber et al., 2013). The micro, meso and macro interplay provides a good case study on cross scale governance challenges, the need for global partnership and inclusivity in climate action.

Though some studies (Tessema, Joerin, & Patt, 2019) account for the role of risk in uptake of technologies in climate change adaptation, gaps on the role of risk on environmental externalities abound. In agriculture, the interplay of risk and environmental externalities is invariably framed in terms of income and consumption smoothening strategies. In dairy production, the tendency among risk averse farmers on average is to raise breeds that are highly adaptable to the local environment (Williams et al., 2000). This is a consumption smoothing strategy, a common practice among the poor/ resource constrained farmers (You, 2014). At national level, macro-economic policy, input-output price ratio, access to credit, institutions regarding land tenure, and management, approaches to research and extension policy and markets and infrastructure influences farmers risk management strategy (Williams, Hiernaux, & Fernandez-Rivera, 2000). For instance (Wekesa, Ayuya, & Lagat, 2018; Shimon, Ogutu, & Mburu, 2016), find profit to be a major motivating factor in adoption of voluntary measures and technologies that internalise environmental externalities.

Pressures or drivers to environmental degradation are critical in enhancing better understanding and managing effects across multiple systems and scales (Suckall et al., 2014). Ruminant livestock, such as dairy cattle generates approximately 14.5% of the total global GHG emissions (Steinfeld, 2006), which is 44% of the anthropogenic GHG emissions (Geber et al., 2013). Methane as one of the GHG spillover system impact the world through climate change impacts (Parish et al., 2018; Liu et al., 2018). Livestock-agroforestry integration as a management practice thus represents how the interplay between human decision and environmental externalities can be envisioned. Agroforestry encompasses integrated approaches (trees and legumes- livestock integration), production system with high potential in climate change adaptation and mitigation, ecosystem services enhancement and productivity improvement (Murgueitio, Calle, Uribe, Calle, & Solorio, 2011).

Under COP 21(UN, 2015a), specifically part (3a), pursuit of synergies between adaptation and mitigation is advocated (UNFCC, 2018). The need for policy innovation is thus implicit and provides an opportunity for Cop 21 to be a turning point for individual and collective action innovation in climate change action and resilience building (UN, 2019). In context of GHG mitigation and adaptation, there should be a focus on the interplay between local interests, institutional framework and fundamental drivers of the problem in the design of programmes, projects and policies (Barreteau et al., 2020; Burch et al., 2019). Combining the effect of adaptation and mitigation pathways on GHG mitigation have the potential to improve the generation of ecosystem services and improve attract funding through multilateral agreements and market based instruments, such Payment for Ecosystem Services (UN, 2019; Elias et al., 2014; Lachapelle et al., 2013).

 (Intended) Nationally Determined Contributions (I)NDCs initiative represent the main national policy frameworks, under the United Nations Framework Convention on Climate Change (UNFCCC), by which Parties to the Paris Agreement communicate their climate commitments to the international community by outlining their progress and resource gaps (UNFCC, 2018). We posit that (I)NDCS could be a focal point for policy innovation i.e. the inclusion of agriculture emissions in global climate change mitigation agreements and risk transformation. (I)NDCS (Fig 1) as conceptualised in our article has the potential to promote stakeholder confluence and address the scale and cognitive challenges, such as the interconnected externalities in land use. This is more critical where individual or local level contribution, (more so from the dominant agricultural sector in developing countries) has been accorded low attention in most climate action policies (Calvin&Bond-lamberty, 2018).
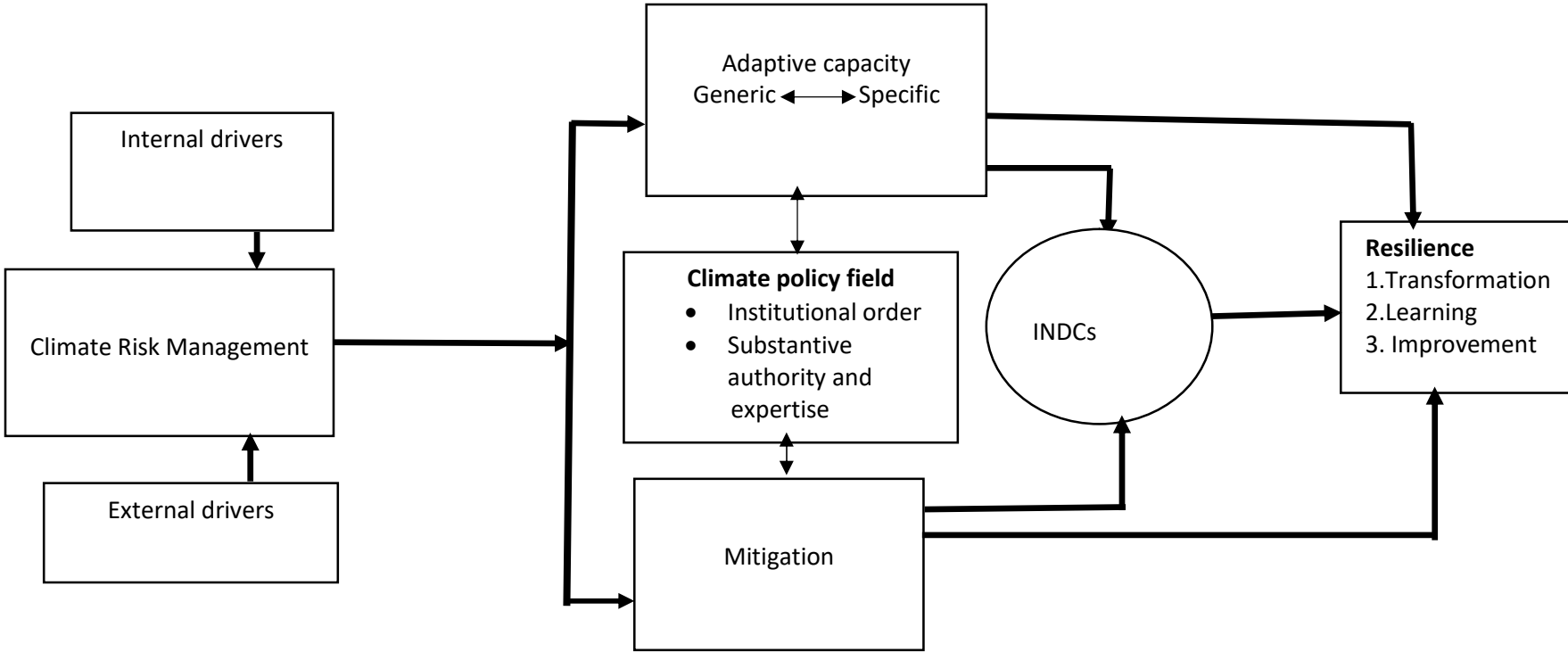
Fig 1: Adaptation-Mitigation interplay through resilience lenses and UNFCCC intended National Determined Contributions (Authors' synthesis of literature). Resilience as the ultimate goal in climate change policy and carbon neutral growth can be realized through both adaptation and mitigation (on the basis of the major economic sector of a country) hence use of complementarity as the logical basis for prioritization of either pathway. (I)NDCs thus provides a window of opportunity for innovation in environmental governance in general and inclusive closing of GHG mitigation gaps from agricultural activities in particular.

