iFEED implication statements- Crop and Livestock diversification

A. Implication Statements for Crop Diversification

Country- Malawi		
Scenario quadrant	**Calibrated statements and scenario description**	**Implication statements**
Low climate risk (RCP2.6) / ineffective agricultural policies (LT)	**Food production**: The mean percentage change to crop production with RCP2.6, scenario lt is -1% **Climate impacts:** Without adaptation, climate change results in mean yields decreasing in this scenario. The impacts of climate change on C3 crop yields (soybean, potato and groundnut) are close to no change with autonomous adaptation. Maize yields are projected to fall in contrast by about 10%,	• There will be no change in crop diversity in this scenario, this implies that maize will still dominate. Although, they will be less significant change to maize yield (present yield ~1t/ha) due to direct impacts of climate change by 2050 in this scenario, lack of crop diversity may cause increasing dominance by a few genetic lineages of crops, which may lead to increase in occurrence of pests or diseases, soil nutrient degradation among other factors. Coupled with low technology, this could lead to harvest failures and exposing communities to food and nutrition insecurity. • There is potential increase in yield for non-maize crops such as Soybean which is a C3 crop by 2050 due to climate impacts. For instance increasing atmospheric CO2 concentrations can also directly affect plant physiological processes of photosynthesis and transpiration. It is suggested that increasing atmospheric CO_2 concentrations to 550 ppm, would on average increase C3 crop yields by 10–20% and C4 crop yields by 0–10%. • For C4 crops, such as maize, CO_2 is concentrated to three to six times atmospheric concentrations and thus it is already saturated Thus, rising CO_2 concentrations confer no additional physiological benefits. (see Gornall et al., 2010) In this case therefore Increase in crop diversity may reduce yield shocks which may be caused by climate impacts by 2050.

	even with autonomous adaptation.	• Effective implementation of climate-smart cropping systems that enhance adaptation strategies such as crop rotation, intercropping, diversity in crop varieties with superior traits, planting early-maturing varieties, soil fertility management are required to adapt to the changing climate and reduce yield shocks by 2050. • It is evident that ineffective policies may influence reduced crop diversification in Malawi, for instance Farm Input Subsidy Program was aimed primarily at increasing maize productivity since 2005/6. As a result, this led to decreased in crop and variety diversity. • A deliberate policy shift towards promoting crop diversification and technology investment including irrigation and crop improvement is a key in this scenario to reduce yield losses by 2050.
High climate risk (RCP8.5)/ineffective agricultural policies (LT)	**Food production**: The mean percentage change to crop production with RCP8.5, scenario lt is -14%. **Climate impacts**: There is an anticipation of maize yield reduction due to high climate risk. However, the projections entail no change in crop diversity and maize will still dominate with 10% reduced arable area by 2050. **Climate and extreme**; Climate projections for the mid-century show an	• The scenario implies that adaptation strategies are not sufficient to reduce the effects of climate risks, coupled with low crop production technology investment leading to reduced yield. • To meet future food demand and maintain well-being, existing cropping systems and policy infrastructure will have to effectively improve. • At a policy-level diversified polyculture assemblages would also be critical in addressing both the trend towards, and consequences of, increasing homogenization in agricultural systems. • Climate variability and change is increasingly impacting crop productivity, through changes for instance temperature and water availability, which affects physiological processes of plant growth and development limiting crop yield. However, different crop species respond differently to the effect of climate impacts and therefore crop diversification is crucial if yield shocks are to be reduced by 2050. • Scenario on climate and extreme events implies that changes in short-term temperature extremes can be critical, especially if they coincide with key stages of crop development. Only a few days of extreme temperature (greater that 32°C) at the flowering stage of many crops can drastically reduce yield. Maize exhibits reduced pollen viability for temperatures above 36°C. In addition, even small changes in mean annual rainfall can impact on productivity and therefore crop improvement strategies needs to be employed to improve yield by 2050.

