GCRFAFRICAP
CLIMATE SMART AGRICULTURE FOR DEVELOPMENT

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Zambia - Food Production: Land Use and Yield Changes
Low Climate Risk / High Market Connectivity

Food production change

Agricultural expansion, optimisation of cropland, technological innovation and adaptation, diversification and irrigation combined result in large increases to crop and livestock production – a more than 200% increase in crop production and more than 160% increase in livestock production (medium confidence). Climate extremes are projected to increase slightly with low climate risk – as a result, relatively bad years of domestic food production can be expected to become more common.

With relatively low direct climate impacts, meat and dairy production can be significantly increased with the value of investing in policy coupled with technology. There is a 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. If meat/dairy production increases income generating opportunities in the meat and dairy sector and value chains likely to increase. With higher food availability, there is potential for food prices to decline and affordability to increase.

Land use and irrigation

This scenario is characterised by an increase in arable areas of 5%, and an increase in livestock pasture areas of 25%. There are possible impacts on biodiversity/forests/wildlife due to increases in production areas - potentially leading to reduced wild food safety nets.

Irrigation areas have expanded to include all arable crop areas. Irrigation water demand therefore is projected to increase by over 20 times by most climate models – policy decisions will need to account for this uncertainty in demand if wanting to plan for large scale irrigation expansion. Policy shifts towards increased irrigation would have to be matched with increased research emphasis on making irrigation more sustainable and resilient to (albeit relatively low) climate risks.

Increases in irrigation water use has potential to contribute towards increased crop production. However, increase in irrigation water use could put pressure on water resources. Pressure to meet irrigation demand could result in tensions over transboundary water resources within the Zambezi River basin which is shared by several southern African countries. Technological innovation would have to prioritise development of more efficient irrigation systems. Irrigation water use changes are similar in direction (and to a degree magnitude) to the high climate risk for the same market (efficiency) scenario which underlines the need to make irrigation more efficient and less water intensive for the low climate risk scenario. Development of rainfed agricultural systems would reduce the irrigation water demand per unit area and offset pressure on water for irrigation while making food systems resilient to future climate change.

Water and land use conflicts might increase between agricultural users and other consumers (due to expansion, increased productivity and irrigation) including conflicts between livestock, crop production and hydro-electric needs if policies are not coherent/complementary. There would be increased need for robust cross-sectoral planning and regulation for land and resources (e.g. water, energy, mining/minerals, forests/biodiversity etc.). There would be increased demand on extension services linked to irrigation / crop changes. There is potential for inequality to rise, as upscaling of irrigation technologies does not reach all households and/or households cannot access or afford them.

Yield change, crop diversification and adaptation

Crop diversity increases substantially in this scenario, with maize areas falling by 15% proportionately, and other arable areas approximately evenly divided between the other crops. Maize remains the crop associated with the highest growing area however. Crop areas are optimised to maximise production – in other words, the mixture of crops that returns the highest possible crop production is used in future (although the total national area of each crop is approximately equal, where each crop is placed within the country is optimised to maximise production).

In this scenario crop diversity increases substantially. It is clear that with good market incentives, availability of improved cultivars, diverse crops and varieties, planting 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. Opportunities to promote 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.

It is assumed that the same percentage change to crop yields experienced from 1961 to 2010 (i.e. management and technology improvements to yields) will continue to 2050 – i.e. a substantial yield improvement compared to the baseline. This amounts to more than a doubling of crop yields on average. Crop adaptation allows planting dates to vary, and crop varieties to vary, and where there is a significant trend for warming to reduce the length of crop growing seasons, varieties are assumed to be available that can compensate for this.

With adaptation of new varieties and irrigation, crop yields will most likely increase slightly for maize, potato and groundnut, with little change for soybean. **Effectively implemented irrigation and crop varietal improvements across the country result in significantly reduced yield shock rates (medium confidence).**

If markets are inclusive and sustainable, yield increases may raise incomes. If markets are not inclusive or sustainable, yield increases have limited impacts on incomes. There would be increased demand on extension services (e.g. agricultural and climate). There is potential for inequality to rise, as upscaling of agricultural technologies (seeds varieties and irrigation) does not reach all households or households cannot afford to purchase technologies

It can take up to 20 years from initial investment in breeding for new varieties to be available and in farmers' fields. This process may be shorter in contexts in which effective markets and policy facilitate the movement of genetic material and improve access to new varieties for farmers

With temperatures expected to be warmer by 1C by 2050, continued investment in crop breeding is required in order to ensure that the adaptation of crops can keep pace with changing conditions. This may include investments in technologies that speed up the breeding process. Well connected and efficient markets may be contributing to demand driven investments in crop breeding under this scenario.