2.2. The Kenyan Dairy production systems in Context

Generally, smallholders are constrained due to a number of factors, interlia institutional failures, market and price risks, all (in)directly linked to weather fluctuations (Becx et.al., 2012). In Kenya, 1.8 Million small-scale farmers account for 73 % of all marketed milk (KNBS, 2017). Annual milk production stands at 5.28 Billion litres from 4.5 Million heads of cattle of which 0.6 Billion litres is marketed formally (KDB, 2020). The dairy production system, however is generally inefficient and characterised by high production, market and price risks (FAO, 2019). Western, Kenya is disproportionately representative of low institutional support in the smallholder dairy sector which amplifies the risks for farmers. None of the 23 processors and only a few of the 47 cooling plants are found in Kakamega and Bungoma counties (KDB, 2020). Though promotion of fodder production and preservation across various agroecological zones has been promoted to address production risks, dismal uptake has been observed among smallholder farmers (Rademaker et al. 2016). Climate hazards across different sectors cause economic losses estimated at 3% (G.o.K, 2015) of the country's Gross Domestic Product (GDP), more so in the highly climate sensitive agriculture sector.

Under the two tier governance system, the development of agricultural policy is the responsibility of the central Government, while the implementation is the responsibility of the county governments (Makoni et al. 2014). Such governance, however tend to undermine organizational and policy coherence as allocated resources by central government to devolved units do not seem to match the devolved functions. In particular, the price policy is not in the purview of devolved units which renders such units powerless in price policy and price risk policy responses. In most cases, policy responses have been adhoc and more so to pacify farmers rather than to address the underlying constraints that undermine resilience building to market and production risks. For example, though vertical integration approaches which have potential to address credit and input constraints, as well as processing capacity among small scale farmers (Williams et al., 2000) are policy relevant and sustainable, the focus of most county governments has been on hardware solutions (Bebe et al., 2016), .i.e. construction of milk sheds, which to a large extent fail to sustainably address the price risk constraints.

In many systems where fodder is in short supply, variation in quantity is much more important than variation in quality for determining nutrient supply to the animal (Thorne et al., 2002). The increasing supply of milk from smallholder farmers across agro-ecosystems in Kenya is however accounted for by increased number of producers rather than productivity in such systems. This production strategy results in high production costs and presents ecological threats to land, soil, water, and biodiversity (Bebe et al., 2016), as well as increased methane emission risks (Volenzo et al 2019; FA0, 2019). This is especially true for the study area from a view point of weather variability, underlying and on-going vulnerabilities, such as low fodder acreages and land subdivision, all which amplifies production risks.

3.0 METHODOLOGY
3.1 Theoretical background

Most of the natural resource management technologies have both larger spatial scales and longer time horizon impacts or externalities and affect economic units or households that are not party to management decision (Knox, Meinzen-dick, & Hazell, 1998). In the context of SDG on climate action for GHG mitigation and adaptation, increased need to frame of food systems around the principles of sustainability increases due to the layered nature of agents within and among countries which necessitates multilevel efforts or global strategy in search of effectiveness (Burch et al., 2019; Rey et al., 2017). It is more so in passive spillover systems where agents do not directly influence the process in GHGs emissions (Liu et al., 2018). Framing and causal relationships is thus critical in visualising externalities and sustainability in land use (Ness et al., 2010). For example, short term decisions on risk management influence allocation of assets (Siegel & Alwang, 2005), with far reaching impact on sustainability and poverty dynamics. Evaluation of market infrastructure and incentives as critical determinants of intensification in adaptation (Paavola, 2008) are critical in our

case study. This is on account that (in)formal institutions provide signals on production and price risks or the constraining factors that affect the flow of spillovers between the sending, receiving and spillover system (Parish et al., 2018). Our classification of spillovers as spatial externalities and leakages from (in)direct land use changes associated with climate change adaptation follows spillover system classification by Friis & Nielsen (2017). Our methodology, specifically the assessment of interplay between externalities and adaptation decision making processes is based on dairy feeding strategies as to provide a baseline in visioning, scaling up and translation of risk theory into effective climate action.

To put our method to perspective, we critically review performance (strength and weaknesses) of telecoupling and the Drivers–Pressures–State–Impacts–Responses (DPSIR) models in an attempt to integrate the interlay of risk and governance on performance of global and local initiatives on adaptation and climate change mitigation. The strength and weakness of DPSIR and meta (tele)coupling analytical models are summarised in Table (2). As a decision making tool, telecoupling can elicit feedbacks between systems and account for the changes across time (Tara, Killion, & Carter, 2018). Tele(Meta)coupling as an analytical lens can be explored to examine the often overlooked agent decision making processes (Liu 2017). As an analytical tool for mainstreaming of sustainability concerns in research and policy (Hull & Liu, 2018; Parish et al., 2018 ; Liu et al., 2013), it can be explored to land use changes (Eakin et al., 2014). It can thus be used in examining how legislation, control policies and incentives affect flows, such as GHG emissions and for monitoring, implementation and improvement of environmental governance and policy (Liu, 2017).

The DPSIR framework provides and communicates knowledge on the state and causal factors regarding environmental issue (Ehara et al., 2018; Svarstad et al., 2008). It is applied to identify and describe processes and interactions in H-E, a form of ecosystem approach (Shu-dong, Mueller, Bur, Xing-jin, & Ying, 2013). The bias of DPSIR model towards a single sector, ecological or biophysical factors or socio-cultural dimensions, however limits its utility (Lewison et al., 2016), especially where broad policy measures that address drivers pressures and state as well as behavioural dimensions are required (Ness et al., 2010). Additionally, DPSIR model pays less attention to maladaptive coping strategies (Suckall et al., 2014; Carr et al., 2007). Given that local resources and initiatives are critical in resilience building ((Kuruppu & Willie, 2015; Wisner et al., 2004), DPSIR is an ineffective risk transformation tool. However, it can facilitate strategic visioning, setup of administrative mechanisms and values, ex ante assessments, inform design of policy instruments, administration of economic, legislative and voluntary mechanisms, as well as guide monitoring and evaluation schemes that assess effectiveness of environmental projects and programs (Swart et al., 2013).We thus combine the two models with a view of addressing specific limitations of the two and informing CPI.

