

# Global Forum on Biological Control and Training Workshop on Biological Control

Nairobi, Kenya 26-30 June 2023

## Establishment of sentinels, assess dispersal of parasitoids and model area of spread

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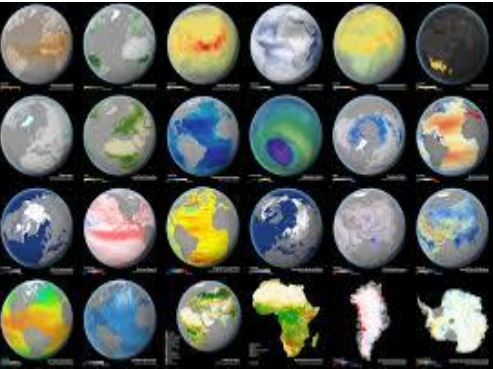
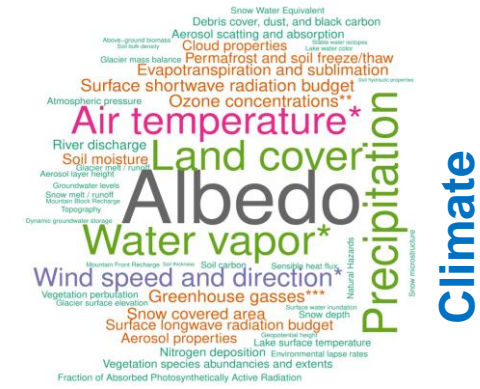
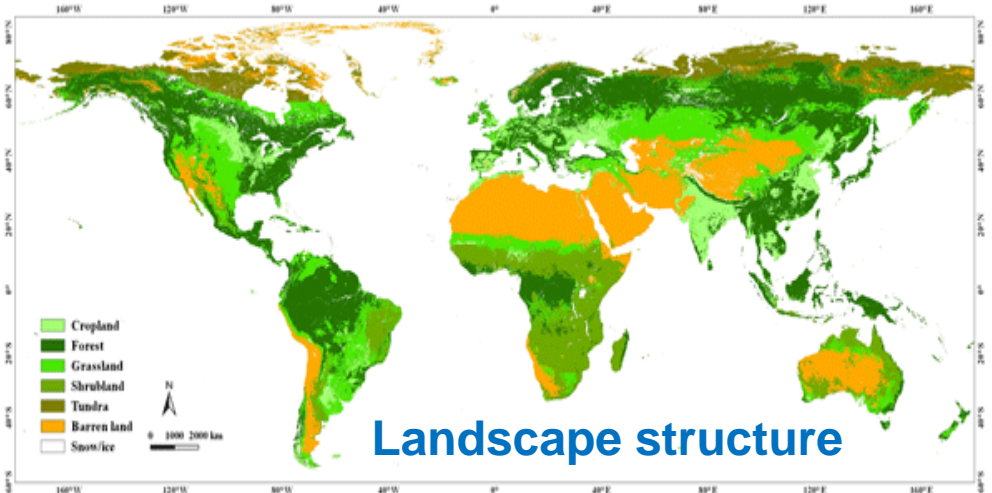
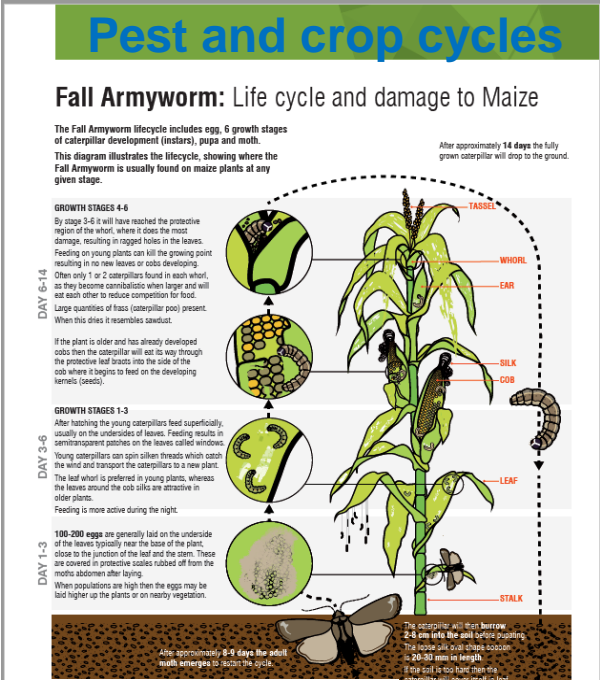
# Establishment of suitable sites