	increase in average temperatures by 2-4°C in every month, as compared to the 1990 – 2010 period Model projections for mid-century show varying rainfall patterns. (See calibrated statements for more details)	• Water is vital to plant growth, so varying precipitation patterns have a significant impact on agriculture. As over 90-95% per cent of total agriculture in Malawi is rain-fed. Crop diversification is, therefore, a natural insurance mechanism for farmers facing greater risk of crop failure due to the climate variabilities and unforeseen yield shocks. • Maize yield can be significantly alleviated with autonomous adaptation strategies which include development of new maize varieties to cope with stress: which include heat, drought, floods and pest and diseases. On the other hand, investment in alternative diverse staple crops that are naturally tolerant to multiple stresses e.g cassava, Sorghum, millets, sweet potato may reduce the adverse effects of climate for future sustainable crop production. • Furthermore, investment in irrigation technology and effective implementation of climate-smart cropping systems that enhance adaptation strategies such as crop rotation, intercropping, diversity in crop varieties with superior traits, planting early maturing varieties, soil fertility management are required to adapt to the changing climate, improve yield and protect the environment by 2050.
`Low climate risk (RCP2.6) /effective agricultural policies	**Food production**: The mean percentage change to crop production with RCP2.6, scenario ht is 728% **Climate impacts** With adaptation of new varieties and irrigation, crop yields will most likely increase slightly - by around 10% in the	• The positive mean change in yield increases due to effective policies with high crop production technologies by 2050 is possible. In this scenario crop diversity increases substantially. • Despite less effect of climate risk in this projection, effective design, and strategic implementation of policy with high technology investments such as irrigation use promotion of diverse cropping systems, improved farmers access to improved cultivars for both maize and non-maize crops, promotion of climate-smart technologies, good agricultural practices and, sustainable land management would tremendously improve yield and reduce yield shocks by 2050. • The value of investing in high technologies in Malawi is clear in terms of adaptation. In this scenario with good policy maize and groundnuts yield increases by 10% and

	case of maize and groundnut, with more modest increases for potato and soybean likely	crop diversity increases with modest increase in yield for potato and soybean. It is possible to achieve yield gain of 5t/ha from present 1t/ha by 2050. • Diverse cropping systems may enhance yield stability, food security and climate variability buffering. It may also have instant and long-term impacts on soil condition and functionality which improves crop yields. • However, key trade-offs would be optimising production of priority profitable crops over diversification for community nutrition security and climate-resilient.
High climate risk (RCP8.5) / effective agricultural policies (HT	**Food production**: The mean percentage change to crop production with RCP8.5, scenario ht is 719% **Climate impacts** With adaptation of new varieties and irrigation, crop yields will most likely increase - by more than 10% in the case of maize and groundnut. Modest increases are also likely for soybean, however potato could see decreasing yields	• Crop diversity increases substantially, and adaptation strategies are employed in this scenario indicating that effective policy development and implementation can influence the crops production. • Cereal yield gain of ~5t/ha or more from present yield of 1t/ha is possible by 2050. Effective policies implementation implies adoption of modern technologies to adapt to the rapid climate changes, planting early-maturing and/or stress tolerant crops, sustainable land management including conservation agriculture. This could enhance water and crop productivity. • In this scenario the assumption is that diverse cropping systems is practiced and may enhance yield stability, food security and climate variability buffering. It may also have instant and long-term impacts on soil condition and functionality which improves crop yields. • In most of the areas where irrigation is introduced, the cropping pattern has become more diversified, especially so if there is proper regulation of water delivery. Due to low productivity from agriculture coupled with high population pressure and negligible area of land available for expansion of cultivation, the available option is intensification of crop diversification using modern technologies and use of new technologies such as protected cultivation. • Malawi's vision agenda 2063, Malawi's National Resilience Strategy 2018-2030, National Agricultural Policy (NAP) and many agricultural policies, are an opportunity

		which places a great deal of emphasis on food crop diversification for community nutrition security and commercialisation. • The clear assumption in this scenario would be strategic thinking around how exactly crop diversification could be promoted and achieved among different types of farmers with the aim of contributing to yield, risk reduction, and nutrition security (Kamkwamba et al. 2018)

