IFEED Implication Statements for Irrigation and Water Use

1-Malawi

A- Low climate risk (rcp2.6), ineffective agricultural policy (LT)

This scenario is characterised by no changes to the agricultural land use pattern. No increase to irrigation areas is assumed. Crop diversity remains unchanged in this scenario, meaning that maize is still the crop associated with the largest growing area. No technology trend on crop yields is assumed – i.e., yield change (and production) is driven by climate change only. This scenario is also associated with a -1% decrease in crop production. The mean percentage change in irrigation water use for this scenario is a 13% (range across models -20% to 33%; 1/18 climate models are outliers). This becomes mean 15%, range -17% to 33% after removing the lower limit outliers.

Implications

- Adaptation to climate change is not sufficient and does not keep pace with projected changes in the climate, leading to a decline in crop production. A 13% increase in irrigation water use appears to be insufficient to offset the impacts of climate change on crop production.
- Increasing irrigation water use coinciding with no increase in land under irrigation could entail both the increase in irrigation water demand per unit area, possibly due to climate change, as well as irrigation systems becoming less efficient. Policy directions would have to explore options for achieving irrigation targets more efficiently in a changing climate.
- Increasing demand for irrigation water per unit area may translate to growing pressure on water resources & energy production. Without new developments/policies/technologies to improve the efficiency of irrigation systems, vulnerabilities may arise which could lead to unhealthy competitions between water users across different sectors and geographical boundaries. For example, since 2015 a multi-year dry period (including the 2015/16 El Niño event) has already led to prolonged low lake levels and reduced outflows, causing socio-economic disruption through impacts on hydropower energy generation (which supplies 94% of national on-grid energy) leading to frequent load-shedding across the country (Conway et al., 2017).
- Inadequate adaptation and inefficient irrigation systems should provide a basis for policy and adaptation decision making which includes exploring the possibility of irrigation to offset some of the climate related crop production challenges.
- Agricultural system failure may provide a basis for future investment that could lean towards options for expanding irrigation areas. Development of rainfed systems and improved efficacy of existing irrigation systems could be a focal point for agricultural development before options for expansion are explored.
- Apparent uncertainty in model projections of future changes in irrigation water use as indicated by apparent differences in the direction and magnitude of projections (-20 – 33%). Planning would have to account for this.

B- High climate risk (rcp8.5), ineffective agricultural policies (LT)

This scenario is characterised by a 10% reduction in all arable and livestock pasture areas. Irrigation areas are reduced by 10%, along with all other agricultural lands. This scenario is associated with a -14% decrease in crop production. The mean percentage change in irrigation water use for this scenario is 5% (range across climate models -17 to 38%; 0/18 climate models is outliers).

Implications

- Policy decisions and (low) technological innovation do not keep pace with changes in climate which account for a -14% change in yields under this scenario. The potential for irrigation to offset some of the challenges associated with food production is not realised (assuming that there would be a share of water resources enough to sustainably meet irrigation targets). Adaptive measures in place do not completely offset climate related challenges to food production as such agricultural policies would have to explore more (suites of) adaptation options along with the extent to which irrigation would potentially help enhance adaptation.
- A decrease in land under irrigation coinciding with a slight increase in irrigation water use could potentially imply declining efficiency in irrigation systems. This would necessitate the need for making irrigation more climate smart such that irrigation targets are achieved with an optimal use of water resources which may themselves be under threat due to climate change among other stressors.
- As the outcome of this scenario could prompt a shift in policy and agricultural development narratives, research emphasis would have to be placed on avenues for sustainably pursuing irrigation-focused crop production.
- Apparent uncertainty in model projections of future changes in irrigation water use as indicated by apparent differences in the direction and magnitude of projections (-17 – 38%). Planning would have to account for this and significant impacts would also be felt on hydropower energy provision.

C- Low climate risk (rcp2.6), effective agricultural policy (HT)

This scenario is characterised by a large increase in arable and pasture areas – using up any areas that are not forested, designated as protected or urban land. This amounts to a 57% increase in both arable crop land and livestock pastureland. All arable crop areas are irrigated to a small extent in future. This scenario is also associated with 728% increase in crop production (the mean percentage change in irrigation water use for this scenario is 1136%. Range across climate models 756 to 1506%; 0/18 climate models are outliers).

