Predicting the future prevalence of pests and diseases affecting major food Crops in Zambia

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Introduction

Pest and diseases are a major cause of yield losses with up to 40% of global crop yields being lost to the destruction caused by plant pests.

- Climate change is an important determinant of abundance and distribution of pests.
- Climate change affects the population, dynamics and status of insect pests through the influence of extreme weather conditions on the pest physiology and behaviour.
- This includes changes in phenology, distribution and community composition of ecosystems.
- For the pests to survive, they either adapt to new conditions or shift their distribution to more favourable areas
- This leads to an increase in diversity and abundance of these pests and the diseases they are vectors of.
- Species of pests that are situated in cool climates and those that grow during winter periods will be disadvantaged by global warming as cool areas become warmer, while those that are based in warmer climates will benefit as climates in higher altitudes become more conducive for their survival.
- Increase in temperatures will result into shortened life cycles of pests causing insect pests to be more abundant due to rapid population growth, therefore, becoming more destructive to crops.

Methodology

Crops selection

Stakeholder participation

Crops: Groundnut, Bean, Rice, Soybeans and Cowpeas

Pests and diseases selection

Selection was based on their occurrence and the impact on crop yields or the economy.

Desk review of existing literature

Best thriving environment

Ranges of environmental variables suitable for the growth and development of the selected pests from literature.

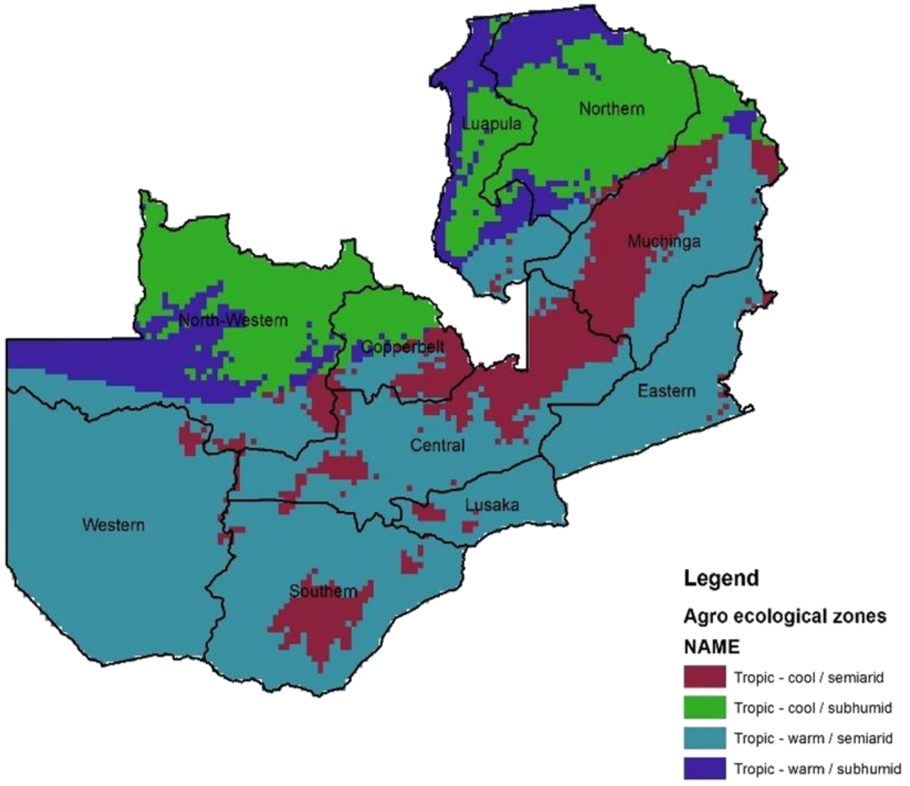
Pests and diseases for selected crops with their conducive environment for growth and development

Pest/disease	Scientific name	Temperature	Relative humidity
GROUNDNUTS			
Groundnut aphids	Aphis craccivora	24-28.5°C	65% - 86.5%
Early leaf spot	Cercospora arachidicola	25 to 30 °C	>75
Groundnut rosette	Groundnut rosette	24-28.5°C	65% - 86.5%
Pod borer,bollworm	Helicoverpa armigera	See Soybean	
Groundnut bruchid	Caryedon gonagra	23-35 °C	70 - 90%
BEAN			
Bean Anthracnose	Colletotrichum lindemuthianum	13-26°C	65%-96%
Bean rust	Uromyces appendiculatus	18–25 °C	>85%
Bean bruchids	Acanthoscelides obtectus	20–28 °C (Soares et al. 2015)	60-70%
Maruca pod borers	Maruca vitrata	See cowpea	
Aphids	Aphis fabae /Aphis craccivora	See groundnut	
RICE			
Rice blast	Pyricularia oryzae/ Magnaporthe grisea	25 - 28 ◦C	80% - 100%
African rice gall midge	Orseolia oryzivora	25˚C - 35˚C	>60%
Armyworms	Spodoptera frugiperda	26 ˚C - 30 ˚C	50% - 100%
SOYBEAN			
Frogeye leaf spot	Cercospora sojina	25-30°C	>90%
Red leaf blotch	Coniothyrium glycines	20 - 25˚C (Hartman and Sinclair 1992)	95% - 100%
Pod borer, bollworm	Helicoverpa armigera	25-30°C	>45%
COWPEA			
Leaf spots of cowpea	Mycosphaerella cruenta	25-30°C	70 – 92%
Cowpea aphid borne mosaic virus (CAMV)	Potyvirus	20-25 °C	>45%
Cowpea (weevil) seed beetles	Callosobruchus maculatus	17°C - 37°C	44 – 90%
Aphids	Aphis craccivora	See groundnut	
Maruca pod borer	Maruca vitrata	19.5-29.3°C	40-93%

Grouping of pests

- The pests and diseases were divided into two groups; those pests and diseases that thrive in cool temperatures of less than 25°C and those that thrive in warm temperatures of greater than 25°C.

Group	Temperature	Environment
A	13-25°C	Cool
B	25-30°C	Warm



Pests and disease suitability modelling

Targeting tools (https://targetingtools.ciat.cgiar.org/), the suitability tool

Modelling was done for the current climatic scenario and future climatic scenarios.

For periods 2030s and 2050s and for RCP2.6, RCP 4.5 and 8.5.