## ❖ Pest bio-ecology



Landscape



Space and time



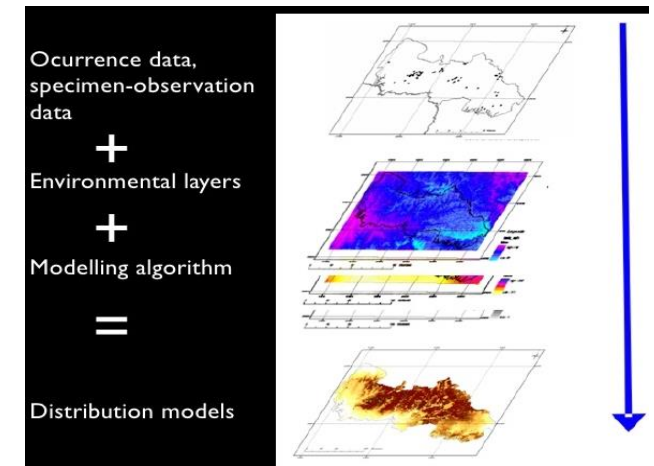
# Modelling scenarios



## I. Occurrence (presence) observations only



Species distribution models(SDM)  
Ecological niche models (ENM)

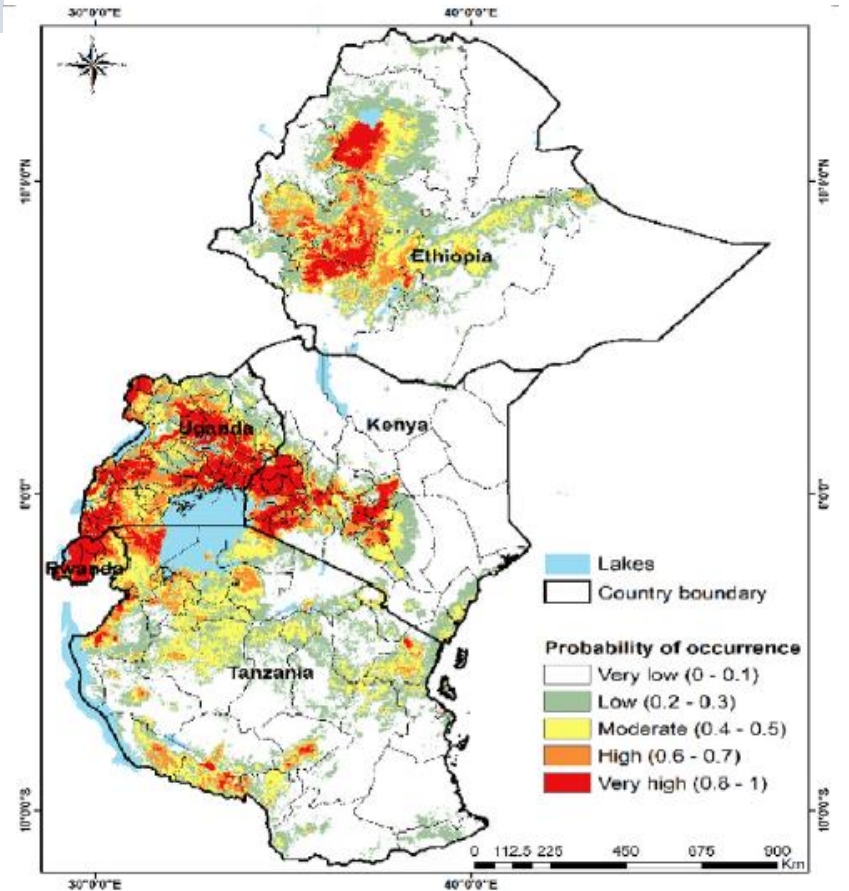
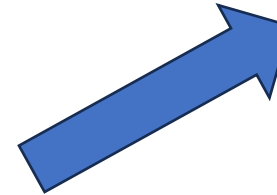
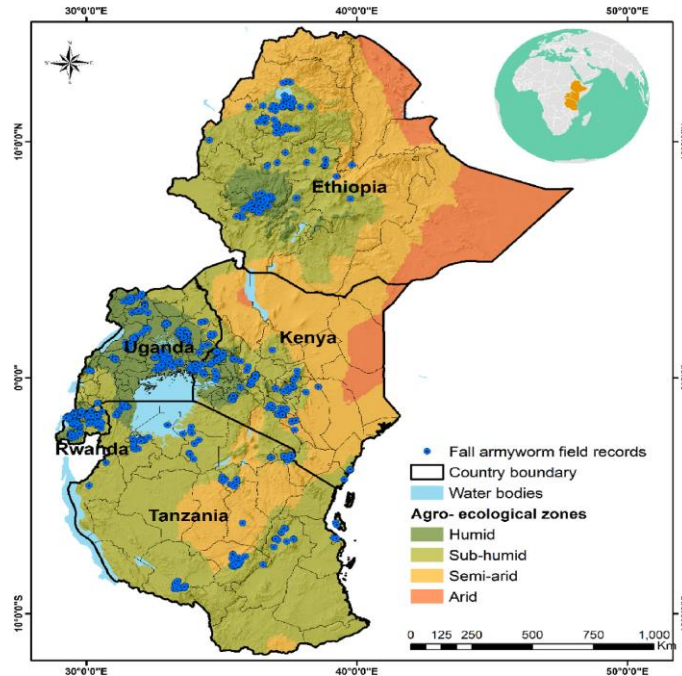