Implications for irrigation water use

- Agricultural policy with emphasis on irrigation will enhance adaptation to climate change, with a notable impact on the change in irrigation water use.
    - For context, the irrigation water use by the end of 2012 was 934 M m^3 (million cubic meters) per year. The irrigation master plan projects that, by the end of 2035, irrigation water use will have reached 2,272 M m^3 per year. This follows an increase from 104,000 hectares of land under irrigation in 2012 to 220,000 hectares in 2035.
- A 1136% increase in irrigation water use may however imply that significant pressure is put on water resources. [the assumption is, in this instance, that water resources are going to be available to meet that demand but future climate change could actually limit the availability of water resources for Agriculture and other sectors in Malawi (see (Bhave et al., 2020; Conway et al., 2017) for example in relation to Water – Energy – Food nexus issues).
- Key trade-offs would have to be employed to meet the increase in demand for water for irrigation under this scenario. Water resource availability would be a key constraint towards achieving irrigation targets and accounting for this would help decision makers aim for more realistic policy targets.
- The key role irrigation plays in meeting food production targets under this scenario demands investment towards climate smart irrigation technologies as well as efforts to make rainfed agricultural systems more efficient and resilient to offset some of the pressure on irrigation and associated water resources.

- Current and projected developments in agriculture sit in this trajectory with the expectation that land under irrigation will increase with a consequent increase in irrigation water use. This could potentially offset some of the challenges associated future climate change on crop production but the extent to which such systems are themselves susceptible to future climate change remain largely unknown.

- Increase in irrigation water could also be associated with diminishing water quality caused by the increase in the use of chemicals (pesticides and inorganic fertilizers) which may lead to pollution of water bodies downstream of irrigation schemes [*see calibrated statements on pests for reference*].

- Apparent uncertainty in model projections of future changes in irrigation water use as indicated by apparent differences in the magnitude of projections (756 – 1506%). Plans based on project may have to reflect this and cross-sectoral planning (that is currently lacking as detailed in England et al., 2018) would need to be instigated.

D- high climate risk effective agricultural policy (high technology)

This scenario is characterised by a large increase in arable and pasture areas – using up any areas that are not forested, designated as protected or urban land. This amounts to a 58% increase in both arable crop land and livestock pastureland. Irrigation areas have expanded to include all arable crop areas. This scenario is also associated with a 719% increase in crop production. The mean percentage change in irrigation water use for this scenario is 1130% (range across climate models 817 to 1668%; 1/18 climate models are outliers). This becomes mean 1098%, range 817 to 1584% after removing the upper limit outliers.

Implications for irrigation water use

- Agricultural policy with emphasis on irrigation will enhance adaptation to climate change, with a notable impact on the change in irrigation water use.
- A 1130% increase in irrigation water use may however imply that significant pressure is put on water resources. [the assumption is, in this instance, that water resources are going to be available to meet that demand but future climate change could actually limit the availability of water resources for Agriculture and other sectors in Malawi (see (Bhave et al., 2020; Conway et al., 2017), notably energy production for example).
- Key trade-offs would have to be employed to meet the increase in demand for water for irrigation under this scenario. Water resource availability would be a key constraint towards achieving irrigation targets and accounting for this would help decision makers aim for more realistic policy targets.
- The key role irrigation plays in meeting food production targets under this scenario demands investment towards climate smart irrigation technologies as well as efforts to make rainfed agricultural systems more efficient and resilient to offset some of the pressure on irrigation and associated water resources.
- Current and projected developments in agriculture sit in this trajectory with the expectation that land under irrigation will increase with a consequent increase in irrigation water use. This could potentially offset some of the challenges associated future climate change on crop production but the extent to which such systems are themselves susceptible to future climate change remain largely unknown.
- Increase in irrigation water could also be associated with diminishing water quality caused by the increase in the use of chemicals (pesticides and inorganic fertilizers) which may lead to pollution of water bodies downstream of irrigation schemes.

- Apparent uncertainty in model projections of future changes in irrigation water use as indicated by apparent differences in the magnitude of projections (817–

1668%). Plans based on such projections would have to reflect this and cross-sectoral water resource planning will be vital.

2 - Tanzania

A- Low climate risk, low technology

This scenario is characterised by increases to agricultural land, using up all areas that are not forested, designated as protected or urban land. This amounts to a 58% increase of arable crop land and livestock pasture. No increase to irrigation areas is simulated however – i.e., irrigation areas remain the same as the baseline. This scenario is also associated with a mean 65% increase in crop production. This scenario is associated with a mean percentage change to irrigation water of 30% (range across climate models -1 to 73%; 1/18 climate models are outliers). This becomes mean 27%, range -1 to 68% after removing the upper limit outliers.