Table 2: Strength and weakness in policy assessment models

	Model	
	DPSIR	**Telecoupling**
Strength	• Enables integrative , multidimensionnel assessments (Ness et al., 2010) • Identifies and visualises cause-effect relationships (Smalling and Dixon, 2006;Ness, Anderberg, & Olsson, 2010) • Communication tool among decision and policy makers (Svarstad et al., 2008; Ehara et al., 2018;Tscherning, Helming, Krippner, Sieber, & Gomez, 2012) • Participatory planning(Kontogianni et al., 2005) • Considers cross-sectoral and environmental issues (Niemeijer & de Groot, 2008; Ojeda-Martınez et al., 2009)	• Robust approach that facilitates snowballing hence use of grounded theory (Hull & Liu, 2018;Liu, 2017; Friis & Nielsen, 2017) • Accounts for emission footprints including factors that increase the likelihood of spillovers (Xiong et al., 2018) and how agents proactively predict potential negative spillovers (Hull & Liu, 2018).The application of metacoupling gives flexibility to disregard distance magnitude in terms of processes(Hull & Liu, 2018; Liu, 2017) • Ability to assess governance arrangements, social networks, values and knowledge(Eakin, 2017)
Weakness	• Less consideration for maladaptive coping strategies particularly the informal responses to climate change at local levels yet they cumulatively influence pressures or drivers, acritical element in assessment of sustainable development at larger scales such as the national level (Suckall et al., 2014;Carr et al., 2007), • promotes selective identification of issues which undermines the linking policy options to land use, land use change, environmental and social economic impacts (Svarstad et al., 2008).	• Little data or analysis on spillover effects(Liu et al., 2018;Parish et al., 2018), • Inadequate to support evidence based policy decisions and analysis that require data from primary agents (Parish et al., 2018; Xiong et al., 2018; Olesen, Kittler, & Price, 2015). • Robust to allow use of qualitative and ethnographic methods to capture diffuse flows and their causal interlinkages (Friis & Nielsen, 2017)

3.2 Field data and literature review

We employed mixed methods approach consisting of agent survey and methane emission simulation from various dairy cattle feeding strategies. The article findings are supplemented through document analysis and Key Informant (KI) interviews among regulatory, advisory and implementation agencies in Kakamega and Bungoma counties, Western Kenya. To assess production risks, interview among randomly selected farmers was undertaken focussing on the available dairy feeding options and institutional factors influencing their choice. Extensive literature on climate policy was undertaken from Grey literature i.e. books, as well as peer reviewed publications. KI interviews were conducted among formal institutions in land use and climate change action, milk marketing, environmental management, national adaptation strategies and plans. Focus Group Discussion (FDGs) was also undertaken to elicit information on factors influencing choice of dairy feeding strategies. We used smallholder production systems and particularly ruminant production systems and the lens of risk to highlight the increasing attention to shifting vulnerabilities.

3.3. Empirical models

3.3.1. Gross Margin Analysis

Gross margins of various adaptation measures in terms of dairy cattle feeding strategies were evaluated and compared. Costs for inputs and total revenues obtained from field data were utilized in the comparison. The mathematical model (Equation (1) was applied.

$$GM = P.Q - VC = P.Q - V_1X_1 - V_2X_2 - \ldots V_nX_n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where   GM = Gross margin

P = Price of the produce = Quantity of the produce sold

VC = Total Variable cost of production.

X_i = Level of ith input used; V_i = Variable cost of ith input used

3.3.2. Methane emissions simulation

The simulation model adopted follows methanogenesis model as described by (Mills et al., 2003) in equation 2. Modelling saves time and resources and allows for integration of results from many experiments already performed to quantify and represent large and complex systems in a mathematical form which allows for prediction of methane production from cattle without performing extensive and costly experiments (Hirooka, 2010; Ellis *et.al.*, 2007). Simulation of methane emission from different feeding strategies and Ms was carried out and comparisons were made against conventional strategies, namely Napier (*Pennisetum* species) and Boma rhodes (*Chloris gayana*). Simulated quantitative models give a range of scenarios that can be traced in both directions in an iterative way to develop scenarios and project impacts in H-E systems (Turner *et.al.*, 2010; Downing and Patwardhan, 2002). The worst case scenario model can be used in disaster planning (Downing and Patwardhan, 2002). This study used non-linear monomolecular models due to their adaptability across diet types and intake levels. Non-linear monomolecular models do not require detailed dietary information to be used in simulating methanogenesis in cattle (Mills *et al.*, 2003). Furthermore, non-linear models account better for observations at the extreme methane output feed intake ratios. Comparisons were based on farmer practices, as well as exploratory and practical feeding regimes and rations on all possible ranges. Where information is lacking, estimation of certain inputs can be made according to data published elsewhere in literature (Mills *et.al.*, 2001). Feed value data in the simulation was thus obtained from literature data by Thorne et al., 2002; Debala *et.al.*,2011; Dereje *et.al.*,2010; Gebrehawariat *et.al*, 2010; Muia *et.al.*,1999; Mills *et.al.*, 2001;2003; Dzowela, 1985; Muinga et al., 1995; 1993 and Smith et al., 1989.

Methane (Mj/day)=1.06 (S.E 2.41) + 10.27(S.E 3.59) dietary forage proportion+ 0.87(S.E 0.074) DMI…………………………………………………………………………………………………(2)

Where:

DMI = Dry matter intake

SE = standard error

3.3.3. Estimation of ecoefficiency

GHG emissions management policy for the agriculture sector has shifted from absolute emissions to production efficiency with the objective of minimising emission per unit output (UNFCCC, 1998). The global policy is reflected through eco-certification initiatives which guide the global market and provides signals for farmer decision and responsiveness (Zimmerer et al., 2018). Eco-efficiency (equation 3) was thus used as an integrated indicator for assessing the economic and environmental feasibilities (Masuda, 2016). Individual global warming potential for a period of 100 years for each gas was 1 to CO_2 and 21 to CH_4 (IPCC, 1997). All the emissions were estimated using Intergovernmental Panel on climate change (IPCC) default emission factors in livestock management (IPCC, 2006). To assess the environmental impacts the figures were fed into an equation for calculation of eco-efficiency. Scenarios were thus built to elicit methane emissions levels from various dairy feeding strategies with supplementation levels as proxy for price risks.

Eco-efficiency= Net farm income/ global warming potential…………………………………….(3)

(Non)supplementation levels is an exemplar of interplay between market price risks, institutions, management options and risk attitude. The break-even price for dairy farmers during our survey was Kes 25 (100 Kes = 1 $) which is the minimum price at which a rational agent will commit to the dairy enterprise. This price level provides the baseline information for evaluation of market risk on ecoefficiency. The mean price for the lower band at Kes (20 and 15) and the upper band at Kes (30 and 45) provide such scenarios. In fitting the data, the 18 litre production level per cow was adjudged as carbon neutral point. 18 litres was thus taken as the reference point for assessing effect of price risks on CH_4 emissions and representative of environmental externalities. Three level of dairy productivity viz; the lower production point as 0-9 litres; medium level of 9-18 litres and the upper point of 18-27 litres and 27-36 litres. In Kenya, the upper point production levels represents envisioned dairy productivity levels in the agricultural sector transformation policies.