Group	Relative humidity	Temperature
A	45%-96%	13-25°C
B	40-100%	25-30°C

Modelling Data

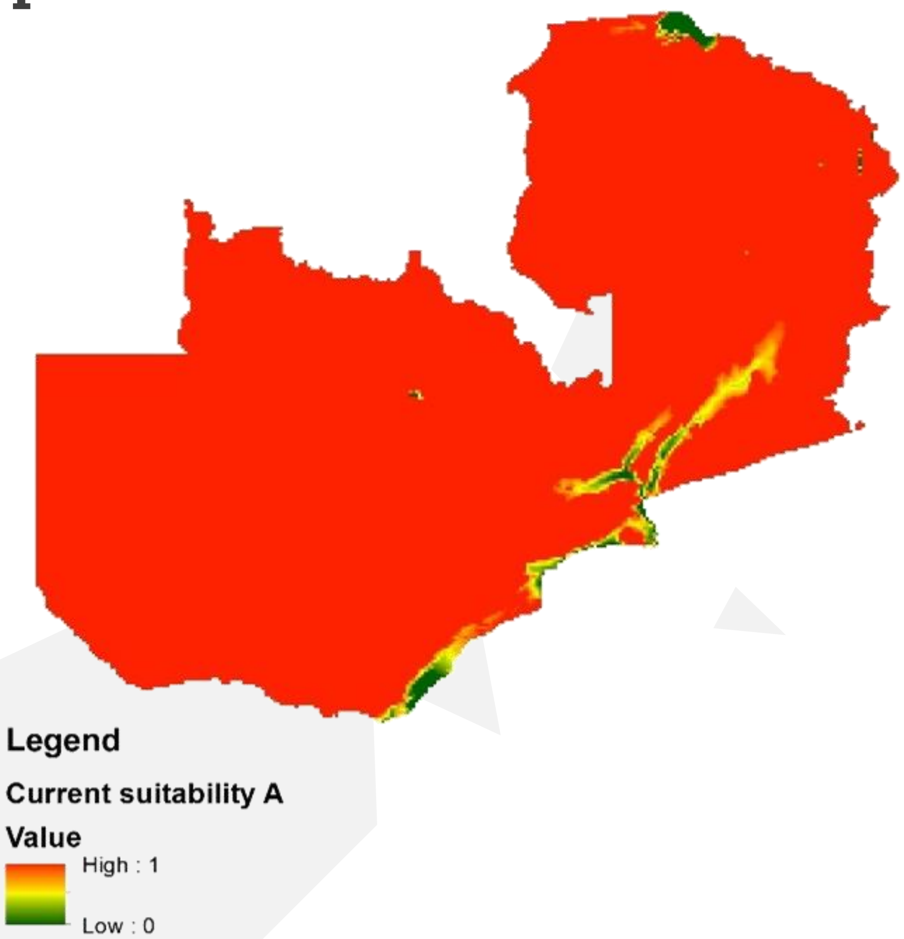
Temperature and relative humidity

- Temperature is important in the growth of pests and development of diseases as it influences the physiological processes of insect pests, encourages the development of crop diseases and is the driving force behind insect pest's development, growth and behaviour.
- Insects are poikilothermic ("cold-blooded"); and their body temperature varies with that of the environment.
- Rain, high relative humidity and high soil moisture favours the development of most plant diseases
- The severity of pathogens that infect aerial tissues is greatly promoted by rain and high humidity

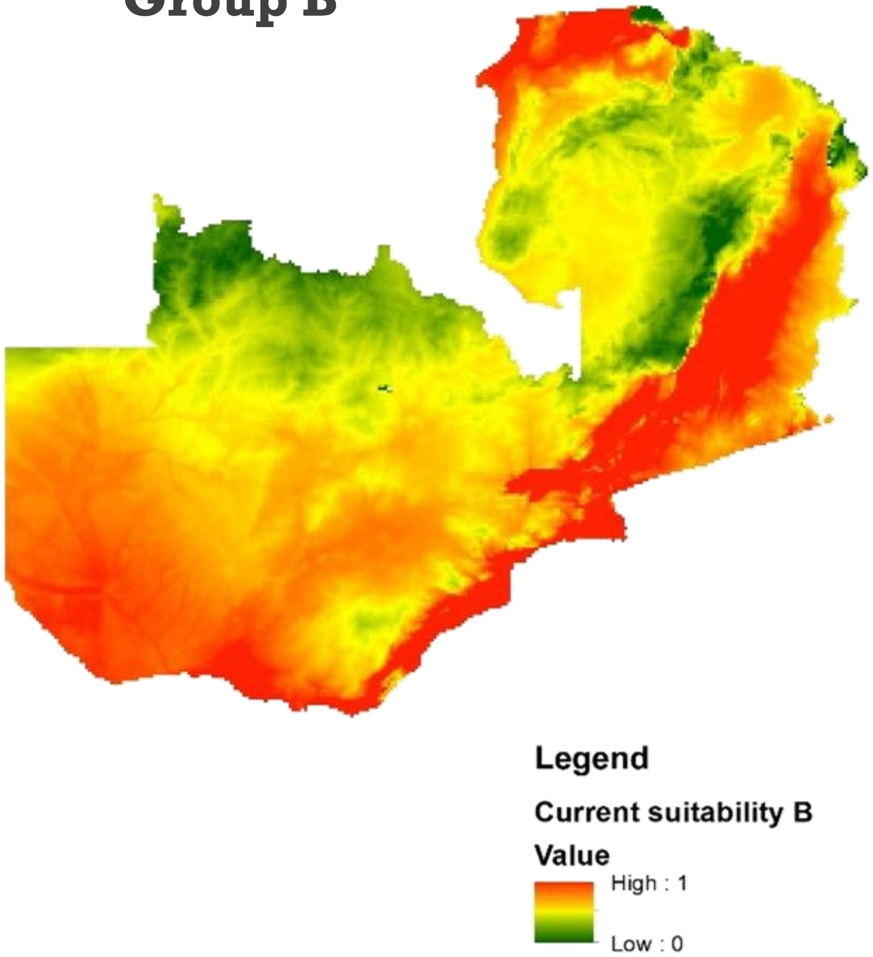
- Geospatial data was downloaded for both current and future scenarios. Current scenario data was obtained from Worldclim while future data was obtained from CCAFS climate portal. Relative humidity was calculated based on a method developed by the Numerical Terradynamic Simulation Group at the University of Montana