Country- Tanzania		
Low climate risk (RCP2.6) / Low technology	**Food production**: The mean percentage change to crop production with RCP2.6, scenario It is 65%. This scenario**:** Crop diversity increases with potential increase in growing land for non-maize crops such as cassava, sorghum and beans by 2050. **Climate impacts**: Without adaptation, climate change results in mean yields decreasing in this scenario. The impacts of climate change on C3	• Crop diversity increases with potential increase in growing land for non-maize crops such as cassava, sorghum and beans by 2050. • With the potential increase in arable land of about 58%, modern technology investment including irrigation and crop improvement for non–maize crops is required to improve yield and reduce yield shocks by 2050. • There is potential increase in yield for non-maize crops such as Soybean which is a C3 crop by 2050 due to climate impacts. For instance increasing atmospheric CO2 concentrations can also directly affect plant physiological processes of photosynthesis and transpiration. It is suggested that increasing atmospheric CO_2 concentrations to 550 ppm, would on average increase C3 crop yields by 10–20% and C4 crop yields by 0–10%. In this case therefore Increase in crop diversity may reduce yield shocks which may be caused by climate impacts and by 2050. • Maize yield can be significantly alleviated with autonomous adaptation strategies which include development of new maize varieties to cope with stress: which include heat, drought, floods and pest and diseases. On the other hand, investment in alternative diverse staple crops that are naturally tolerant to multiple stresses e.g

	crop yields (soybean, potato and groundnut) are close to no change with autonomous adaptation, with some small gains for soybean projected. Maize yields are projected to fall in contrast by about 7%, even with autonomous adaptation	cassava, Sorghum, millets, sweet potato may reduce the adverse effects of climate for future sustainable crop production. • Furthermore, climate-smart cropping systems that enhance adaptation strategies such as crop rotation, intercropping, are required to improve yield. Modern technologies to adapt to the rapid climate changes, planting early maturing and/or drought-resistant crops and variety to vary, sustainable land management including conservation agriculture, could enhance water and crop productivity.
High climate risk (RCP8.5) / Low technology	**Food production**:The mean percentage change to crop production with RCP8.5, scenario It is 38% **Climate impacts**: A downward trend in yields, coupled with increasing yield variability in the case of potato, contributes to, approximately, a doubling in the number of years of yield shocks for maize and groundnut and ~6 times more shocks for potato. Soybean yields show a smaller increase in shocks (30%, on average).	• Crop diversity decreases with maize area doubling. despite the direct effect of climate, the scenario implies no adaptation strategies coupled with low technology interventions for instance irrigation to reduce the effects of climate risks on crop production which will lead to reduced yield by 2050. • Cereal yield gain of ~5t/ha or more from present yield of 1t/ha is possible by 2050. Options include investing in irrigation, production technologies and practices such as stress-adapted crop germplasm, conservation agriculture, and diversified production systems stabilize agricultural production and incomes and, hence, reduce the adverse impacts of climate-related risk under some circumstances. • Maize yield can be significantly alleviated with autonomous adaptation strategies which include development of new maize varieties to cope with climate impacts. On the other hand investment in alternative diverse staple crops that are naturally tolerant to drought stress e.g cassava, Sorghum, millets, sweetpotato may reduce the adverse effects of climate for future sustainable crop production • Scenario on climate and extreme events implies that changes in short-term temperature extremes can be critical, especially if they coincide with key stages of crop development. • The key challenge to adoption of modern technologies includes access to information and farmers perception among other factors.

Low climate risk (RCP2.6) / High technology	**Food production**: The mean percentage change to crop production with RCP2.6, scenario ht is 685%	• The positive mean change in yield increases due to effective policy implementation coupled with high modern crop production technologies by 2050 is possible. In this scenario crop diversity increases substantially. • It is clear that with crop improvement and adaptation strategies i.e availability of improved cultivars, crop varieties to vary, planting early-maturing and/or drought-resistant crops, coupled with good agronomic practices and sustainable land management, it is possible to achieve cereal yield gain of above 5t/ha from present 1t/ha by 2050. • An opportunity to promote an improvement of non-maize crops that are adaptable to drought stress are enhanced. Diverse cropping systems may enhance yield stability, food security and climate variability buffering. They may also have instant and long-term impacts on soil condition and functionality which improves crop productivity.
High climate risk (RCP8.5) / High technology	**Food production**:The mean percentage change to crop production with RCP8.5, scenario ht is 1676%	• Crop diversity decreases followed by high agricultural production technologies including Intensive cultivation, mechanisation which will reduce number of crops grown from 36 crops to 15 crops making up more than 99% arable areas by 2050, but maize area doubles. • Despite reduced crop diversification, the scenario implies prioritising profitable crops such as sugarcane, cassava, potatoes and fruits and vegetables, resulting in larger production gain and avoiding over diversification which can reduce production gains and difficult to manage. • Due to low productivity from agriculture coupled with high population pressure and negligible area of land available for expansion of cultivation, the available option is intensification of crop diversification using modern technologies and use of new technologies such as protected cultivation. • The assumptions are that high technologies to adapt to the changes, planting early-maturing and/or stress-tolerant crops, planting early are employed in this scenario. • The value of policy and technological investment in adaptation strategies is clear in this scenario. investment in irrigation technology and effective implementation of

		climate-smart cropping systems that enhance adaptation strategies such as crop rotation, intercropping, diversity in crop varieties with superior traits, planting early maturing varieties, soil fertility management are required to adapt to the changing climate, improve yield and protect the environment by 2050. • The trade-offs would be community diet diversification over commercialisation