Without adaptation maize yields will decline across all regions by 2050. However, if varieties can be developed that sustain the duration of the crop, there is potential for yield benefits (increase of approx. 5%) to be realised.

As the intensity of extreme rainfall and temperature increase over the next 30 years, this investment will pay off in particular in mitigating against the significant yield penalties that we expect to occur more frequently for maize than in the present day.

There is also potential for significant yield gains to be realised within non-maize crops (for which there may be new market opportunities) by 2050, in some cases with less significant adaptation required, so investing in breeding in non-maize crops may be cost effective and contribute to improved nutrition outcomes. Traits that might become particularly important for breeding include drought stress tolerance, adaptation to shorter rainfall seasons, crop pests and disease resistance, nutrition enhancement and food safety traits.

Pests and diseases

An additional 2-5 % yield loss from crop pests and diseases (CPD) is possible if heterogeneous agriculture-natural land cover mosaics are converted to simplified homogenised production systems. (medium confidence). An increase in globalised trade of economically desired plants and animals will reduce farm-level diversity, lead to landscape-level homogenisation, and negatively affect long-term resilience of food systems to crop pests and diseases.

Homogenised production is characterised by reduced crop diversity - due to reliance on a few dominant species, could occur with agricultural expansion and intensification, and transformation of heterogeneous small-scale agriculture to large-scale corporate agriculture. Increased uniformity of cultivars leads to greater vulnerability to CPD. When pests and pathogens evolve to overcome the genetic resistance of the crop, the result can be a severe crop failure with immediate detrimental effects of food availability and nutrition. The negative effects of crop homogenisation will interact and multiply with local habitat loss, landscape simplification, and invasive CPD. There are also reduced wild food safety net options in homogenised agricultural landscapes

An additional 13% crop yield loss due to novel pest and diseases is also possible (medium confidence). Increased trade and homogenisation of agricultural systems will facilitate introduction, establishment, dominance and spread of novel transboundary pest and diseases and invasive species. Acute invasive species – such as fall army warm – could have a devastating impact on production leading to 60-100% of yield losses.

An increase in globalised trade of economically important plants and animals will reduce farm-level diversity, lead to landscape-level homogenisation, and negatively affect long-term resilience of food systems to crop pests and diseases. Due to market integration, farmers will have better access to resistant and improved varieties of crops, mechanisation, and chemical fertilizers and pesticides. However, pests and pathogens may evolve to overcome the genetic resistance of crops and chemical pesticides resulting in severe crop failures with detrimental effects of food availability and nutrition. Market integration will allow better access to chemical fertilizers which will increase plant growth and vigour and enhance the nutritional qualities of crops – e.g., increase in size and number of leaves, which may lead to increase in pest attacks.

Increase in investments for pest management using chemical pesticides by local and regional stakeholders, including farmers, organisations, and governments, causing an increase in costs of agricultural production, reduced profit margins, increase in food prices, and reduction in available income to allocate other household needs.

Any increased trade (import and export) due to higher market connectivity will lead to homogenisation of agricultural systems, which will facilitate introduction and establishment of novel transboundary pest and diseases and invasive species.

Agricultural intensification with irrigation as a central feature can be beneficial for certain pests (such as cutworms), increase the abundance of chewing insects, and reduce the impact of biocontrol mechanisms on pest populations. This will lead to greater use of chemical inputs and increased costs of food production.

By mid-century, moderate changes in climate associated with change in policy for adoption of crop diversification, resistant maize varieties, use of fungicides and biocontrol methods, and improved postharvest and storage technologies, could likely result in no change in maize aflatoxin contamination.

Droughts are likely to occur on a yearly basis, with associated increases in cassava toxicity of around 4x. Given varieties of cassava in the region are 'bitter', this may make processing cassava to reach World Health Organization safety guidelines (10ppm) difficult.

As cassava production becomes proportionally a smaller part of overall production and the overall diet, the impact of cassava toxicity on health is likely to be smaller than in this scenario. However cyanide concentrations will still likely be high enough during droughts that consumption of cassava will pose health risks.