4.0. Results

A coherent and effective response to the local, national and global challenges and opportunities on climate change is critical in climate policy. In East Africa, food security, economic, social and environmental objectives are intertwined to guide member countries in framing policy objectives for decoupling GHG emissions from agricultural development (FAO, 2017). Accordingly, Kenya has a number of strategies, governance frameworks, laws and guidelines on climate action such as, the Climate Change Response Strategy (G.o.K, 2010); Climate Smart Strategy (G.o.K, 2017); Agricultural Sector Transformation Strategy (G.o.K, 2019) and Green Economy Strategy under the vision 2030 (G.o.K, 2007). The Green Economy Strategy and Implementation Plan (GESIP), underpins Kenya's commitment to undertake a transition to a green economy (G.o.K, 2007). The NDCs submitted by Kenya largely focus on policies for sustainable agriculture development and climate change action (G.o.K, 2015). The low carbon pathways towards food and nutrition security productivity and resilience in the agricultural sector is reiterated in the national adaptation plan (G.o.K, 2018). The climate resilient, low carbon sustainable agriculture, adaptation to climate, and mitigation (G.o.K, 2017) are consistent with external coherence and integration principles in climate policy discourses.

Policy field is evident in terms of several institutions, policy products/inputs i.e. policy, programs, legislation and rules and expertise evidenced through knowledgeable persons, coalitions and thinktanks that work in tandem (Massey et al., 2014; Massey & Huitema, 2013). In Kenya policy field in Climate change action is uncoordinated. Though the formulation and setting of sectoral climate change

units at county level and ministerial and climate change plans under the proposed climate financing program (Republic of Kenya, 2016) suggest semblance of vertical climate policy integration, they do not work to address the Adaptation-mitigation divide and capture synergies a cross steering mechanisms. They are also characterised with inadequate understanding on the interplay of risk on land-use and the potential outcomes at local and extra local levels (Volenzo & Odiyo, 2020).

The need for vertical and horizontal integration is critical in scale matching .i.e. GHG mitigation with the scale of solution or individual emission contributions to mitigation and local responses (Biesbroek et al., 2010). Policy coherence signals the optimisation of synergies and co-benefits hence reduction of negative interactions with the resulting complementarily between adaptation and mitigation (Di Gregorio et al., 2017), enhancing climate policy integration. Though innovative instruments i.e. Payment for Ecosystem Services (PES) have the potential to reduce GHG emission (Shimon et al., 2016), most of such projects and programs on climate change adaptation and mitigation are donor driven with tendency for duplication (Chesterman & Neely, 2015). Duplication tend to undermine coherence and effectiveness (Weitz et al., 2017).

Furthermore there seems to be lack of a comprehensive cross-sectoral strategy, as well as overarching goals in the management of environmental externalities in programming. The low horizontal integration is inspite of the presence of National Environmental Management Authority (NEMA) as a central authority in environmental management. Under the climate change Act, policy, coordination and oversight is placed under a directorate in the ministry of environment. However, enforcemt is under NEMA. In previous studies cognitive failure and low capacity on enforcement by NEMA are among key cross scale challenges undermining effectiveness (Volenzo & Odiyo, 2020). Additionally, most of the national climate change action adaptation plans focuses on coping mechanisms with low attention to procedural mechanisms (i.e. EIA and SEAs) that may address environmental externalities in adaptation planning.

A review of documents reveal that most of the existing policies, strategies and legislations do not provide for coordination of climate smart Agriculture (CSA) related issues. Further, the various CSA instruments provide limited innovative interventions on adaptation and mitigation. Though several donor funded projects are in place, they do not capture synergy between various sectors .i.e. agroforestry and livestock. This is apparently due to inadequate mechanisms for linkages and coordination between CSA agencies and stakeholders which results in overlaps and inefficiency in implementation of programs (G.o.K, 2017). The fragmentation is especially critical in process of environmental safeguards which requires effective coordination between line Ministry and environmental agency on the coordination of compliance and enforcement of environmental laws.

Kenya's National Adaptation Action Plan (NAPAs), 2015-203 aims to consolidate the country's vision on adaptation. This is evidenced by macro- level adaptation actions that seek to enhance long term resilience and adaptive capacity which have linkages to various economic sectors, as well as the identification of county-level vulnerabilities. However, the existing Napas do not elaborate concrete proposals or processes for implementation and measuring effectiveness. Secondly, the domiciling of agricultural policy formulation with central government while implementation lies with county governments tend to undermine integration and coherence. This is compounded by lack of expertise at local level in planning and implementation for specific risk assessment and risk management actions inspite of such expertise being available at higher level (G.o.K, 2017). Though there is semblance of high-ranking institutional mandate and corresponding enforcement mechanisms in climate change action, climate change directorate as the agency with governmental mandate to enforce a top-down form of government-led policy integration, there is risk of conflict in the various agencies. This is aptly captured in inherent conflicts in the mandate of climate directorate and Nema.

Shifting adaptation to local level without corresponding additional support and resources reduce effectiveness in adaptation planning (Nalau et al., 2015). Though agriculture is the mandate of devolved

governments, the price policies are not in their purview but the central government. This is compounded by oligopolistic structure in the milk value chain where only 5 of the 23 milk processors (KDB, 2020) control 80% of market value in the milk value chain. For example, in 2019, the ministry of Agriculture only intervened after presidential directive to stem widespread discontent among small scale farmers receiving extremely low output prices. In most cases, such directives are however short-lived as the cycle of droughts always triggers downward revision of milk prices. Upward revision of prices however seldomly materialises during dry weather with farmers resorting to coping mechanisms, such as Ms without supplementation to manage the market and price risks.

Climate change is a key driver in production and price risks faced by resource constrained farmers in Kenya. The correlation of dairy feeding strategies and methane emissions is thus a window of opportunity in interrogating the framing of adaptation as a local responsibility. Focus on risk aspect in programming is critical as incentives mediate behavioural responses in adaptation action and capturing the full contribution of local action .i.e. agricultural production in mitigation and/or neutralising GHG impacts. Some of the opportunities to incentivise farmers and address market and price risks lie in vertical integration in the milk value chain. Vertically coordinated cooperatives as source of credit, new technologies and stable output market could minimize financial risks faced by the farmer and deepen intensification (Williams *et.al.*, 2000). However, this has been accorded low attention by the county and central governments alike in the process entrenching price and market risks in the dairy industry, more so in areas that are less linked to urban markets.