Country-South Africa		
Scenario Quadrant	**Calibrated Statements**	**Implication Statements**
Low climate risk (RCP2.6) / Low land reform (LT)	**Food production**: The mean percentage change to crop production with RCP2.6, scenario is 117% **Climate impacts**: Without adaptation, climate change results in mean yields decreasing in this scenario. The impacts of climate change on maize, soybean and potato still result in small yield losses (< 5%) even with autonomous adaptation, with little change to groundnut yields projected	• Crop diversity slightly increases with potential 10% increase in growing land for non-maize crops by 2050. However, maize remains the main crop. • This scenario implies unchanged land tenure system, mainly characterised by optimized crop production and commercialization coupled with slight increase change in crop diversity where profitable major crops are prioritised with potential 10% increase in growing land for non-maize crops by 2050. • Crop diversity provides biological means of controlling the incidence of pest outbreaks and the transmission of pathogens. • Maize yield can be significantly alleviated and increased with autonomous adaptation which include development of new maize varieties to cope with stress coupled with moderate technology investment including, irrigation, crop improvement and sustainable land management which may increase production efficiency. • At farm level, crop diversification reduces the sensitivity of production to climatic variability. choice of diverse crops that are stress-tolerant and climate smart

		cropping systems that enhance crop water use efficiency and investment in technologies are ideal to reduce the effects of climate. • It is evident that delay in implementation of land reform coupled with moderate technology investment favours potential yield increase by 2050 in this scenario.
High climate risk (RCP8.5) /Low land reform (LT)	**Food production:** The mean percentage change to crop production with RCP8.5, scenario lt is 178% **Climate impacts**: Without adaptation, climate change results in mean yields decreasing in this scenario. The impacts of climate change with autonomous adaptation result in yield losses of 4-14% for maize, soybean and potato, although groundnut shows little change to mean yields. **Climate and Extreme:** Climate projections for the mid-century show an increase in average temperatures of ~2.5°C in every month, as compared to the 1990 – 2010 period	• Crop diversity slightly increases with potential 25% increase in growing land for non-maize crops by 2050. This scenario though implies maize remains the main crop by 2050. • While change in long-term mean climate will have significance for food production and may require ongoing adaptation, greater risks to food security may be posed by changes in year-to-year variability and extreme weather events. Historically, many of the largest falls in crop productivity have been attributed to anomalously low precipitation. However, even small changes in mean annual rainfall can impact on productivity. • Maize yield can significantly be increased with moderate technology investment including irrigation which may increase production efficiency and reduce yield shocks. • Despite a need for an effective progress in policy implementation process on land reform which is very critical in South Africa for community investments in food production, this scenario implies unchanged land tenure system, mainly characterised by optimized crop production and commercialization coupled with slight increase change in crop diversity where profitable major crops are prioritised. • It implies adequate adaptation strategies which include, climate-smart cropping systems, early planting, use of early maturing varieties/and or stress tolerant, varying in crop species and varieties, soil fertility management are employed. • Land suitability, social norms, income level, and contact with extension officers are key challenges which hinder wide adaptation of crop diversification.