If CPD pressures increase, any reductions in yields for cash crops are likely to lead to acute income loss, undermining household resilience and increasing financial vulnerability. Reductions in yields for subsistence crops are likely to lead to increased food insecurity. There would be increased demand on extension services, particularly for (chemical) crop pest and disease management practices and/or biocontrol measures. There would also be an increased demand for R&D on biocontrol measures.

Increase in pests/diseases will lead to an increased reliance/need for pesticides, herbicides and fungicides. Increased use of chemical inputs has negative impacts on human and environmental health. Increased need for chemical control has multiple implications:

a. Technologies may not reach all households
b. Not all households can afford to purchase inputs
c. Not all farmers are able/prepared to use them
d. Gendered inequality exacerbated as women typically have less access to inputs than men

Increase in CPD can lead to increased labour demand on farms to implement control measures. There is potential for inequality to rise, as upscaling of pest/disease control technologies does not reach all households and/or households cannot access or afford technologies. If agriculture becomes unviable (e.g. too expensive, too labour intensive, or successive pest/disease outbreaks), we may expect an increased need to diversify away either a) from agriculture, or b) to alternative crops. Agricultural livelihood outcomes (income, food security) dependent on ability to adapt e.g. availability of / affordability of inputs (pesticides/fungicides, seed varieties, labour requirements for adaptation/adoption), knowledge of new practices. However, livelihood opportunities could be generated if pest-resistant crops can be propagated / biocontrol measures can be produced and sold locally.

Appendix 1: Calibrated Statements

Climate Impacts Calibrated Statements

- RCP2.6 HT: With adaptation of new varieties and irrigation, crop yields will most likely increase slightly for maize, potato and groundnut, with little change for soybean. High Confidence.

Food Production Calibrated Statements

Scenario description:

This scenario is characterised by an increase in arable areas of 5%, and an increase in livestock pasture areas of 25%. Irrigation areas have expanded to include all arable crop areas.

Crop diversity increases substantially in this scenario, with maize areas falling by 15% proportionately, and other arable areas approximately evenly divided between the other crops. Maize remains the crop associated with the highest growing area however. Crop areas are optimised to maximise production – in other words, the mixture of crops that returns the highest possible crop production is used in future (although the total national area of each crop is approximately equal, where each crop is placed within the country is optimised to maximise production).

It is assumed that the same percentage change to crop yields experienced from 1961 to 2010 (i.e. management and technology improvements to yields) will continue to 2050 – i.e. a substantial yield improvement compared to the baseline. This amounts to more than a doubling of crop yields on average. Crop adaptation allows planting dates to vary, and crop varieties to vary, and where there is a significant trend for warming to reduce the length of crop growing seasons, varieties are assumed to be available that can compensate for this. All of these factors combined result in large increases to crop and livestock production.

CS1: crop production

The mean percentage change to crop production with RCP2.6, scenario ht is 252% (range across climate models 233 to 271%; 0/18 climate models are outliers).

Robustness:
Medium robustness. Highly robust with respect to the range of climate model uncertainty as there are 0 outliers. The underlying yield projections are associated with medium confidence for one of the four modelled crops. The other three crop yield projections are associated with high confidence. For the majority of crops, average projections across these four crops are used, and therefore the productions projections for other crops are less certain. Overall, this suggests medium robustness.

Agreement:
Medium agreement. The production changes in this scenario are based on an optimistic future where yield trends are maintained and crop areas expand. Literature suggests yields can improve drastically given the correct policy interventions. The climate change impact literature has high agreement with iFEED projections for three of four crops. The other crop is associated with medium agreement. There is less literature available for the majority of other crops included in the analysis. Overall, this suggests medium agreement, given uncertainties in the literature concerning future food production and yields for all crops, and in particular a lack of studies to compare to food production projections.

Medium Confidence (medium robustness and medium agreement).

CS2: livestock production

The mean percentage change to livestock meat production with RCP2.6, scenario ht is 250% (range across climate models 230 to 266%; 0/18 climate models are outliers).

The mean percentage change to livestock dairy production with RCP2.6, scenario ht is 183% (range across climate models 169 to 193%; 0/18 climate models are outliers).

Robustness:
Medium robustness. High robustness with respect to climate model uncertainty as 0 outliers. The underlying yield and crop production projections are associated with medium confidence. Simple methods have been used to translate future crop and pasture production to future livestock production, assuming historical relationships between the two persist. This suggests medium robustness.