# Modelling scenario I



## Maximum Entropy (MaxEnt) and other machine learning algorithms

- SDMs provide a pathway that statistically links the **spatial variations** in the biotic and abiotic **variables** to the **distribution** of a particular **species**



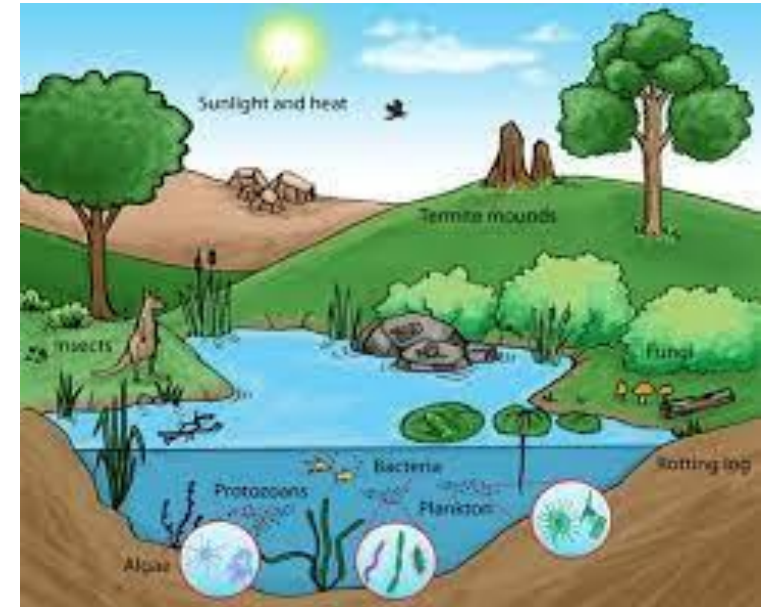


# Modelling scenarios



## Assumptions

- Environmental factors **drive species** distribution
- Species are in **equilibrium** with their environment
- **Limiting variables** – are they really limiting?
- Coincidence with climate or climate shift
- Evidence for **species dying**/not reproducing due to **climate**
- **Collinearity** of variables
- Static vs dynamic approaches: data snapshot or time series response?