Low climate risk (RCP2.6)/ High land reform (HT)	**Food production:** The mean percentage change to crop production with RCP2.6, scenario ht is 101% **Climate impacts**: With adaptation of new varieties and irrigation, crop yields will most likely increase by around 10% for maize, groundnut and soybean, with little change for potato.	• The positive mean change in yield increases due to effective policy implementation on land reform coupled with high crop production technologies, sustainable management including crop improvement strategies. • In this scenario crop diversity increases substantially by 2050, indicating effective policy design and implementation. • Policy shift towards land reform would have to be integrated with high technology investment (improved crops varieties, irrigation), information on land investment potential for rural communities, diverse use of the land to avoid yield losses which may come due to land policy change. • Changes in food demand pattern provide strong stimulus to diversification. Household income and food prices strongly influence the pattern of food consumption and this might be taken into account if crop diversification is to be achieved.
High climate risk (RCP8.5)/ High land reform	**Food production:** The mean percentage change to crop production with RCP8.5, scenario ht is 139% **Climate impacts:** With adaptation of new varieties and irrigation, crop yields will most likely increase by around 10% for maize, groundnut and soybean. Yields could still decrease slightly for potato however. **Yield shocks**: Yield shock rates largely decrease due to the	• Crop diversity increases substantially, indicating the value of policy investment can influence the crops being grown within a given region • The scenario implies non-maize crops area expanding by 25% by 2050. • Since there is a potential for increased access to irrigation water which is an important factor of crop diversification and expansion of arable land. Introduction of irrigation has largely led to high productivity as well as multiple cropping. • Diverse cropping systems may enhance yield stability, food security and climate variability buffering. It may also have instant and long-term impacts on soil condition and functionality which improves crop yields. • The value of policy and technological investment in adaptation strategies is clear in this scenario. Yields are increased and crop diversity increases which is a buffer to yield shocks

	applied technology trend to yields and irrigation. If not assuming this technology trend increase to mean yields, and with no benefits from irrigation in future, yield shocks typically increase	• Policy shift towards land reform would have to be integrated with high technology investment, information on land investment potential for rural communities, small holder farmers strong support system, diverse use of the land to avoid yield losses which may come due to land policy change. Effective policies imply high technologies to adapt to the changes, planting early-maturing and/or drought-resistant crops, sustainable land management. • The clear challenge is to ensure that improved technologies including varieties for diverse crops are available to farmers. • High land reform will imply increased productive land for Small and marginal land holders to efficiently diversify if well supported. • Crop diversification is not only limited by land, climate and socioeconomic factors but it also depends greatly on technology development. The technology as embodied in seed, fertilizer, draught power, and so on can also shift the advantage of one crop vis-à-vis other. • Experiences, however, suggest that technological changes of this nature have mostly led to more specialization and concentration rather than diversification. The most significant technological change that has remarkably impacted the cropping pattern is irrigation. • The nature of cropping pattern and the extent of diversity are influenced by policy interventions. The government policies that directly or indirectly affect crop diversification are: pricing policy, tax and tariff policies, trade policies and policies on public expenditure and agrarian reform.

Country-Zambia		
Scenario	**Calibrated statements and Scenario description**	**Implication statements**

Low climate risk (RCP2.6) / Low market efficacy (LT)	**Food production**: The mean percentage change to crop production with RCP2.6, scenario lt is 8% **Climate impacts**: Without adaptation, climate change results in mean yields decreasing in this scenario. The impacts of climate change on maize, soybean and groundnut still result in yield losses of around 10% even with autonomous adaptation, but some small gains for potato are projected.	• Crop diversity increases with potential increase in growing land for crops such as cassava, sorghum and beans by 2050. • High technology investment including irrigation and crop improvement for non–maize crops is required to improve yield by 2050. • Modern technologies coupled with climate-smart cropping systems to adapt to the rapid climate changes, diverse crop species and varieties, planting early-maturing and/or stress-tolerant crops, sustainable land management including conservation agriculture, could enhance water and crop productivity. • One principle of conservation agriculture is rotating cereal crops with legumes, which has a positive impact on crop diversification • Crop diversification can improve resilience in a variety of ways: by engendering a greater ability to suppress pest outbreaks and dampen pathogen transmission; buffering crop production from the effects of greater climate variability and extreme events; and improving soil fertility though diversification with leguminous crops
High climate risk (RCP8.5) / Low market efficacy (LT)	**Food production**: The mean percentage change to crop production with RCP8.5, scenario lt is -1% **Climate impacts**: Without adaptation, climate change results in mean yields decreasing in this scenario. The impacts of climate change with autonomous adaptation result in yield losses of more than 10% for maize, soybean and groundnut, although potato	• The scenario implies insufficient adaptation strategies coupled with low technology interventions to reduce the effects of climate risks on crop production which will lead to reduced yield. • This will lead to increased food insecurity. In order to meet future food demand and maintain well-being existing cropping systems and policy infrastructure will have to change. In this scenario crop diversity increases and non-maize area increased by 20% by 2050, with no adaptation strategies. • Maize yield can be significantly alleviated and increased with autonomous adaptation. Choice of diverse crops that are adaptable to biotic and abiotic stress and cropping systems that enhance crop water use efficiency and investment in technologies such as irrigation, will be ideal to reduce the effects of climate. • One of the adaption strategies that the Zambian government outlined in its National Climate Change Response Strategy (NCCRS) is enhancing farming systems that encourage crop diversification.