Agreement:
Medium agreement. There is literature to suggest that livestock production efficiency could increase in future; however, climate change could also make certain livestock production more difficult due to diseases and heat stress. Overall, there is little to suggest that livestock production could not continue to be related to the available amounts of livestock feed. However, the lack of specific projections with which to compare to iFEED suggests medium agreement.

Medium Confidence (medium robustness and medium agreement).

CS3: irrigation

The mean percentage change to irrigation water with RCP2.6, scenario ht is 2582% (range across climate models 1828 to 3609%; 0/18 climate models are outliers).

Yield Shocks Calibrated Statements

Effectively implemented irrigation and crop varietal improvements across the country result in significantly reduced yield shock rates. Medium Confidence.

Pests and Diseases Calibrated Statements

CS1: An additional 2-5 % yield loss if heterogeneous agriculture-natural landcover mosaics are converted to simplified homogenised production systems.

Increase in globalised trade of economically desired plants and animals will reduce farm-level diversity, lead to landscape-level homogenisation, and negatively affect long-term resilience of food systems to crop pests and diseases.
Homogenised production characterised by reduced crop diversity - due to reliance on a few dominant species, could occur with agricultural expansion and intensification, and transformation of heterogeneous small-scale agriculture to large-scale corporate agriculture. Increased uniformity of cultivars leads to greater vulnerability to CPD. When pests and

pathogens evolve to overcome the genetic resistance of the crop, the result can be a severe crop failure with immediate detrimental effects of food availability and nutrition. The negative effects of crop homogenisation will interact and multiply with local habitat loss, landscape simplification, and invasive CPD.

Robustness
There are only few studies quantifying yield losses because of homogenisation and climate change. This the robustness is low.
Agreement
Agreement between studies on increased impact of pests under climate is medium. Studies largely agree on the increased pest prevalence and vulnerability under homogenised agriculture. Therefore, we put this as medium agreement.
Low Confidence (low robustness, medium agreement)

CS2: additional 13% crop yield loss due to novel pest and diseases.
Increased trade and homogenisation of agricultural systems will facilitate introduction, establishment, dominance and spread of novel transboundary pest and diseases and invasive species. Acute invasive species – such as fall army warm – could have a devastating impact on production leading to 60-100% of yield losses.
Robustness: There is limited local-scale evidence. Hence, low robustness.
Agreement: most studies indicate towards the negative impacts of novel pest and diseases on crop yields. Thus, high agreement.
Medium Confidence (Low robustness, High agreement)

Climate Extremes Calibrated Statements

By mid-century, climate models show average temperatures warming by roughly 1-2°C throughout the year compared to 1990-2010, with a corresponding increase in the number of growing degree days during the rainy season. There is also increased occurrence and frequency of temperature extremes, including days with average temperature above 35°C. Rainfall trends are much less robust; however, climate models show a weak tendency toward lower rainfall totals during the wettest months (December-April) accompanied by more rainfall on very wet days. There are also slight trends towards longer extreme dry spells around the start and end of the rainy season (October and April) and shorter extreme wet spells during the October-April period. This is consistent with a general shortening of the rainy season across Zambia. The number of months experiencing drought conditions is also projected to increase. However, there is significant disagreement between climate models for projections of rainfall and related quantities.

Appendix 2: Implication Statements

Irrigation Water Use Implication Statements

This scenario is characterised by an increase in arable areas of 5%, and an increase in livestock pasture areas of 25%. Irrigation areas have expanded to include all arable crop areas. This scenario is also associated with a 252% increase in crop production. The mean percentage change to irrigation water for this scenario is 2582% (range across climate models 1828 to 3609%; 0/18 climate models are outliers).

Implications for Irrigation Water Use

- Increase in irrigation water use has potential to contribute towards increased crop production. However, increase in irrigation water use could put pressure on water resources.
- Pressure to meet irrigation demand could result in tensions over transboundary water resources within the Zambezi River basin which is shared by several southern African countries.
- Technological innovation would have to prioritise development of more efficient irrigation systems. Irrigation water use changes are similar in direction (and to a degree magnitude) to the high climate risk for the same market (efficiency) scenario which underlines the need to make irrigation more efficient and less water intensive for the low climate risk scenario.
- Development of rainfed agricultural systems would reduce the irrigation water demand per unit area and offset pressure on water for irrigation while making food systems resilient to future climate change.
- Policy shifts towards increased irrigation would have to be matched with increased research emphasis on making irrigation more sustainable and resilient to the high climate risk under rcp8.5.
- There is agreement in model projections with regards to the direction of change in the mean percentage change. However, there is still considerable degree of uncertainty (as can be seen from the spread in the projected change) and policy decisions and investment would have to respond to that.