4.2 *Dairy cattle feeding adaptation strategies and price risks*

FGD, key informant, farmer interviews and observation checklists revealed that Ms and deferred harvesting of napier grass is the most preferred dairy cattle feeding risk management strategy. Deferred harvesting of napier grass as a risk management strategy to weather variability risks was practiced by about 70% of the respondents who grew the fodder (Table 1). Less than 15 % and 3% of the farmers used hay and silage respectively. Cross tabulation of the frequencies reveals that feed conservation is influenced by breed type, agro-ecological zonation and income level from farm and non-farm sources. Silage making an adaptation opportunity, especially during peak and above normal rainfall periods, is poorly adopted. About 85% of the sampled households attributed this to lack of technical knowhow and information. As a result, surplus fodder available during above normal /peak rainfall periods is wasted. Use of hay legumes was practiced by less than 1 % of the farmers' citing limited land sizes and lack of technical information.

Breeds of low production merit and low management standards were evident in 65% of households in the main maize zone and 75% in the main sugarcane zones. This could be a risk management strategy and which contributes to low adoption of feed conservation strategies by farmers. The results from methane simulation suggest that deferred harvesting of Napier is an in-efficient adaptation strategy as it increases methane emission risks by up to 30% (**SP1**).Though sustainable Ms based rations could be built on existing programmes such as push- pull in striga/stem borer control, fodder legumes and agro-forestry systems, less than 5 % of the sampled farmers used legume fodder as supplements, whereas at least 85 % of the famers used Ms without any supplementation. This is reflected in productivity losses of up to 70% of the milk production potential during droughts.

Table 1: Nutritional interventions practiced by farmers

Nutritional intervention	% Awareness		% Adopted		OAW (%)	OA (%)
	Maize zone	Sugarcane zone	Maize zone	Sugarcane zone		
Molasses	25	21	15	12	23	13.5
Minerals	48	45	27.5	16.3	46.5	16.3
Legume fodder	5	7	1	1	6	1
Potato vines	25	42	13.5	33.5	33.5	24.4
Grain residues	40	23	25	3	31.5	14
Silage	30	28	3	2	29	2.5
Hay	76	42	13	9	59	11
Ms	95	90	87	83	92.5	85
Napier (Deferred)	85	75	75	65	80	70

Source: Authors field data analysis. OAW; Overall awareness, OA; Overall adopted

The constraints in dairy feeding strategies are summarised in Table (2). About 95% of the farmers attributed deferred harvesting to lack of knowledge and skills on alternative feed conservation technologies, as well as and lack of capital. The finding suggests that farmers' feed risk management strategies, information/ knowledge gaps and risk attitude can actually exercabate existing disaster risks, such as GHGs emissions and associated global warming outcomes. Silage making was practiced by less than 3% of the respondents in the study area. As an adaptation strategy, ensiling of fodder resources could ensure optimization of the available rainfall, attain better quality as well as realizing higher quantity of harvested fodder. This may in turn reduce methane emission risks from enteric fermentation processes.

About 95% of the respondents who used supplementary feeding/concentrates in Ms rations reported stabilized milk production especially during extreme drought episodes. About 98 % of the surveyed households, however were un-aware of balanced Ms/residues based ration formulation as dry season feeing strategy. This is attributed to inadequate extension education on feed compounding, feeding rates and fodder requirements planning. Importantly, farmers who used concentrates in Ms rations had a drop of less than 20% (relative to Napier) in milk production while those without supplementation had 50-70 % drop in production during extreme dry weather spells. The drop in milk production for Ms supplemented rations may be attributed to in-adequate levels of the supplements noted in sampled households. About 95% of the respondents using supplements, irrespective of production level, rationed the level of concentrate at less than 1kg cow^{-1}day^{-1}. The farmer practices though being nutritionally sub-optimal are rational, in the face of prevailing financial and market risks. Such practices are reflective of farmers' rational decision making on production risk management.

Table 2: Constraints in adapting dairy feeding strategies (%)in Bungoma and Kakamega counties

Constraint	Sugarcane Zone n=221	Maize Zone n=179	Mean N=400
Shortage of Labour	23	36	29.5
Lack of capital(credit)	55	60	57.5
Lack of information on alternative strategies	75	55	65
No barriers	2	5	3.5
Low and unstable prices	75	92	83.5
Others	4	6	5
Land shortage	82	85	83.5

Source: Authors Field data Analysis

4.3 Methane emissions and Dairy feeding strategies

The livestock, agriculture and forestry sectors as the largest GHG emitters in Kenya account for approximately 67% of emissions, with livestock sub-sector contributing about 90% of the emissions from AFOLU (G.o.K, 2017). The GHG emissions are expected to rise, consistent with a growing population and expanding economy, with emissions increasing from 73 million tons of carbon dioxide equivalent (MtCO2e) in 2010 to 143 MtCO2e in 2030 (G.o.K, 2017). The observation is critical in that maladaptation, moreso the use of Ms without and/ or suboptimal supplementation levels coping strategies as a result of market risks are common (Volenzo, Odiyo, & Obiri, 2019). Supplementary file (SP1) provides the simulated methane emissions from various adaptation strategies in dairy feeding. In the simulation, Ms has the highest upper limit emission levels at 26 Mj/kg. The emissions reduce with progressive supplementation with farm grown napier and legume fodder.

Though the highest CH_4 mitigation effect in the dairy feeding strategies is from external inputs, such effect is not significantly different ($p \leq 0.05$) when the effect of farm grown legume fodder such as *leuceana spp, Desmodium and sesbania* is taken into account. In effect farm produced legume fodder .i.e. dairy-agroforestry and regenerative agricultural systems could be as effective in the mitigation of ruminant related GHG emissions. However the adoption of legume fodders are extremely low at around 1% of the surveyed households (Table 1). About 84 % of the farmers attributed this to competition between food crops and fodder production objectives as a result of limited land holdings. Evidently there is need for enabling policy for CSA business models, incentives and finance for scaling up CSA (Solomon et al., 2018).This includes the adoption of vertically integrated cooperatives to sustainably address the pervasive price and market risks and ultimately deepen GHG emission mitigation

Supplementary File1(SP1): Simulated Methane emissions from dairy cattle feeding strategies

Supplementary File 2 (SP2), provides variation of prices for various feeding strategies. The locally available dairy feed resources have the lowest cost and price variance over seasons hence low price risks as compared to external resources such as cotton seed cake (CSC) and highly significant at ($p \leq 0.05$). The highest price variance is apparent in feeding strategies that have highest impact on CH_4 mitigation while the lowest variance is in the local resource such as Ms, which also have the highest methane emission potential. The price variation hence market risks are significant ($P \leq 0.05$). In the study area majority of the farmers tended to exclusively rely on Ms as a risk management strategy, a response that is attributed to the significant market and price risks. Such strategies increase methane emissions by up to 30% per unit of milk produced (Volenzo et al., 2019).