Results: Current suitability

Group A

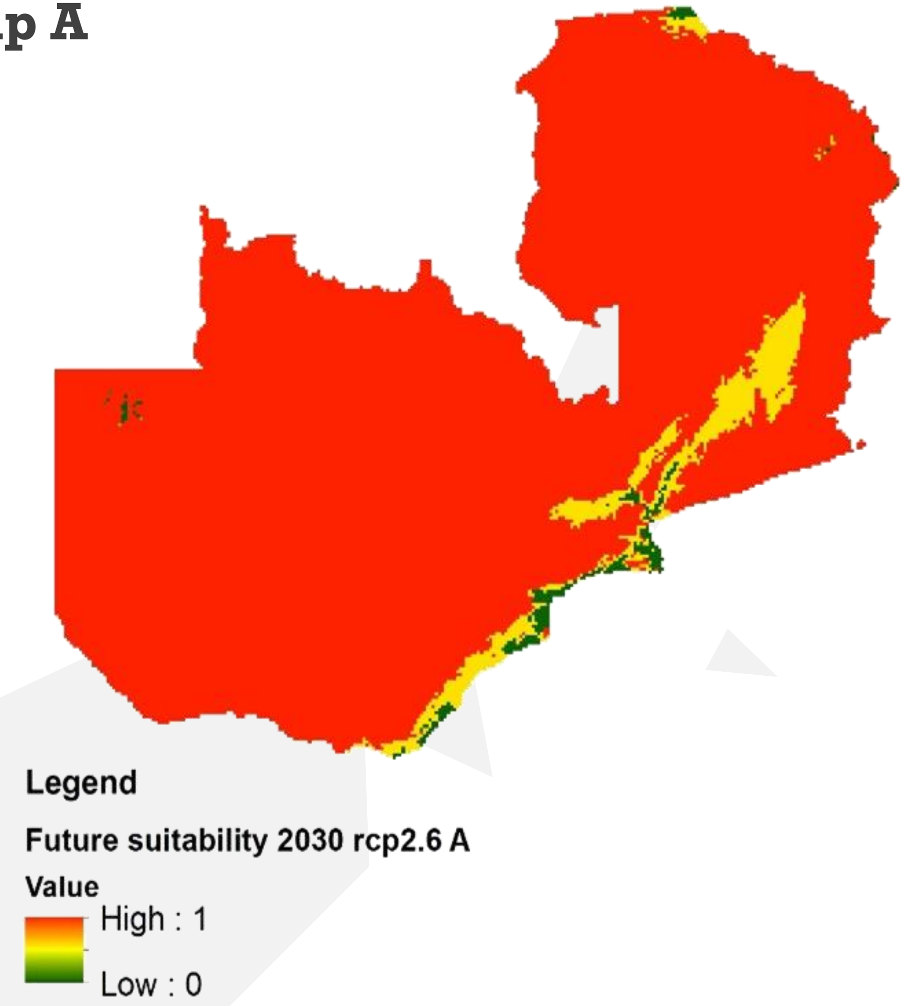


Group B

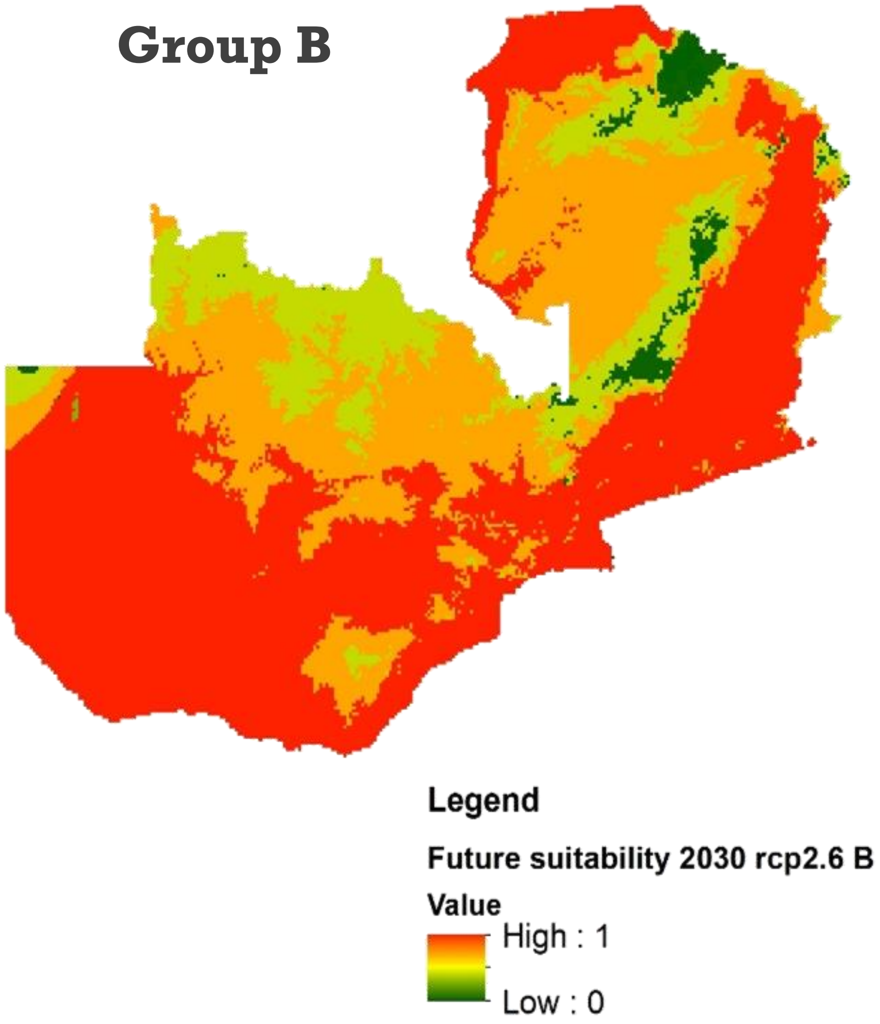


Results: Future suitability 2030 RCP 2.6

Group A