Implications for Irrigation Water Use

- Increasing irrigation water use coinciding with no increase in land under irrigation could entail both the increase in irrigation water demand per unit area, possibly due to climate change, as well as irrigation systems becoming less efficient. Policy directions would have to explore options for achieving irrigation targets more efficiently in a changing climate.
- Increasing demand for irrigation water per unit area may translate to growing pressure on water resources. Without the necessary developments/policies/technologies to improve the efficiency of irrigation systems, new vulnerabilities may arise which could lead to unhealthy competitions between water users across different sectors and geographical boundaries.
- Development of rainfed agricultural systems has the potential to improve efficiency and resilience of production systems to climate change. Improved efficiency in irrigation systems could also translate to enhanced productivity for irrigation systems and necessitate optimisation of the rainfed-irrigate system combination for improved production and water use efficiency.

B- High climate risk, low technology

This scenario is characterised by increases to agricultural land, using up all areas that are not forested, designated as protected or urban land. This amounts to a 58% increase of arable crop land and livestock pasture. All arable areas become rainfed in 2050 in this scenario. This scenario is also associated with a 38% increase in crop production. The mean percentage change to irrigation water for this scenario is -100% (range across climate models -100 to -100%; 0/18 climate models are outliers).

Implications for Irrigation Water Use

- Future climate allows for conversion of farming systems to being entirely rainfed without reducing crop production. While 'benefits' of irrigation are forgone in this scenario, the realisation of positive changes in crop production indicates the potential that rainfed systems have to sustain crop production. Nonetheless, irrigation benefits realised in other scenario highlight the disparity between the two systems and present possible optimal rainfed-irrigation combinations that may translate to increased crop production while conserving water resources and sustainable meeting water use requirements in other sectors.
- The distinction between rcp8.5 -high tech vs rcp8.5-low tech indicates the potential that technology must improve crop production and meet rising demand for food and raw materials while providing a platform for agricultural commercialisation. However, whole these gains are apparent, any future policy shifts translating to high level of technology would have to be cautious of the implications for increasing irrigation water use under this climate 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 the high climate risk under this scenario.
- Increased production despite turning all systems into rainfed may indicate that sufficient rainfall will be sustained (with indications for a wetter future in those instances). Where this is the case, rainwater harvesting, and other low-cost soil and water conservation methods may further enhance the efficiency of rainfed systems while providing scope for seasonal low cost irrigation.
- There is agreement in model projections with regards to the direction of change in the mean percentage irrigation water use. However, there is still considerable degree of uncertainty (as can be seen from the spread in the projected change: -100 – 100%) and policy decisions and investments would have to be responsive to that and cross-sectoral planning will be vital (Pardoe et al., 2018).

C- Low climate risk, high technology

This scenario is characterised by a large increase in arable and pasture areas – using up any areas that are not forested, designated as protected or urban land. This amounts to a 58% increase in both arable crop land and livestock pastureland. Irrigation areas have expanded to include all arable crop areas. This scenario is also associated with a 685% increase in crop production. The mean percentage change to irrigation water for this scenario is 607% (range across climate models 309 to 860%; 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. At the local scale, competing user needs may underline the need for effective trade-offs. [See for example, (Siderius et al., 2021)]
- Local scale differences in the geographical context may result in non-uniform change in the potential for irrigation in future climate prompting the need for exploration of several other sources of water as well as technologies including basin transfers and desalination.
    - Effectively, more water resources would have to be developed to meet irrigation water demand against a background of water use requirements in other sectors.
- Increasing irrigation water use
- Technological innovation would have to prioritise development of more efficient irrigation systems for sustainable irrigation development given the pre-existing high threat of climate change under rcp8.5.
- 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 the high climate risk under this scenario.
- Policy shifts towards increased irrigation arable land and irrigation expansion would have to be matched with increased research emphasis on making irrigation more sustainable and resilient.
- There is agreement in model projections with regards to the direction of change in the mean percentage irrigation water use. However, there is still considerable degree of uncertainty (as can be seen from the spread in the projected change: 309 – 860%) and policy decisions and investments would have to be responsive to that.

D- High climate risk, high technology

This scenario is characterised by a large increase in arable and pasture areas – using up any areas that are not forested, designated as protected or urban land. This amounts to a 58% increase in both arable crop land and a 29% increase in livestock pastureland. Irrigation areas have expanded to include all arable crop areas. This scenario is also associated with a

1676% increase in crop production. The mean percentage change to irrigation water for this scenario is 608% (range across climate models 358 to 787%; 0/18 climate models are outliers).