# Modelling scenario I



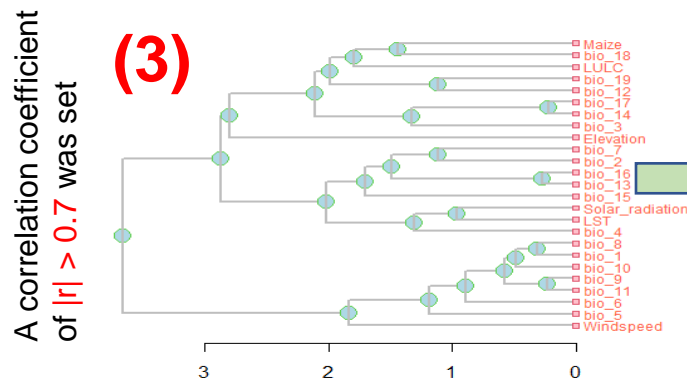
## (1) FAW/ parasitoid occurrence



## (2) Environmental, LULC and crop

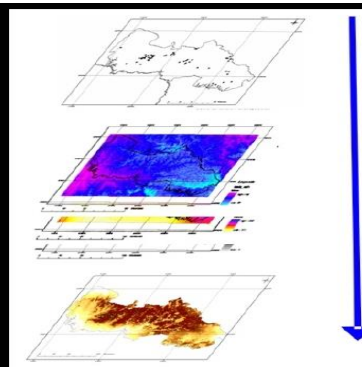
Variable	Description	Units
Bio1	Annual Mean Temperature	°C
Bio2	Mean Diurnal Range (Mean of monthly (max temp - min temp))	°C
Bio3	Isothermality (BIO2/BIO7) (×100)	-
Bio4	Temperature Seasonality (standard deviation ×100)	-
Bio5	Max Temperature of Warmest Month	°C
Bio6	Min Temperature of Coldest Month	°C
Bio7	Temperature Annual Range (BIO5-BIO6)	°C
Bio8	Mean Temperature of Wettest Quarter	°C
Bio9	Mean Temperature of Driest Quarter	°C
Bio10	Mean Temperature of Warmest Quarter	°C
Bio11	Mean Temperature of Coldest Quarter	°C
Bio12	Annual Precipitation	mm
Bio13	Precipitation of Wettest Month	mm
Bio14	Precipitation of Driest Month	mm
Bio15	Precipitation Seasonality (Coefficient of Variation)	-
Bio16	Precipitation of Wettest Quarter	mm
Bio17	Precipitation of Driest Quarter	mm
Bio18	Precipitation of Warmest Quarter	mm
Bio19	Precipitation of Coldest Quarter	mm
Land surface temperature	Surface Temperature and Emissivity	K
Landcover/Land use	Land cover classes in the area	-
Elevation	Terrain of the land surface	m

### Variable Correlation Clusters

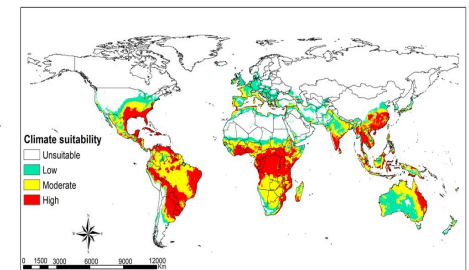


## (4)

Occurrence data,  
specimen-observation  
data  
+  
Environmental layers  
+  
Modelling algorithm  
=  
Distribution models