	shows little change to mean yields. High Confidence	• Crop diversification may, however, also entail competition for resources among various crops. For example, over-diversification may place pressure on agricultural land and farm management resources and may therefore reduce farm efficiency in some cases. Farmers education on suitable crops for different farming systems to embrace crop diversification are required.
Low climate risk (RCP2.6) / High market efficacy (HT)	**Food production**: The mean percentage change to crop production with RCP2.6, scenario ht is 252% **Climate impacts**: With adaptation of new varieties and irrigation, crop yields will most likely increase slightly for maize, potato and groundnut, with little change for soybean.	• The positive mean change in yield increases due to effective policy implementation which monitors market efficiency coupled with modern high crop production technologies by 2050 is possible. • In this scenario crop diversity increases substantially. It is clear that with good market incentives, availability of improved cultivars, diverse crops and varieties ,planting early-maturing and/or stress-resistant crops (stress which include heat, drought, flooding), coupled with good agronomic practices and sustainable land management, it is possible to achieve cereal yield gain of above 5t/ha from present 1t/ha by 2050. • An opportunity to promote an improvement of non-maize crops that are adaptable to drought stress are enhanced. Diverse cropping systems may enhance yield stability, food security and climate variability buffering. • At the farm level, diversification may also ensure balanced nutrition with the least dependence on off-farm enterprises, thus minimizing to a great extent the import of agricultural commodities
High climate risk (RCP8.5) / High market efficacy (HT)	**Food production**: The mean percentage change to crop production with RCP8.5, scenario ht is 564% Climate impacts: With adaptation of new varieties	• Crop diversity decreases followed by high agricultural production technologies, Including Intensive cultivation, mechanisation which will reduce number of non-maize crops by 2050. • The scenario implies significant policy implementation effort to improve farm efficiency focusing on high technologies to adapt to the changes, planting early-maturing and/or drought-resistant crops.

	and irrigation, crop yields will most likely increase. More modest increases are likely for potato compared to maize and groundnut, however soybean yields could still decrease.	• Despite reduced crop diversification, the scenario implies prioritising the high yielding crops such as sugarcane, cassava, potato, banana and wheat, resulting in larger production gain and avoiding over diversification which can reduce production gains and difficult to manage. • In most of the areas where irrigation is introduced, the cropping pattern has become more diversified, especially so if there is proper regulation of water delivery. Due to low productivity from agriculture coupled with high population pressure and negligible area of land available for expansion of cultivation, the available option is intensification of crop diversification using modern technologies and use of new technologies such as protected cultivation. • Efficiency in Farmers' accessing improved inputs such as certified seed and fertilizer, information on agronomic practices, and farmer's education on maize and other non-maize crops is required to increase yield by 2050. • Relative profitability of high-value commodities in relation to other crops plays an important role in determining the status of diversification. To speed up the process of agricultural diversification of high-value commodities, there is a need to take a series of measures to reform institutional arrangements, which can appropriately integrate production and markets. • The fundamental principle of most successful diversification programmes is that they are driven by market demand. However, crop diversification may also improve diet diversification which improves community nutrition security and climate resilience