<u>Implications for Irrigation Water Use</u>

- 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. At the local scale, competing user needs may underline the need for effective trade-offs. [See for example, (Siderius et al., 2021)]
- Local scale differences in the geographical context may result in non-uniform change in the potential for irrigation in future climate prompting the need for exploration of several other sources of water as well as technologies including basin transfers and desalination.
    - Effectively, more water resources would have to be developed to meet irrigation water demand against a background of water use requirements in other sectors.
- Technological innovation would have to prioritise development of more efficient irrigation systems for sustainable irrigation development given the pre-existing high threat of climate change under rcp8.5.
- 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 the high climate risk under this scenario.
- 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 irrigation water use. However, there is still considerable degree of uncertainty (as can be seen from the spread in the projected change: 358 – 787%) and policy decisions and investments would have to be responsive to that.

3- Zambia

A- Low climate risk (rcp2.6), low technology (LT)

This scenario is characterised by no changes to the agricultural land use pattern. No increase to irrigation areas is assumed. This scenario is also associated with an 8% increase in crop production. The mean percentage change to irrigation water for this scenario is 40% (range across climate models 25 to 72%; 1/18 climate models are outliers). This becomes mean 38%, range 25 to 71% after removing the upper limit outliers.

<u>Implications</u>

- Sustaining irrigation (without increasing the irrigated areas) has the potential to offset some impacts of climate change on crop production.
- Maintaining current rates of irrigation has the potential to sustain water resource productivity while alleviating pressure (on) and depletion of water resources which could hinder development of other sectors.
- Technological innovation would have to prioritise development of more efficient irrigation systems for sustainable irrigation development to maintain relatively lower rates of change in the mean irrigation water use.
- Improved efficiency in rainfed agricultural systems would reduce the irrigation water demand per unit area and offset pressure on water for irrigation, while making food systems resilient.
- 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 and be aware of cross-sectoral linkages across the Water-Energy-Food Nexus (Pardoe et al., 2020).

B- High climate risk(rcp8.5), low market efficiency (LT)

This scenario is characterised by a 10% decrease in arable crop land and livestock pasture. Irrigation areas increase so that all arable areas are irrigated in 2050. This scenario is also associated with a -1% decrease in crop production. The mean percentage change to irrigation water for this scenario is 1959% (range across climate models 1360 to 2500%; 1/18 climate models are outliers). This becomes mean 1994%, range 1397 to 2500% after removing the lower limit outliers.

Implications for Irrigation Water Use

- Decrease in crop production possibly owing to the decrease in arable crop land, regardless of the increase in land under irrigation. The same climate scenario, but for the different socio-economic scenario is associated with an increase in crop production – linked to an increase in arable crop land. Diminishing crop production may translate into pressure to increase arable crop land and, consequently, land under irrigation.
- 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.
- Local scale differences in the geographical context may result in non-uniform change in the potential for irrigation in future climate prompting the need for exploration of several other sources of water as well as technologies including basin transfers. This could also provide clarity in terms of the areas that are more suitable for irrigation expansion.
    - Effectively, more water resources would have to be developed to meet irrigation water demand against a background of water use requirements in other sectors.
- Technological innovation would have to prioritise development of more efficient irrigation systems for sustainable irrigation development given the pre-existing high threat of climate change under rcp8.5.
- 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 the high climate risk under this scenario.
- 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 for irrigation water use. 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.

C- Low climate risk (rcp.26), high market efficiency (HT)

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.

D- High climate risk(rcp8.5), high market efficiency (HT)

This scenario is characterised by an increase of 5% in arable and livestock pasture areas. Irrigation areas have expanded to include all arable crop areas. This scenario is also associated with a 564% increase in crop production. The mean percentage change to irrigation water for this scenario is 2595% (range across climate models 1708 to 3159%; 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.
- Local scale differences in the geographical context may result in non-uniform change in the potential for irrigation in future climate prompting the need for exploration of several other sources of water as well as technologies including basin transfers.
    - Effectively, more water resources would have to be developed to meet irrigation water demand against a background of water use requirements in other sectors.
- Technological innovation would have to prioritise development of more efficient irrigation systems for sustainable irrigation development given the pre-existing high threat of climate change under rcp8.5.
- 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 the high climate risk under this scenario.
- 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.

4 – South Africa

A- Low climate risk, low land reform

This scenario is characterised by no changes to the arable crop land, but a 10% increase in livestock pasture area. No increase to irrigation areas is assumed. This scenario is also associated with a 117% increase in crop production. The mean percentage change to irrigation water for this scenario is 3% (range across climate models -2 to 10%; 0/18 climate models are outliers).