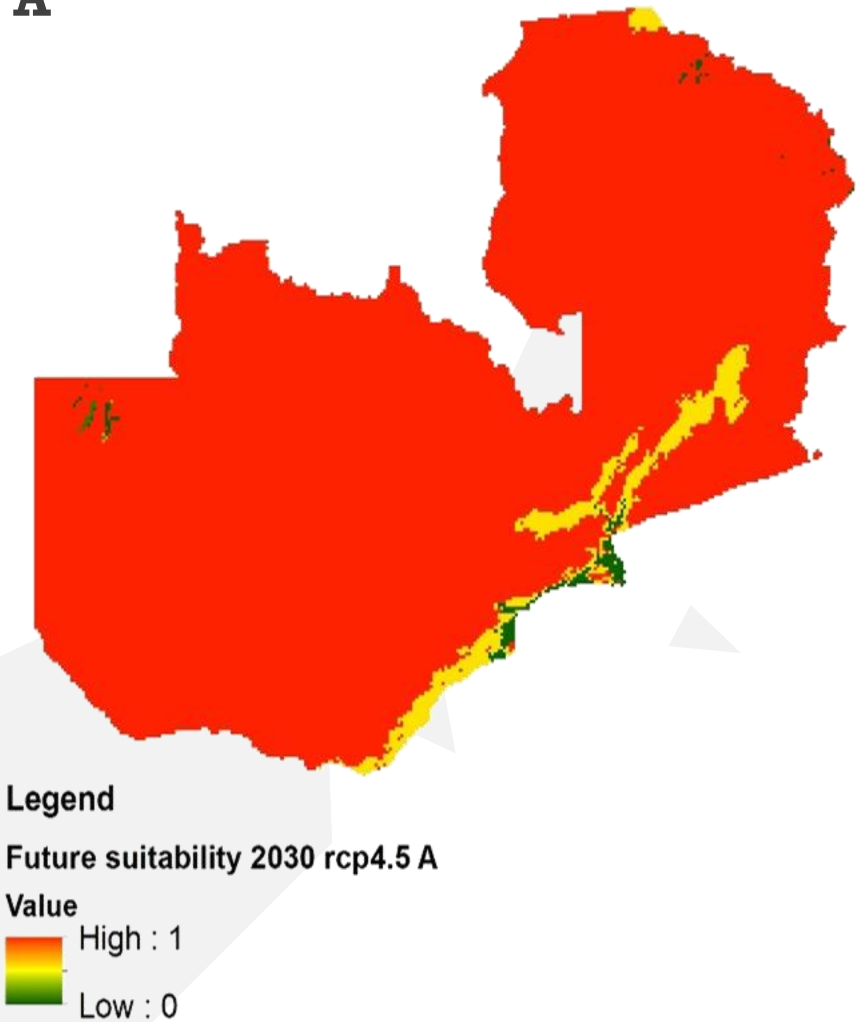


Group B

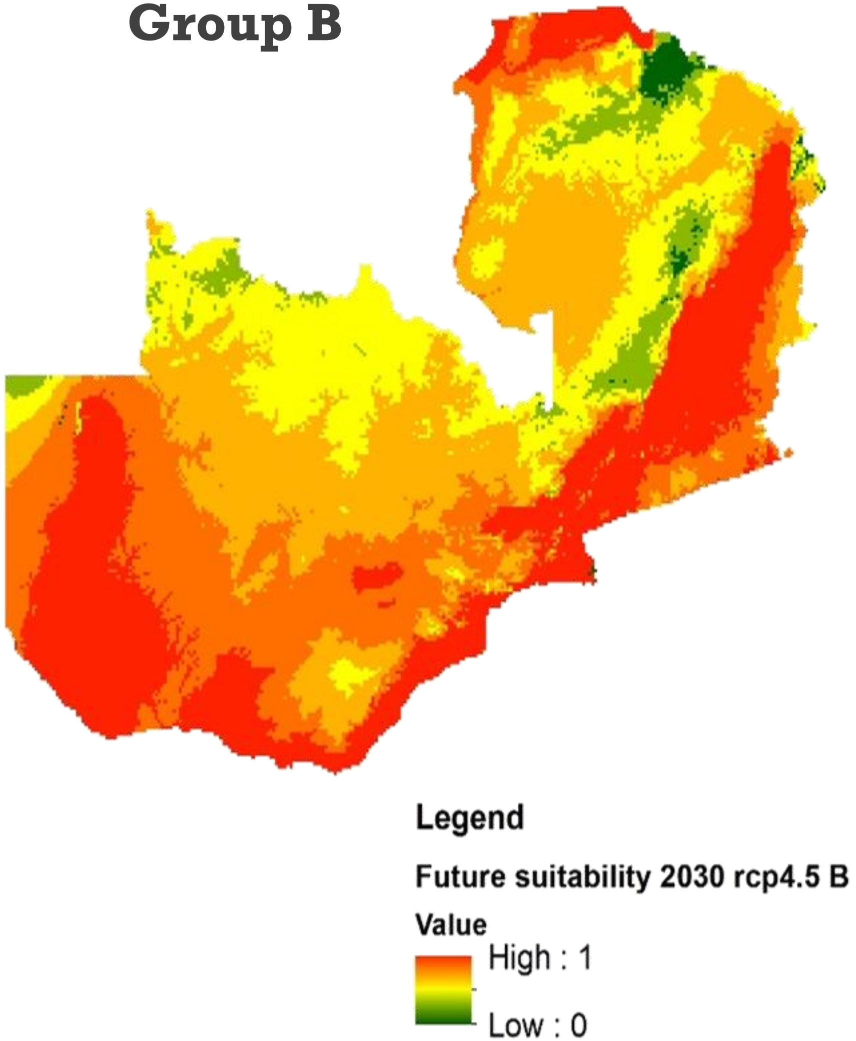


Results: Future suitability 2030 RCP 4.5

Group A

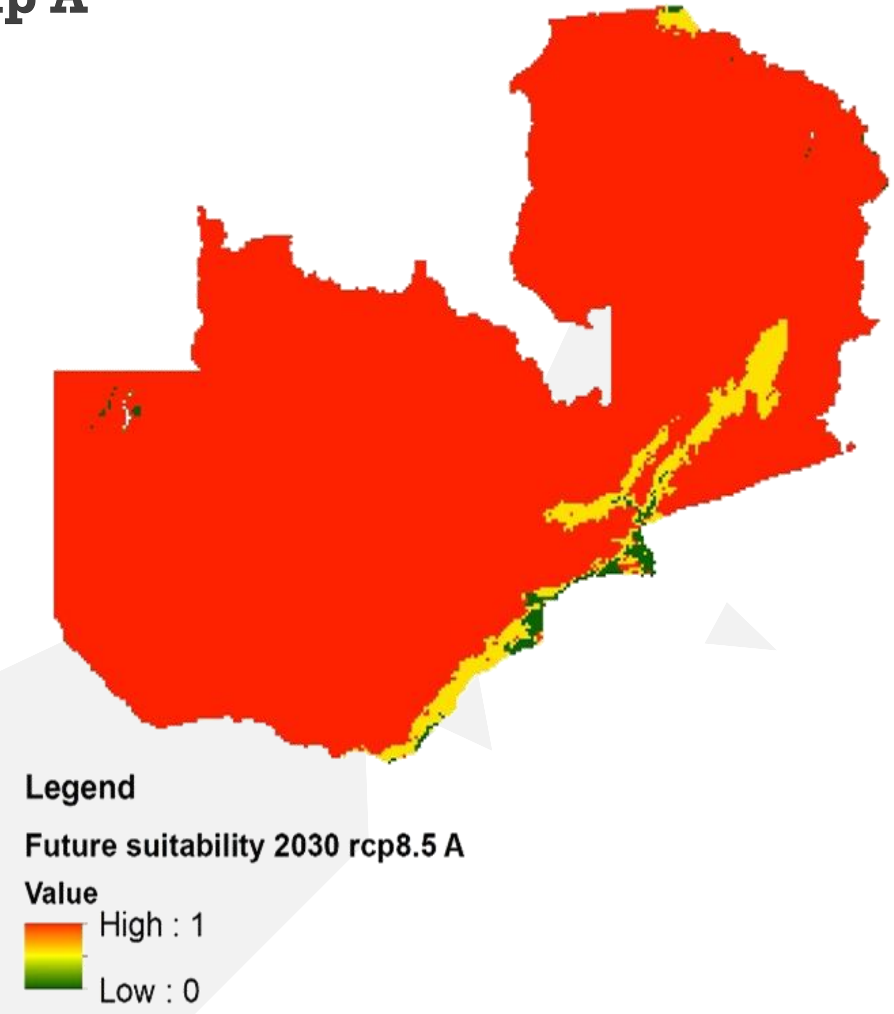


Group B