Aflatoxins Implication Statements

Implications

By mid-century, moderate changes in climate associated with change in policy for adoption of crop diversification, resistant maize varieties, use of fungicides and biocontrol methods, and improved postharvest and storage technologies, could likely result in no change in maize aflatoxin contamination.

Crop and Livestock Diversification Implication Statements

- 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

- 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

Crop Pests and Diseases Implication Statements

IS11: An increase in globalised trade of economically important plants and animals will reduce farm-level diversity, lead to landscape-level homogenisation, and negatively affect long-term resilience of food systems to crop pests and diseases.
Homogenised production characterised by reduced crop diversity, due to the reliance on a few dominant crops, could occur with agricultural expansion and intensification, and transformation of heterogeneous small-scale agriculture to large-scale corporate agriculture.

IS12: Due to market integration, farmers will have better access to resistant and improved varieties of crops, mechanisation, and chemical fertilizers and pesticides. However, pests and pathogens may evolve to overcome the genetic resistance of crops and chemical pesticides resulting in severe crop failures with detrimental effects of food availability and nutrition.
IS13: Market integration will allow better access to chemical fertilizers which will increase plant growth and vigour and enhance the nutritional qualities of crops – e.g., increase in size and number of leaves, which may lead to increase in pest attacks.

LS14: Increase in investments for pest management using chemical pesticides by local and regional stakeholders, including farmers, organizations, and governments, causing an increase in costs of agricultural production, reduced profit margins, increase in food prices, and reduction in available income to allocate other household needs.

LS15: Increase in monocultures will lead to farm-scale homogenisation which will reduce biodiversity and associated ecosystem services such as biocontrol, pollination and nutrient recycling consequently causing decreases resilience food system and increased vulnerability to CPD attacks.

LS16: Increased trade (import and export) due to higher market connectivity will lead to homogenisation of agricultural systems, which will facilitate introduction and establishment of novel transboundary pest and diseases and invasive species.

LS17: Agricultural intensification with irrigation as a central feature can be beneficial for certain pests (such as cutworms), increase the abundance of chewing insects, and reduce the impact of biocontrol mechanisms on pest populations. This will lead to greater use of chemical inputs and increased costs of food production.

Cassava Toxicity Implication Statements

Mid century

Droughts are likely to occur on a yearly basis, with associated increases in cassava toxicity of around 4x. Given varieties of cassava in the region are ‘bitter’, this may make processing cassava to reach World Health Organization safety guidelines (10ppm) difficult.

As cassava production becomes proportionally a smaller part of overall production and the overall diet, the impact of cassava toxicity on health is likely to be smaller than in the LT scenario. However cyanide concentrations will still likely be high enough during droughts that consumption of cassava will pose health risks.

End of century

Droughts will become more common than in the mid-century period, with associated increases in cassava toxicity of around 4x. Given varieties of cassava in the region are ‘bitter’, this may make processing cassava to reach World Health Organization safety guidelines (10ppm) difficult.

As cassava production becomes proportionally a smaller part of overall production and the overall diet, the impact of cassava toxicity on health is likely to be smaller than in the LT scenario. However cyanide concentrations will still likely be high enough during droughts that consumption of cassava will pose health risks.

Seed Systems Implication Statements

It can take up to 20 years from initial investment in breeding for new varieties to be available and in farmers’ fields. This process may be shorter in contexts in which effective markets and policy facilitate the movement of genetic material and improve access to new varieties for farmers

With temperatures expected to be warmer by 1C by 2050, continued investment in crop breeding is required in order to ensure that the adaptation of crops can keep pace with changing conditions. This may include investments in technologies that speed up the breeding process. Well connected and efficient markets may be contributing to demand driven investments in crop breeding under this scenario.

Without adaptation maize yields will decline across all regions by 2050. However, if varieties can be developed that sustain the duration of the crop, there is potential for yield benefits (increase of approx. 5%) to be realised.