Supplementary File 2 (SP2): Effect of output price variations on risk management at different supplementation levels of basal diets on Gross Margin

Table (3) provides variance in prices in the main dairy feeding strategies in the study area. The mean production price for local resource, Ms is Kes 3.2 against 17.9 for external input supplemented strategy. The variance in price is representative of risk levels and is significant across the various feeding strategies. The highest variance is noted in external input supplemented strategies. This is in contrast to very low variance hence low market and price risks in the locally available feed resources.

Table 3: Interplay of weather variability and price risks in dairy feeding strategies

Feeding strategies	Sum	Mean	Variance
Ms	25.42731	3.1784138	7.50663259
Ms+L	57.91576	7.2394698	34.5475737
Ms+Cs+M	61.871	7.733875	40.508577
NaP	103.9636	12.995448	129.364698
Nap +L	43.52767	5.4409587	16.5573137
Nap+csc+M	85.59153	10.698941	84.9298324
Ms+Nap	43.12944	5.3911801	16.1476138
Ms+Nap+csc	126.1856	15.7732	194.706271
Ms+Nap+Csc+Nap	143.54	17.9425	254.540736

Source : Authors calculation based on field survey data among resource constrained farmers, 2019. Nap= Napier

4.4. Eco-efficiency

Externalities provide a case study where scope mismatches, sustainability, coherence, integration and sectoral focus in climate adaptation policy could converge. According to Wekesa et al., (2018), the cost of CSA technology constrain small scale farmers' adoption of technologies that have positive potential on environmental sustainability. Table (4) provides the effect of various dairy feeding strategies on ecoefficiency. The effect of resource integration or integrated production is apparent in the effect of various feeding strategies on ecoefficiency. The lowest ecoefficiency is in dairy feeding resources that rely on local coping mechanisms represented by Maize Stover(Ms) at 3.3 4± 6.79. Evidently, the highest ecoefficiency is in feeding strategies that utilise external resources but which are highly vulnerable to price shocks at 20.39 ± 276.78. The variation between ecoefficiencies in all the feeding strategies are significant (p= 0.05). This is of policy relevance on the account variance in the price of external inputs is a source of risk to small scale farmers yet they are critical in dairy productivity and GHG mitigation.

Table 4 : comparison of Ecoefficiency between various dairy feeding strategies

Feeding strategies	Sum	Mean Eco. Eff.	Variance
Ms	30.02501149	3.336112388	6.792123135
Ms+L	73.41963411	8.157737123	37.81806142
Ms+Cs+M	78.53766667	8.726407407	44.31109005
NaP	132.740564	14.74895156	140.8670766
Nap +L	54.70085363	6.077872626	18.13858411
Nap+csc+M	109.1209412	12.12454902	92.60482285
Ms+Nap	54.17916464	6.019907182	17.68684163

Ms+Nap+csc	161.2733193	17.9192577	211.8180597
Ms+Nap+Csc+Nap	183.54	20.39333333	276.7824

Source: Authors' calculation from field data, 2019

5.0 Discussion

5.1 Measures of effectiveness in climate policy

In policy, effectiveness or implementation success is largely based on delivery of goods and services from policy effort (Dupuis & Knoepfel, 2013; Biesbroek et al.,2010). As global commons engender rights and responsibilities, collective action provide appropriate solution space for the management of externalities, which are invariably intertwined with individual preferences and motivations (Folke, Pritchard, Berkes, Colding, & Svedin, 2007). Such philosophy is visualised as collective effort for mitigating GHG externalities through decarbonisation or green growth pathways initiatives (Otto et al., 2020; Vuuren et al., 2017). Solution of scale problems, such as GHG mitigation and environmental externalities is however undermined by free riding and isolation paradox dilemmas (Burch et al., 2019) that weakens incentives for individual action. This may require a focus on principles that transcend accountability and inclusiveness (Weitz et al., 2017). Since effective local responses (UNEP, 2019; IPCC ,2019; UNFCCC, 2018), are just as important as global strategy .i.e. on sustainability and GHG emission mitigation (Jiménez et al., 2020, UN, 2019; Rey et al., 2017; World Bank, 2014), a focus on voluntary pledge and critical mass or collective action are necessary for a 50% decrease emissions in by 2050 and less than 2^0c rise in temperature required for a stable climate (UNFCCC, 2018). This highlights the role and criticality of local- global policy initiatives in implementation success or effectiveness (Otto et al., 2020). Since individual action is a function of agent attributes (Ness et al., 2010) and critical to collective action (Adger et al., 2006) and scale outcomes (Barreteau et al., 2020; Burch et al., 2019), a focus on micro and macro factors influencing societal and environmental management outcomes (Ehara et al., 2018), emerges as integral to the management of spillovers (Liu et al., 2018)

Though effectiveness by default refers to the extent to which various policy instruments and committed resources contribute to the achievement of a policy goal (Mees et al., 2014), the intended and unintended effects or implementation deficit which is a function of policy coherence and integration accurately reflect success or effectiveness of policy effort (Dupuis Knoepfel, 2013). Table 3 summarises how effectiveness is contextualised in existing literature. Effectiveness includes the extent to which climate action and policies focus and address underlying causes, such as shifting vulnerabilities and land degradation (IPCC, 2019), as well as internal processes of change at individual, organizational and technological level (Otto et al., 2020; Pelling et al., 2015). It also involves the linking of disaster risk reduction to climate risk management, adaptation through better land use and resource based approaches (UNISDR, 2015b). According to (Nalau & Handmer, 2015), effectiveness relates to policy focus on the significant dimension of the problem, hence the extent of implementation as reflected by numbers, range and scale. Since (I)NDCS provide an opportunity for inclusivity, we explored how this can be realised in adaptation planning. The definition and conceptualisation is critical in view of adaptation emissions and the emergent issue of shifting vulnerabilities (Barreteau et al., 2020; Adger and Winkel, 2009).