Results: Future suitability 2030 RCP 8.5

Group A



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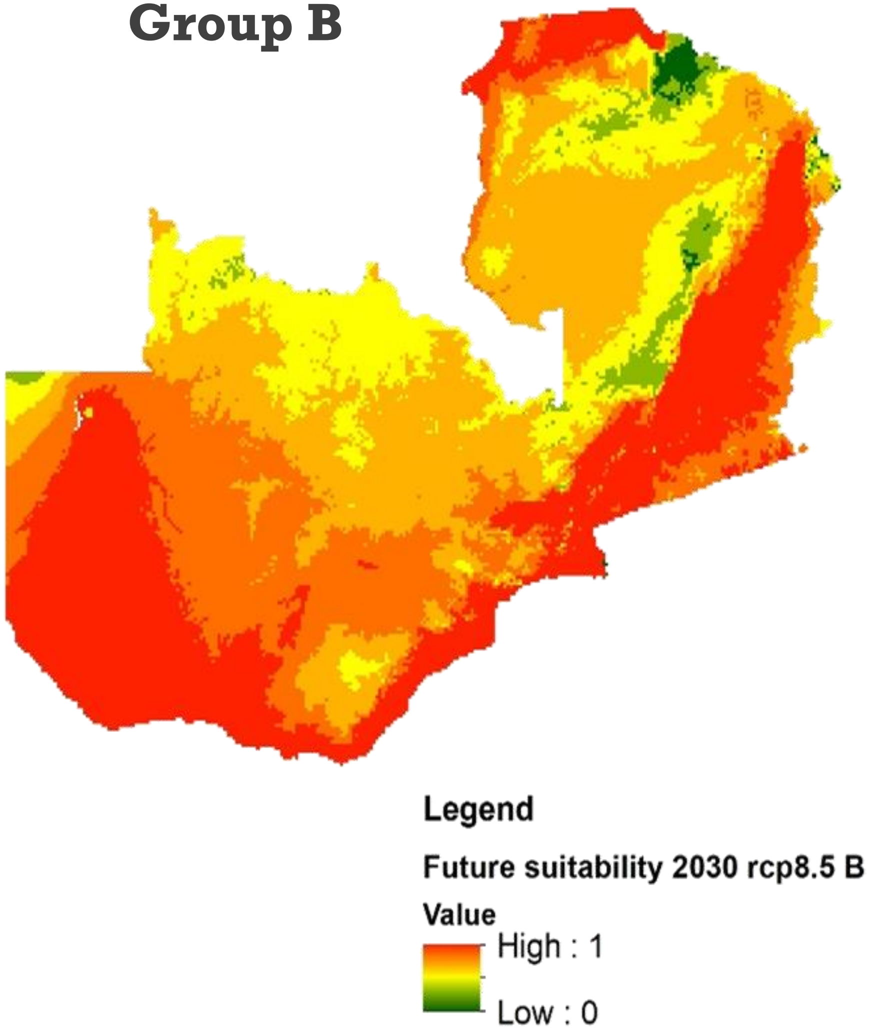
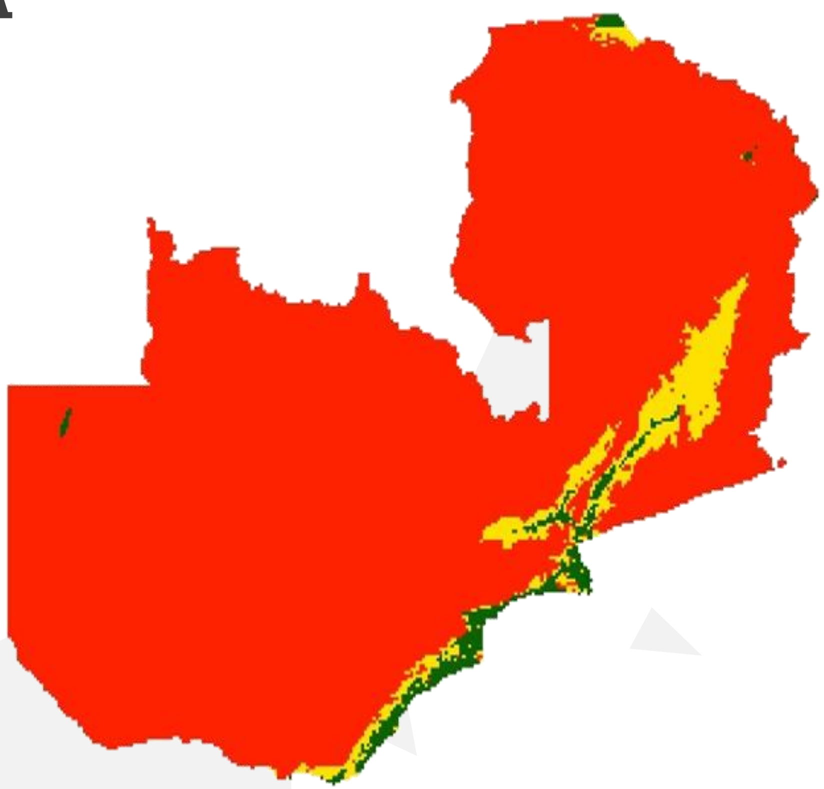