As the intensity of extreme rainfall and temperature increase over the next 30 years, this investment will pay off in particular in mitigating against the significant yield penalties that we expect to occur more frequently for maize than in the present day.

There is also potential for significant yield gains to be realised within non-maize crops (for which there may be new market opportunities) by 2050, in some cases with less significant adaptation required, so investing in breeding in non-maize crops may be cost effective and contribute to improved nutrition outcomes.

Traits that might become particularly important for breeding include drought stress tolerance, adaptation to shorter rainfall seasons, crop pests and disease resistance, nutrition enhancement and food safety traits.

Households and Livelihoods Implication Statements

7a Climate and extremes

IS Applicable to all Scenario Quadrants:

1. Increased demand on extension services - particularly for climate and weather forecasting information
2. See statements 7b-7h

7b Climate impacts

Low Climate / High market efficacy (HT)

With adaptation of new varieties and irrigation, crop yields will most likely increase slightly for maize, potato and groundnut, with little change for soybean. High Confidence.

1. If markets are inclusive and sustainable, yield increases may raise incomes
2. If markets are not inclusive or sustainable, yield increases have limited impacts on incomes

7c Crop pests

IS Applicable to all Scenario Quadrants:

1. Reductions in yields for cash crops are likely to lead to acute income loss, undermining household resilience and increasing financial vulnerability
2. Reductions in yields for subsistence crops are likely to lead to increased food insecurity
3. There would be increased demand on extension services, particularly for (chemical) crop pest and disease management practices and/or biocontrol measures
4. There would be increased demand for R&D on biocontrol measures
5. Increase in pests/diseases will lead to an increased reliance/need for pesticides, herbicides and fungicides
6. Increased need for chemical control has multiple implications:
   e. Technologies may not reach all households
   f. Not all households can afford to purchase inputs
   g. Not all farmers are able/prepared to use them
   h. Gendered inequality exacerbated as women typically have less access to inputs than men
7. Increase in pests lead to increased labour demand on farms to implement control measures
8. There is potential for inequality to rise, as upscaling of pest/disease control technologies does not reach all households and/or households cannot access or afford technologies
9. If agriculture becomes unviable (e.g. too expensive, too labour intensive, or successive pest/disease outbreaks), we may expect an increased need to diversify away either a) from agriculture, or b) to alternative crops
10. Increased use of chemical inputs has negative impacts on human and environmental health
11. Agricultural livelihood outcomes (income, food security) dependent on ability to adapt e.g. availability of / affordability of inputs (pesticides/fungicides, seed varieties, labour requirements for adaptation/adoption), knowledge of new practices
12. Livelihood opportunities generated if pest-resistant crops can be propagated / biocontrol measures can be produced and sold locally

Low Climate / High market efficacy (HT)

1. Reduced wild food safety net options in homogenised agricultural landscapes

7d Emissions and soils

IS Applicable to all Scenario Quadrants:

1.With increased GHG emissions (or to meet the reductions), it is possible that mitigation-focussed CSA may increase, e.g. increase in 'payment for ecosystem services'-type programmes, with potential income for agricultural households/farmers, e.g. to plant trees
2.There would be increased demand on extension services (e.g. forestry/agroforestry).
3.There is potential for inequality to rise, as upscaling of mitigation technologies does not reach all households and/or households cannot access or afford technologies
4. Labour demand/costs to farmer to improve soil organic carbon stocks

7e Food production

Low Climate / High market efficacy (HT)

The mean percentage change to crop production with RCP2.6, scenario ht is 252% (range across climate models 233 to 271%; 0/18 climate models are outliers).

1. If markets are inclusive and sustainable, yield increases may raise incomes
2. If markets are not inclusive or sustainable, yield increases have limited impacts on incomes
3. With higher food availability, there is potential for food prices to decline and affordability to increase
4. Water and land use conflicts might increase between agricultural users and other consumers (due to expansion, increased productivity and irrigation) including conflicts between livestock and crop production needs if policies not coherant/complementary
5. Impacts on biodiversity/forests/wildlife due to increases in production areas - potential to lead to reduced wild food safety nets.

The mean percentage change to livestock meat production with RCP2.6, scenario ht is 250% (range across climate models 230 to 266%; 0/18 climate models are outliers).