Table 4: contextualisation of effectiveness as used in climate policy literature

Dimension of Effectiveness	Rationale	Specification in literature	Challenges and causes of dissonance	References
Collective Action	Cross-scale Efficiency Free riding Individual action as insufficient	Critical mass Inclusivity and responsibility Voluntarism Participation	Legitimacy Dualism in framing Subsidiarity and attribution	Weitz et al., 2017; Adger 2006; Milkoreit et al., 2018; Nalau & Handmer, 2015;IPCC, 2019; UN, 2019; UN, 2015a; UNFCC, 2018; Park et al., 2012; Gordon et al., 2015;Walthall et al., 2012;Smith & Mayer, 2018;Adger, 2003; Wise et al., 2014
Integration	Resource mobilisation Synergy Complementarity	Integrated Resource Management (in agriculture as integrated farming technologies), Mainstreaming Multidisciplinary Policy coherence Nested/ Coupled/Holistic domains Social Ecological system (SES) Human- Environment System (H-E-S)	Decision tools for operationalisation Cognitive failure among actors Coordination failures Segmented project and programme mandates Governance structure	Nalau & Handmer, 2015; Dupuis & Knoepfel, 2013, Massey & Huitema, 2013; Biesbroek et al., 2010; Burch et al., 2019; Mees et al., 2014; Xu et al., 2015; Naess et al., 2015;Weitz et al., 2017;Ness et al., 2010;Nelson et al., 2007; Shimon et al., 2017; Wekesa et al., 2018; Chesterman & Neely, 2015
Transformation	Addressing underlying causes by focusing on Values and goals	Social transitions Participatory planning Diffusion and adoption	Policy problematisation Cognitive failure and fragmentation Project and mandates	Pelling et al., 2015; O'Brien, 2012; Nalau & Handmer, 2015; IPCC, 2014; Rogers, 2004; Massey & Huitema, 2013;Massey et al., 2014;Ness et al., 2010
Externalities	Comprehensive risk assessment on ecology and economic linkages in decision making Collective hazard management	Shifting vulnerabilities Diffuse effects/flows/Leakages Environmental accounting IRM	Integration of decision tools i.e. SEAs/ EIAs/RIA incentive system Risk denial Layered agents and coordinated responses at scale Delimiting the boundary	Ness et al., 2010; Nalau & Handmer, 2015; Suckall et al., 2014; Liu et al., 2018; Naess et al., 2015; Burch et al., 2019, Adger, Eakin, & Winkels, 2009; Barreteau et al., 2020;Vammen et al., 2012; Jordan et al., 2013

Key: IRM (Integrated Risk Management); RIA, Regulatory Impact Assessment; SEA, Strategic Impact Assessment; EIAs, Environmental Impact Assessments

As global climate policy is premediated on the principle of common but differentiated responsibility and capability (UN, 2019;UN, 2015a), voluntary ecosystem based collective action are preferable in the management of environmental externalities (Ness et al., 2010). Addressing the weak links, hence attention to voluntary mechanisms as alternative to regulatory and/ or enforcement could enhance effectiveness in managing externalities (Wise et.al., 2014; Ness et al., 2010).This includes the identification and prioritisation of risk management strategies and shared action between private action and public sectors action across scale where risk chain can be visualised in terms of shocks, internal and external drivers, their management and outcomes (World Bank, 2014). Responses for risk management, however are poorly addressed (Eakin et al., 2014), or are based on BAU models (Milkoreit et al., 2018;Nalau & Handmer, 2015).

In synthesis of existing literature (Fig.2), the role of risk as an attribute of decision making at micro level and how it impacts GHG emissions hence the global GHG spillover system is suggested. Adaptation policy is a thus confluence of internal, as well as internal drivers, both of which are critical drivers in decision making and effectiveness of climate change action (Ampaire et al., 2017; Massey et al., 2014). Accordingly, there is need for critical reflexivity to manage internal processes of change at individual, organizational and technological level, which are key to addressing transformative agenda (Otto et al., 2020; Young, 2006; Pelling et al., 2015). The role of risk which informs our article, however has not been given a nuanced analysis in multilateral intervention targeting net zero carbon economies. Since the realisation of net zero emissions by 2050 (UNFCCC, 2018; UN, 2015a), is underpinned by collective action, an element of critical mass, resolution of functional or scope challenges in Human- Environment (H-E) systems (Otto et al., 2020; Steffen et al., 2018; Folke et al., 2007), and delivery of programmes and projects are some of the policy innovations in pursuit of effectiveness (Dupuis & Knoepfel, 2013). We thus framed effectiveness in terms of impactful collective action effort that enhances synergies between adaptation and mitigation. The reflective advancement model narrows existing gaps on how to incentivise local level action for effective climate action.

The uptake of ideas and technology by agents, such as individual farmers, is accounted through diffusion of technology models which account for decision making (Rogers, 2004). Risk plays a key role in such decision making and uptake of technology (idea) or otherwise (Koundouri et al., 2019). As adaptive capacity, is an interplay of price, institutions and policies (FAO, 2010; UNEP, 2011), they are also integral to risk management. Integrated approaches are thus recommended in institutional-cognitive interplays and environmental risk assessments (Shimon et.al., 2017). Incorporating externalities into decision making as a policy concern (Hulina et.al., 2017; Sikor, He, & Lestrelin, 2017) could thus be achieved through informal and informal institutions i.e. taxation and private certification schemes respectively (Liu et al., 2018; Zimmerer et al., 2018). This is in line with conventional policy instruments, such as subsidies or taxes that shape farmer support for international ecological initiatives and international agreements (Lewis et al., 2008). In our case study, the cost of inputs is critical to decision making in weather related dairy cattle feeding risk management and GHG emissions.

In synthesis of existing literature (Fig.2), risk as an attribute of decision making at micro level impacts GHG emissions and global GHG spillover system. Adaptation is thus a confluence of internal, as well as internal drivers, both of which are critical in decision making and effectiveness of climate change action (Ampaire et al., 2017; Massey et al., 2014). Accordingly, there is need for critical reflexivity to manage internal processes of change at individual, organizational and technological level, which are key to addressing transformative agenda (Otto et al., 2020; Young, 2006; Pelling et al., 2015). The role of risk which informs our article, however has not been given a nuanced analysis in multilateral intervention targeting net zero carbon economies. Since the realisation of net zero emissions by 2050 (UNFCCC, 2018; UN, 2015a), is underpinned by collective action, an element of critical mass, resolution of functional or scope challenges in Human- Environment (H-E) systems (Otto et al., 2020; Steffen et al.,

2018; Folke et al., 2007), and delivery of programmes and projects are some of the policy innovations in pursuit of effectiveness (Dupuis & Knoepfel, 2013). We thus framed effectiveness in terms of impactful collective action effort that enhances synergies between adaptation and mitigation. The reflective advancement model narrows existing gaps on how to incentivise local level action for effective climate action.

Externalities or Shifting vulnerabilities as unintended consequence of one actors' acts of omission or commission increases predisposition to harm on a third party in interdependent systems and processes (Barreteau et al., 2020). Shifting vulnerabilities are visualised as flows and analysed through telecoupling lenses. This presents a strong heuristic lens for examining and describing distal causal relations in land-use (Friis & Nielsen, 2017). Accordingly, parcel-level land-use decisions may aggregate to influence landscape-scale processes, spatial externalities and provisioning of public goods at the regional scale, such as sediment flows in watersheds and the global scale (Lewis et al., 2008). Spillover systems can thus be used to analyse the effectiveness of H-E system and their interplay at local to global scales (Parish et al., 2018; Xiong et al., 2018). In light of sustainability lenses, the assessment of the extent of externalities or maladaptive practice as proxy for externalities and how they are accounted for (Suckall, Tompkins, & Stringer, 2014; Ness et al., 2010) is one of the critical area in CPI.