Results: Future suitability 2050 RCP 2.6

Group A



Legend

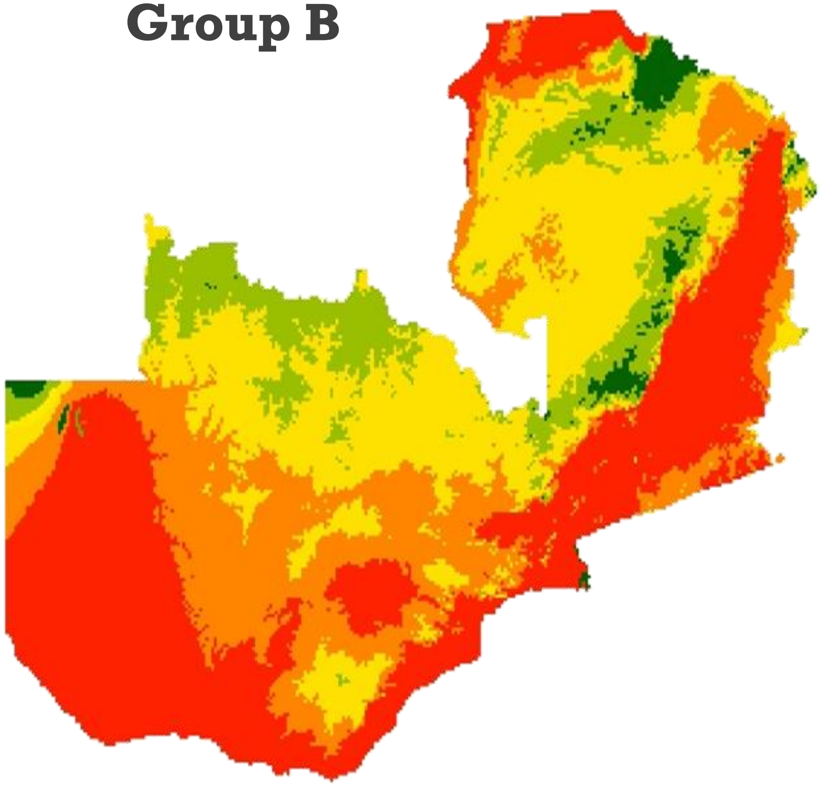
Future suitability 2050 rcp2.6 A

Value

High : 1

Low : 0

Group B



Legend

Future suitability 2050 rcp2.6 B

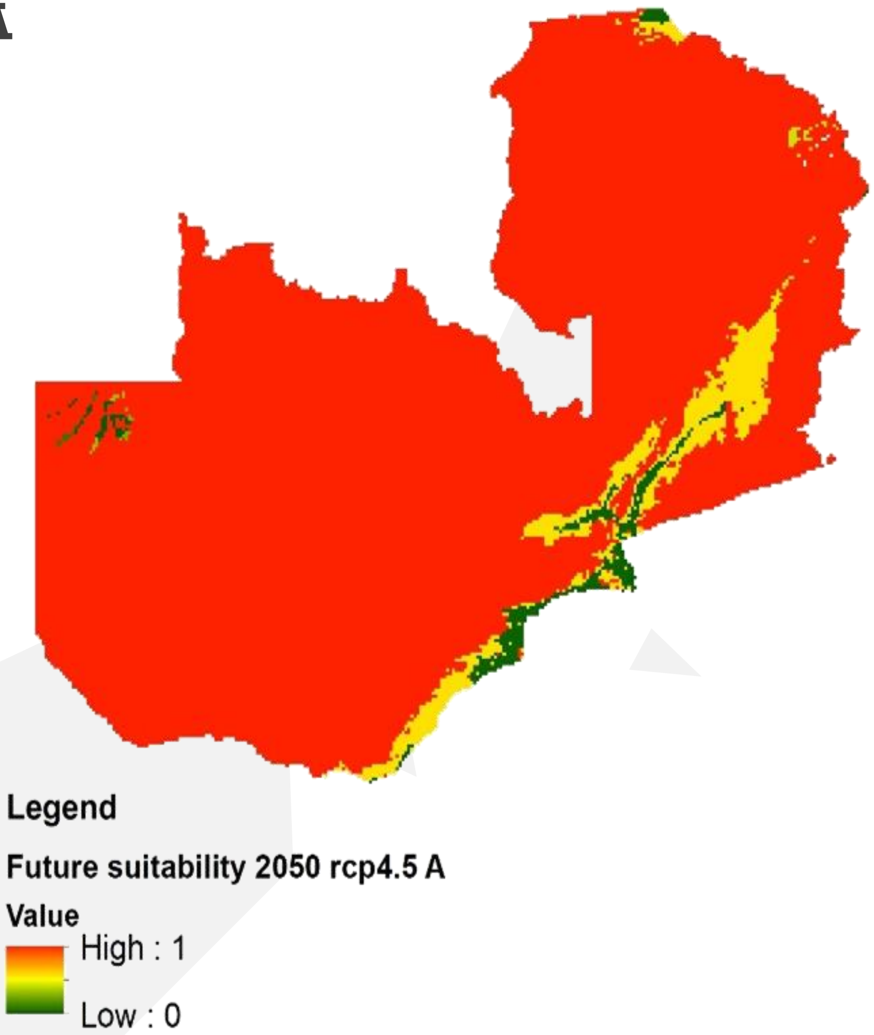
Value

High : 1

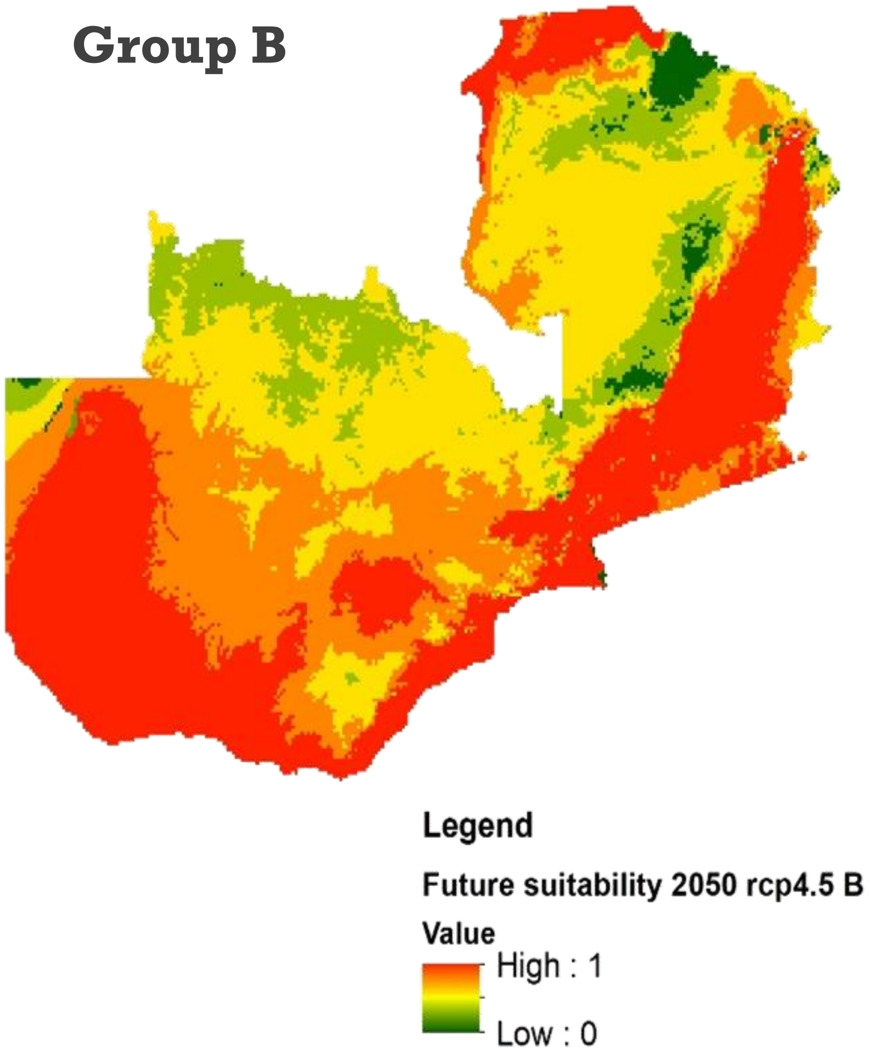
Low : 0

Results: Future suitability 2050 RCP 4.5

Group A

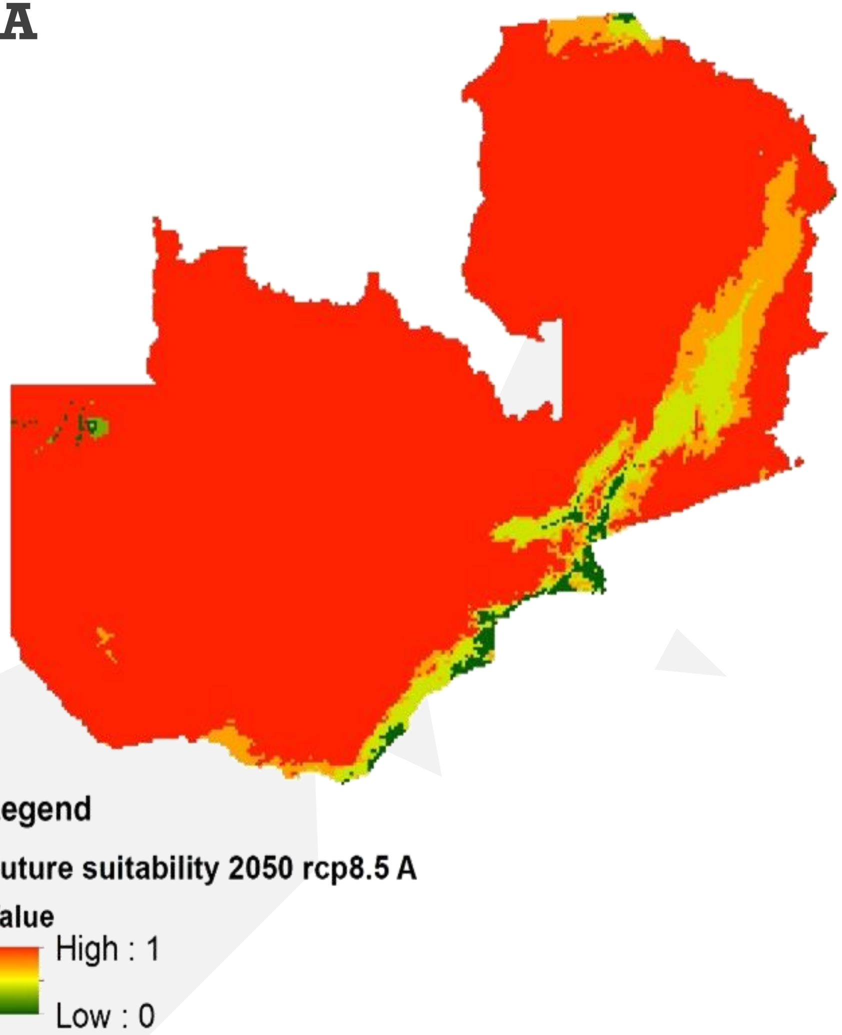


Group B

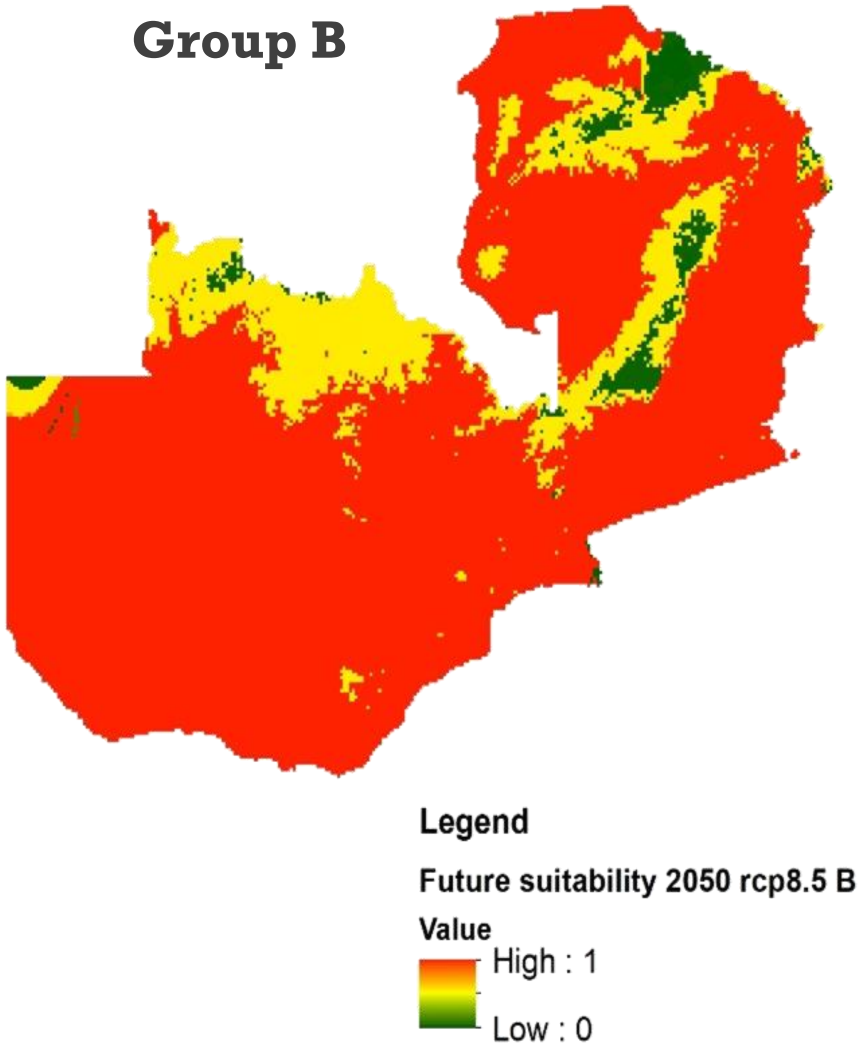


Results: Future suitability 2050 RCP 8.5

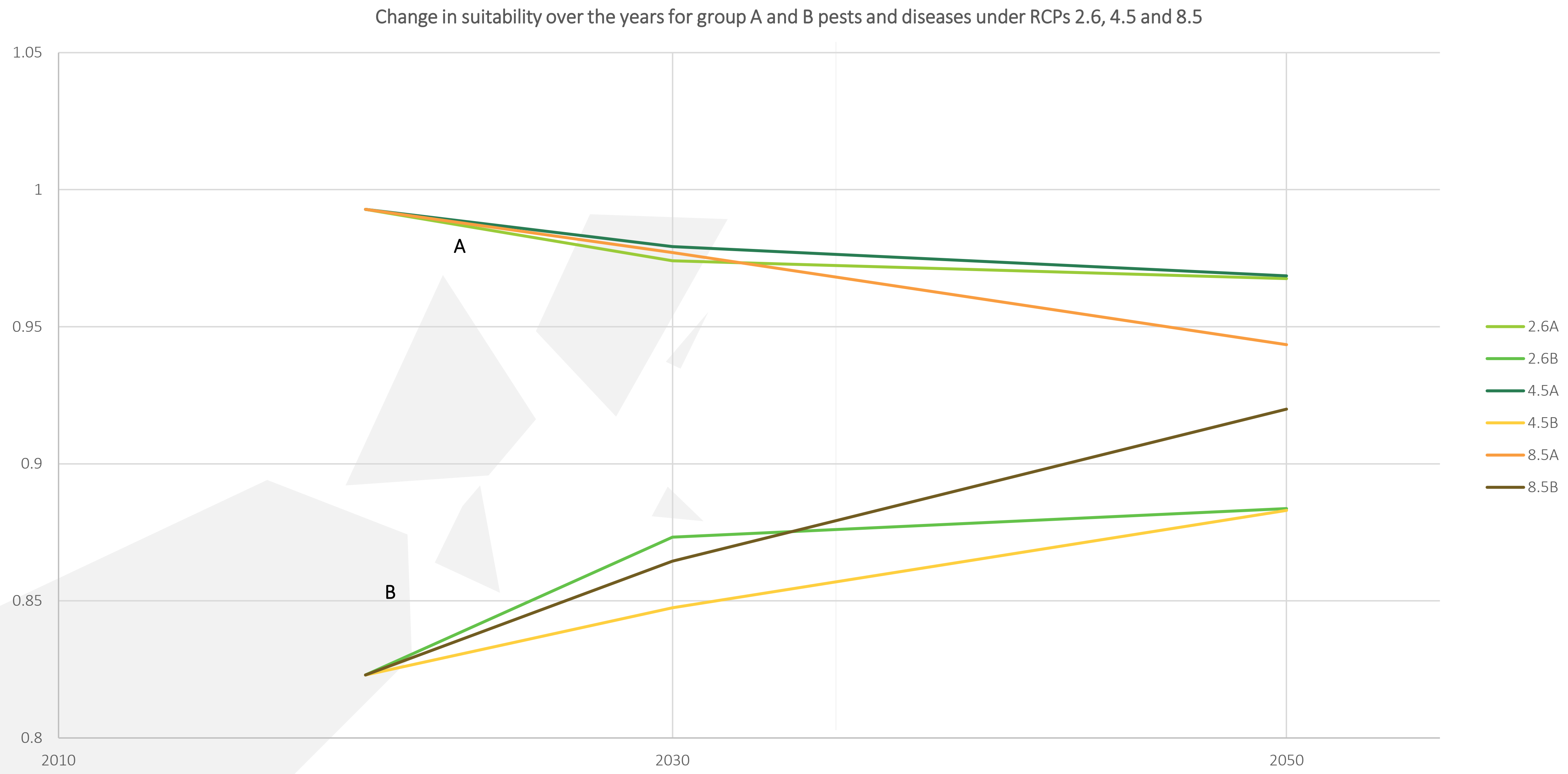
Group A



Group B



Summary



Change in suitability over the years for group A and B pests and diseases under RCPs 2.6, 4.5 and 8.5
1.05
1
0.95
0.9
0.85
0.8
2010
2030
2050
A
B
2.6A
2.6B
4.5A
4.5B
8.5A
8.5B

Conclusion

- Climate change will result in increased distribution of pests and diseases that thrive in warm environments in the period 2020 and 2039 as climatic conditions become more conducive for their growth and development.
- It will also result in the reduction of suitability of pests that thrive in cool climate and are currently spread in all areas of Zambia as the temperature increases.
- In 2050s however, and for RCP 2.6 and 4.5 in both groups, suitability of pests and diseases will decrease while it will increase in RCP8.5 in comparison to 2030s.
- RCP 2.6 and 4.5 reduction in suitability will be as a result of the interventions associated with reversing climate change while RCP 8.5 increase is as a result of adverse effects of climate change leading to the areas becoming more conducive for the growth of development of pests and diseases favoured by warm climate.
- General predictions show that increase in temperatures will lead to the species shifting their geographical ranges to a higher elevation where the species-specific climate requirements essential for their growth, survival and reproduction will be available.


Thank You
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