B. Implication Statements for Livestock Diversification

Country	Scenario Quadrant	Calibrated statements	Implication statements
Malawi	Low climate risk (RCP2.6) / ineffective agricultural policies (LT)	The mean percentage change to livestock meat production with RCP2.6, scenario lt is -1% and the mean percentage change in livestock dairy production with RCP 2.6 , Scenario it is 2%	• The scenario implies less significant direct change to livestock meat and dairy production due to climate impacts by 2050. The most significant trend in livestock production in developing countries is the rapid growth in demand for livestock and livestock products driven by urbanization, population growth and income increases. • Therefore, given the complexity of livestock and crop-livestock systems, a mix of technological, policy and institutional innovations will inevitably be required. Although climate change impacts on livestock are uncertain, livestock diversity may help to buffer the shock which might come due to climate related risks such as diseases.
	High climate risk (RCP8.5)/ineffective agricultural policies (LT)	The mean percentage change to livestock meat and dairy production with RCP8.5, scenario lt is -13% and -6% respectively	• There is a reduction in meat and dairy production due to high climate impact and coupled with low technologies for adaptation. This scenario implies reduced pasture growing area. For community climate resilience, there is a need to focus on identifying appropriate options that can help livestock keepers adapt to high climate risk which include livestock diversity. • Technological advancement to support livestock breeding and animal health as well as feed is paramount to adapt to changing climate and minimize losses by 2050
	Low climate risk (RCP2.6) / effective agricultural policies (HT)	The mean percentage change to livestock meat and dairy production with RCP2.6, scenario ht is 151% and 237% respectively	• Despite less direct significant effect of climate impacts in this scenario, meat and dairy production can be significantly increased with the value of investing in policy coupled with technology by 2050. • Projected potential improvements linking to a combination of feed and nutrition, genetics and breeding, health and environmental management options, with different combinations appropriate to different livestock systems. At this point diversity is critical but also can be limiting due to challenges in management and this might be a trade-off.
	High climate risk (RCP8.5) / effective	The mean percentage change to livestock meat and dairy production with	

	agricultural policies (HT	RCP8.5, scenario ht is 152% and 243% respectively	• The value of investing in effective policy development and implementation with high technology reduce the adverse impacts of climate related risk under some circumstances. • Both meat and dairy production can be significantly increased despite direct impacts of climate related risk. The adaptation options include diversified livestock systems, investment in technology to support production, health, nutrition and breeding. The opportunity is the 58% increase for both arable crop and pasture growing area by 2050 which implies increased availability of feed. • Malawi's National Resilience Strategy 2018-2030 is an opportunity to promote dairy, small stock, poultry, and beef as diversification into these products have been shown to enhance resilience of households and communities.
Tanzania	Low climate risk (RCP2.6) / Low technology	The mean percentage change to livestock meat and dairy production with RCP2.6, scenario lt is 62% and 67% respectively	• There is potential significant trend in livestock production which might be in demand for livestock and livestock products driven by urbanization, population growth and income increases. • Therefore, given the complexity of livestock and crop-livestock systems, a mix of technological, policy and institutional innovations will inevitably be required. livestock diversity helps to buffer the shock which might come due to diseases.
	High climate risk (RCP8.5) / Low technology	The mean percentage change to livestock meat and dairy production with RCP8.5, scenario lt is 73% and 77% respectively	• The present projections are indicating potential for increased production despite considerable gaps in knowledge of how climate change and increasing climate variability will affect livestock systems and the livelihoods of the people who depend on them. • However, for community climate resilience, there is a need to focus on identifying appropriate options that can help livestock keepers adapt to high climate risk which include livestock diversity. Technological improvement to support livestock breeding and animal health as well as feed is paramount to increase productivity.
		The mean percentage change to livestock meat	

	Low climate risk (RCP2.6) / High technology	production with RCP2.6, scenario ht is 289% and for dairy 227%	• Despite non-direct significant effect of climate impacts, meat and dairy production can be significantly increased with the value of investing in high technology. • There are potential improvements linking to a combination of feed and nutrition, genetics and breeding, health and environmental management options, with different combinations appropriate to different livestock systems
	High climate risk (RCP8.5) / High technology	The mean percentage change to livestock meat production with RCP8.5, scenario ht is 530% and for dairy 375%	• The value of investing in good policy implementation with high modern technology reduce the adverse impacts of climate related risk under some circumstances. • Both meat and dairy production is significantly increased despite direct impacts of climate related risk by 2050. Beef production more than doubles and chicken production 10-ford increase than baseline. The scenario takes advantage of the potential investment in increasing pasture areas which can increase the livestock production. • The challenge is to explore uncertainty of increased climate variability which could increase future livestock risk. The adaptation options include diversified livestock systems, investment in technology to support production, health, nutrition, and breeding.
South Africa	Low climate risk (RCP2.6) / Low land reform (LT)	The mean percentage change to livestock meat production with RCP2.6, scenario lt is 122% and dairy is 115%	• There is an Increase in livestock pasture, coupled with moderate technology in this scenario. • It is evident that significant trend in livestock production which might be in demand for livestock and livestock products driven by urbanization, population growth and income increases. Livestock diversity helps to buffer the shock which might come due to diseases. • Therefore, given the complexity of livestock and crop-livestock systems, a mix of technological, policy and institutional innovations will inevitably be required.