1. If markets are inclusive and sustainable, yield increases may raise incomes
2. If markets are not inclusive or sustainable, yield increases have limited impacts on incomes
3. With higher food availability, there is potential for food prices to decline and affordability to increase
4. Water and land use conflicts might increase between agricultural users and other consumers (due to expansion, increased productivity and irrigation) including conflicts between livestock and crop production needs if policies not coherant/complementary
5. Impacts on biodiversity/forests/wildlife due to increases in production areas - potential to lead to reduced wild food safety nets
6. Increased availability, accessibility and affordability of meat products will enhance nutrition outcomes
7. If meat/dairy production increases income generating opportunities in the meat and dairy sector and value chains likely to increase

The mean percentage change to livestock dairy production with RCP2.6, scenario ht is 183% (range across climate models 169 to 193%; 0/18 climate models are outliers).

1. If markets are inclusive and sustainable, yield increases may raise incomes
2. If markets are not inclusive or sustainable, yield increases have limited impacts on incomes
3. With higher food availability, there is potential for food prices to decline and affordability to increase
4. Water and land use conflicts might increase between agricultural users and other consumers (due to expansion, increased productivity and irrigation) including conflicts between livestock and crop production needs if policies not coherant/complementary
5. Impacts on biodiversity/forests/wildlife due to increases in production areas - potential to lead to reduced wild food safety nets
6. Increased availability, affordability and accessibility of meat will enhance nutrition outcomes
7. If meat/dairy production increases income generating opportunities in the meat and dairy sector and value chains likely to increase

7f Irrigation

IS Applicable to all Scenario Quadrants: (severity of issue likely to increase with scale of increase)

1. Water conflicts expected to increase between agricultural users, downstream consumers and other water users (e.g. hydro-electric generation), including conflicts between livestock and crop production needs
2. There would be increased need for robust cross-sectoral planning and regulation for land and resources (e.g. water, energy, mining/minerals, forests/biodiversity etc.)
3. There would be increased demand on extension services linked to irrigation / crop changes
4. There is potential for inequality to rise, as upscaling of irrigation technologies does not reach all households and/or households cannot access or afford them.

7g TNT

IS Applicable to all Scenario Quadrants (except for each Trade optimisation scenario):

1.Hunger/food insecurity would lead to increased reliance on food aid and imports
2.Acute and chronic undernutrition would lead to detrimental health impacts, particularly for children and mothers and already-vulnerable populations
3.There would be declines in labour productivity, due to hunger/ill-health
4.Rise in food prices will likely lead to inequitable food access, with the poorest becoming increasingly vulnerable to food insecurity/ hunger/ undernutrition
5. Inequalities would be exacerbated owing to gender differentiated care roles

IS Applicable across the Scenario Quadrants for Trade optimisation scenario:

1.1.If food is affordable, accessible and nutritionally adequate, then there should be a healthy population.
2.If food is not affordable nor accessible, then only the wealthiest will benefit and marginalised populations will not achieve food or nutrition security

4h Yield Shocks

Low Climate / High market efficacy (HT)

1.There would be increased demand on extension services (e.g. agricultural and climate).
2.There is potential for inequality to rise, as upscaling of agricultural technologies (seeds varieties and irrigation) does not reach all households or households cannot afford to purchase technologies

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About the Agricultural and Food-system Resilience: Increasing Capacity and Advising Policy (AFRICAP) Programme
The Agricultural and Food-system Resilience: Increasing Capacity and Advising Policy (AFRICAP) programme is a four-year research programme focused on improving evidence-based policy making to develop sustainable, productive, agricultural systems, resilient to climate change. The programme is being implemented in Malawi, South Africa, Tanzania, Zambia, and the UK led by the University of Leeds, in partnership with the Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN), a pan-African multi-stakeholder policy network. The programme is funded by the UK Government from the Global Challenges Research Fund (GCRF), which aims to support research that addresses critical problems in developing countries across the world. It is administered by the UK's Biotechnology and Biological Sciences Research Council (BBSRC) - UK Research and Innovation (UKRI).

Implementing Partners: FANRPAN; University of Leeds; University of Aberdeen; the UK Met Office; Chatham House - Royal Institute of International Affairs; the Civil Society Agriculture Network (CISANET), Malawi; Department of Agriculture Research Services (DARS), Malawi; National Agricultural Marketing Council (NAMC), South Africa; Economic and Social Research Foundation (ESRF), Tanzania; and the Agricultural Consultative Forum (ACF), Zambia.

For More Information
Website: https://africap.info/Twitter: @gcrfafricapEmail: contact@africap.info