Implications

- Crop production increases despite no increase in land under irrigation. If sustained, and coupled with efficient and productive rainfed agricultural systems, irrigation has the potential to offset impacts of future climate change. Close to half of the irrigated land already falls in areas that receive less than 500 mm of rainfall annually hence irrigation is central to agricultural development in the country.
  - The land under irrigation across South Africa was 1.3 million hectares by 2010, with an estimate 56% of the 22 045 million m3 (total ground water + surface water) required to meet irrigation needs.
- Sustaining irrigation systems requires responding to changes in climate through improving efficiency of irrigation systems, to make the most of water resources which are already subject to pressure due to myriad of factors (historical, current and emerging).
- Managing and sustaining current irrigation levels could prove to be a challenge at the same time a vital part of the agricultural sector's sustainability in the face of climate change. Potential benefits-notable through increased production-incentivise conservation of water resources, more so as they become fragile due to climate change.
- Equal access to irrigation (through access to secure landholdings and access to water rights) would have to be prioritised in land and water reform processes to ensure that the need to maintain irrigation against possibly diminishing water resources does not result in (or worsen) marginalisation of smallholder/historically marginalised transfers.

B- High climate risk, low land reform

This scenario is characterised by a 10% increase in arable crop land, and a 10% decrease in livestock pasture area. Irrigation areas are increased, so all future arable crop areas are irrigated. This scenario is also associated with a 178% increase in crop production. The mean percentage change to irrigation water for this scenario is 84% (range across climate models 65 to 115%; 0/18 climate models are outliers).

Implications

- The potential for irrigation, to offset the impacts of climate change and improve crop production is realised. Irrigation expansion is in itself a product of land reforms given that secure landholding and water user rights are intertwined and, to an extent, present an opportunity for effective expansion of land under irrigation.
  - For context: By 2010, historically disadvantages only held 15% of water use licences meant for irrigation with the authorities in the water sector working towards increasing the number to 40%. See (Lahiff, 2009).
- Access to water rights for irrigation has the potential to improve crop production by smallholder farmers and translate to the wider increase in production food and raw materials. Yet it also enhances the competition in water use/demand across different sectors. See (Funke & Jacobs, 2011) – 95% of water is primarily used for irrigation by large-scale farmers such that new users would have to compete for available farmers with established commercial farmers. To even such inequalities from the past, water reallocation is prioritised. Such reallocation processes could thus mean taking up water available for use in other sectors.

C- Low climate risk, high land reform

This scenario is characterised by a 10% decrease to the arable crop land, but a 10% increase in livestock pasture area. No increase to irrigation areas is assumed. This scenario is also associated with a 101% increase in crop production. The mean percentage change to irrigation water for this scenario is -6% (range across climate models -10 to 0%; 0/18 climate models are outliers).

Implications

- Crop production increases despite a decrease in arable land and no increase in irrigated land. If sustained, and coupled with efficient and productive rainfed agricultural systems, irrigation has the potential to offset impacts of future climate change. However, as a good portion of the irrigated land already falls in dry areas, decreasing land under irrigation would have to be cautious of where such cuts are done.

- The effective reduction in water under irrigation may present an opportunity for saving water for use in other sectors, while maintaining an optimum level of increase in crop production (while forgoing the benefits of much higher magnitudes of increase in crop production in scenarios A and B). It is however important to note that such irrigation cuts should not translate into infringements of the water rights for smallholder and historically marginalised farmers whose access to irrigation is already limited.

D- High climate risk, high land reform

This scenario is characterised by a 10% fall in arable crop land, and a 15% fall in livestock pasture area. Irrigation areas are increased, so all future arable crop areas are irrigated. This scenario is associated with a 139% increase in crop production. The mean percentage change to irrigation water for this scenario is 67% (range across climate models 42 to 97%; 0/18 climate models are outliers).

Implications

- The potential for irrigation to offset the impacts of climate change and improve crop production is realised. Expanding irrigation to cover all arable land also appears to offset the impact of reducing arable land (or converting it to pastureland). While these gains are apparent even with the reduction of arable land, any land reforms exploiting such relationships would have to be cautious of the inequalities around access to land and water resources.
- Developing rainfed agricultural systems would help reduce pressure on irrigation and water resource which may be high at risk of becoming fragile in future climate.
- All scenarios are characterised by some degree of uncertainty of which decision processes may have to reflect to some extent.

Some Key Literature

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