Transformative lenses to a large extent refer to how different management approaches innovatively deal with a particular problem (Nalau & Handmer, 2015). It includes the embedding of sustainability lens into analysis as to avoid ambiguity and support novel decision making (Pelling et al., 2015; Wise et al., 2014). Combining metacoupling and DPSIR could provide a comprehensive risk assessment tool that links internal and external factors (Xu et al., 2015), as well as assessing the potential impact in decision making. By combining DPSIR and telecoupling, we offer an improved analytical framework tool for CPI innovation and inclusive multilaterism to assess effectiveness in climate policy and scale up GHG mitigation partnerships. The tool can be utilised in formal and informal governance instruments, such as programming eco-certification schemes, resolving the problem of dualism in adaptation- mitigation polices and duplication in programing. The robust analytical and conceptual framework thus has potential for reflective policy design, assessment and review performance in CPI frameworks.

Coordinated multisectoral programming, implementation and monitoring in adaptation planning can be achieved through use of integrated risk management (IRM) approaches (Xu et al., 2015; World Bank, 2014). An IRM model in Fig 2, captures the centrality of risk, values and beliefs as cognitive factors that undermine policy objectives (c.f. Kuruppu & Willie, 2015). The IRM hereustic is critical for reflective advancement of effective collaboration mechanisms between local and global actors .i.e. evaluating climate risks and policy opportunities that address pervasive constraints, such as the duplication of projects and programmes and shifting vulnerabilities. In essence policy innovation need to consider and integrate the interplay between scope and functional fit variables such as motivations and preferences of the primary actors, in essence the centrality of risk dimension as critical component in agent decision making (Weitz et al., 2017; Kuruppu & Willie, 2015). Our model on risk lens in decision making contributes to CPI by addressing the role of decision making gaps on externalities.

Though Western Kenya is an idiosyncratic case in global climate policy agenda, it provides invaluable insights on scope, functional and temporal mismatches and ultimately CPI and coherence from resilience perspective. In particular it is relevant from the emerging issue of shifting vulnerability and global common dilemmas. The limitation of our study mainly lies in the methodology which may under-estimate or over-estimate emission levels. The higher emission limits from the simulation were however relied on as to inform disaster risk reduction. Such quantification of the risks backed by agent data perspectives, improves on the weaknesses in the ubiquitous descriptive telecoupling models (Xiong, Millington, & Xu, 2018), close the gaps on the interplay between agent decision making and environmental externalities.
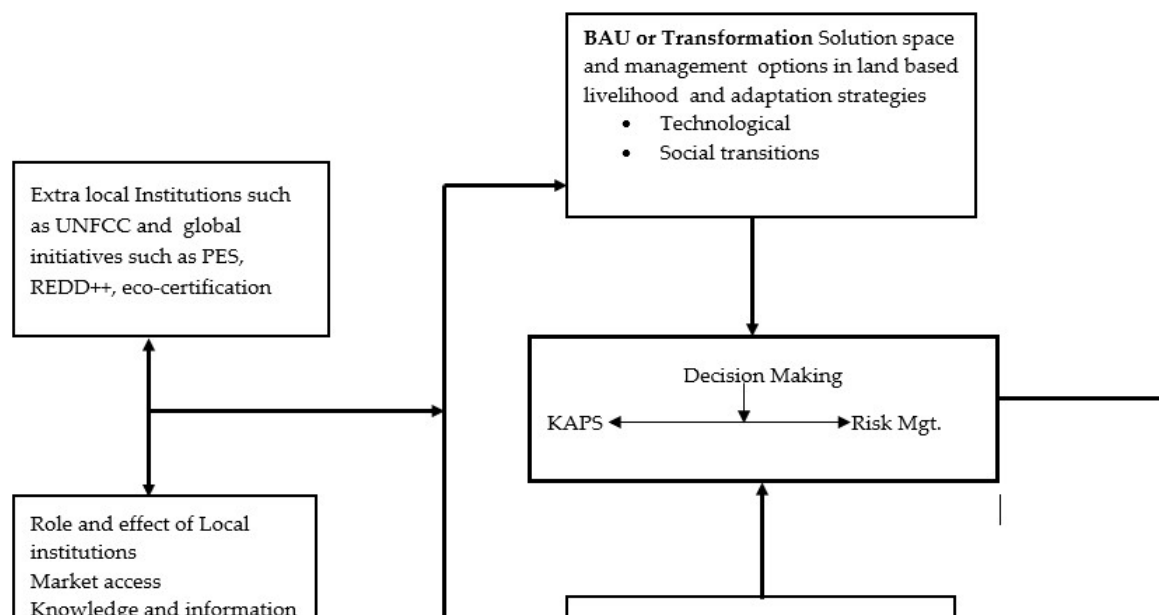
Fig. 2: A heuristic on the centrality of risk in decision making at local level, environmental externalities and effectiveness of global- local action for effective climate policy, adaptation and GHG mitigation. Kaps (knowledge, Attitude and Practices or Behaviour) which affect risk management(Mgt.) are critical and integral to individual and collective decision making and ultimately GHG effect

5.2 Conclusions

Adjusting to climate change related risks largely depend on transforming agriculture and food systems to deepen food security, alleviate poverty and enhance adaptation-mitigation synergies. Building synergies and shared action between private action and public sectors across scale which to a great extent depend on policy and organizational coherence, is critical in managing the embedded shifting vulnerabilities and other sustainability problems in the transformation process hence effective climate action. However, in agrobased economies where adaptation to climate change risks is an urgent need, its contribution to GHG emissions and closing GHG emission gaps is accorded low attention in climate change mitigation agenda. This article has suggested a scheme that combines two analytical policy tools, DPSIR and telecoupling in examining the visualisation of externalities into climate policy discourses and resolution of systemic failures in climate policy. The purpose has been to provide a tool for reflective advancement in climate policy innovation. The scheme is contextualised in terms of the pervasive adaptation-mitigation dualism and scope challenges in mainstreaming externalities into adaptation planning. The article has framed the deepening GHG effect, as a global common challenge whose diffusion across scale reflect global interconnectivity of socio-ecological systems. The study underscores the utility of complementarity lenses and framing as the logical basis for the prioritisation and optimisation of adaptation-mitigation synergies in climate action initiatives and the resolution of pervasive adaptation-mitigation dualism. Of equal importance is the role and the need for policy and organisational coherence which have the potential to address duplication in climate action programming.

Declaration of Interest: The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article

Author's contribution: Dr. Volenzo Tom Elijah was the originator of research idea and conceptual framework and wrote the manuscript, Prof. John Odiyo advised refined the concept, organisation, editing and revising the manuscript.

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