	High climate risk (RCP8.5) / Low land reform (LT	The mean percentage change to livestock meat production with RCP8.5, scenario lt is 129% and dairy is 123%	• The present projections are indicating potential for increased production despite considerable gaps in knowledge of how climate change and increasing climate variability will affect livestock systems and the livelihoods of the people who depend on them. • This scenario implies unchanged land tenure system, mainly characterised by commercial farmers with moderate adaptation strategies. • However, for community climate resilience, policy shift towards identifying appropriate options that can help livestock keepers adapt to high climate risk which include livestock diversity is required. • Moderate technological investment would support increased pasture growing areas, livestock breeding and animal health as well as feed for increased productivity.
	Low climate risk (RCP2.6)/High land reform (HT)	The mean percentage change to livestock meat production with RCP2.6, scenario ht is 122% and dairy is 113%	• Despite no direct significant effect of climate impacts, meat and dairy production can be significantly increased with the value of investing in policy coupled with technology. • There is increased potential improvements linking to a combination of feed and nutrition, genetics and breeding, health and environmental management options, with different combinations appropriate to different livestock systems. at this point diversity is critical but also can be limiting due to challenges in management. • Policy shift towards land reform would have to be integrated with high technology investment, information on land investment potential for rural communities, small holder farmers strong support system, diverse use of the land to avoid losses which may come due to land policy change
	High climate risk (RCP 8.5)/ Hing land reform (HT)	The mean percentage change to livestock meat production with RCP8.5,	• The value of investing in policy on land reform with high technology could reduce the adverse impacts of climate related risk under some

		scenario ht is 124% and dairy is 116%	circumstances. Both meat and dairy production can be significantly increased despite direct impacts of climate related risk. • Policy shift towards land reform would have to be integrated with high technology investment, information on land investment potential for rural communities, small holder farmers strong support system, diverse use of the land to avoid losses which may come due to land policy change. • The adaptation options include diversified livestock systems, increased pastureland, investment in technology to support production, health, nutrition, and breeding.
Zambia	Low climate risk (RCP2.6) / Low market efficacy (LT)	The mean percentage change to livestock meat production with RCP2.6, scenario lt is 4% and dairy is 5%	• Despite direct effect of climate there is a slight increase to meat and dairy products. There is potential significant trend in livestock production which might be in demand for livestock and livestock products driven by urbanization, population growth and income increases. Therefore, given the complexity of livestock and crop-livestock systems, a mix of technological, policy and institutional innovations will inevitably be required. • Livestock diversity helps to buffer the shock which might come due to diseases. opportunity to promote dairy, small stock, poultry, and beef as diversification into these agricultural products have been shown to enhance resilience and income of households and communities
	High climate risk (RCP8.5) / Low market efficacy (LT)	The mean percentage change to livestock meat production with RCP8.5, scenario lt is -5% and dairy is -2%	• There is decreased meat and dairy production due to high climate impact and yet low technologies for adaptation. For community climate resilience, there is a need to focus on identifying appropriate options that can help livestock keepers adapt to high climate risk which include livestock diversity.

			• The adaptation options include diversified livestock systems, diversified feed coupled with high investment in technology to support production, health, nutrition and breeding is paramount to increase productivity.
	Low climate risk (RCP2.6) / High market efficacy (HT)	The mean percentage change to livestock meat production with RCP2.6, scenario ht is 250% and dairy is 183%	• Despite insignificant direct effect of climate impacts, meat and dairy production can be significantly increased with the value of investing in policy coupled with technology. • There is significant trend in meat and dairy productivity linking to a combination of feed and nutrition, genetics and breeding, health and environmental management options, with different combinations appropriate to different livestock systems by 2050
	High climate risk (RCP8.5) / High market efficacy (HT)	The mean percentage change to livestock meat production with RCP8.5, scenario ht is 135% and dairy 114%	• The value of investing in policy on improved market efficiency with high technology reduce the adverse impacts of climate related risk under some circumstances. • Both meat and dairy production can be significantly increased despite direct impacts of climate related risk by 2050. The scenario takes advantage of the potential investment in increasing pasture areas which can increase the livestock production. • The challenge is to explore uncertainty of increased climate variability which could increase future livestock risk. The adaptation options include diversified livestock systems, investment in high technology to support production, health, nutrition, and breeding.

Some References

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