## (5)





# Modelling scenario I



## (1) FAW occurrence data

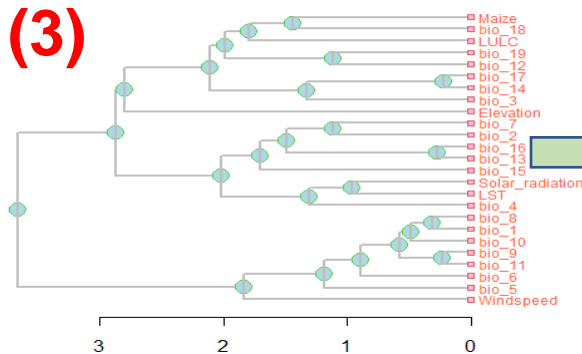


## (2) Environmental, LULC and crop

Variable	Description	Units
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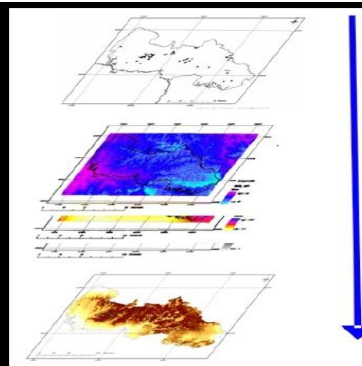
## Variable Correlation Clusters

A correlation coefficient of  $|r| > 0.7$  was set

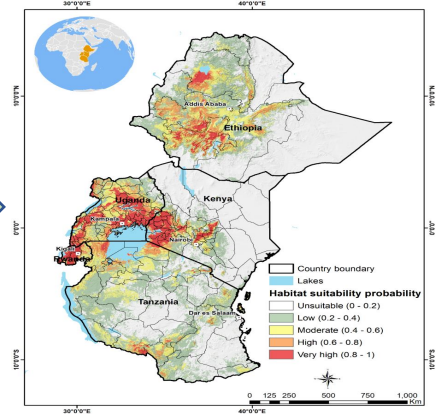


## (4)

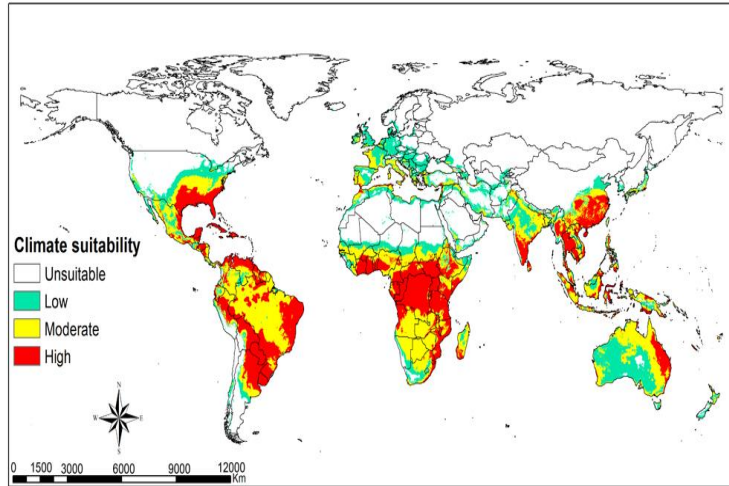
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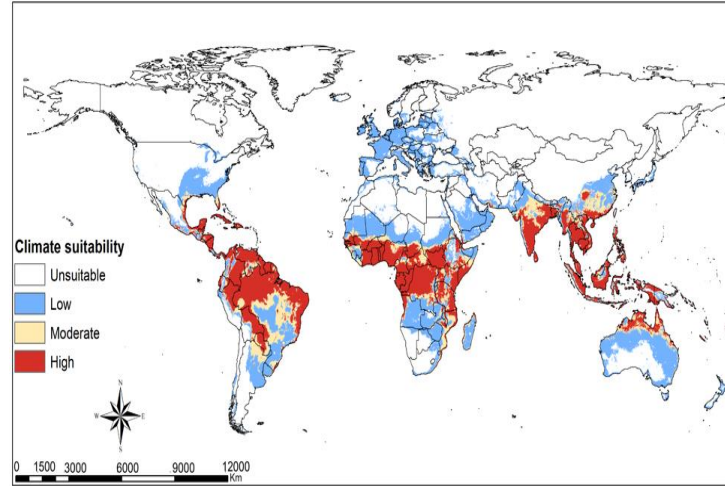
## (5)



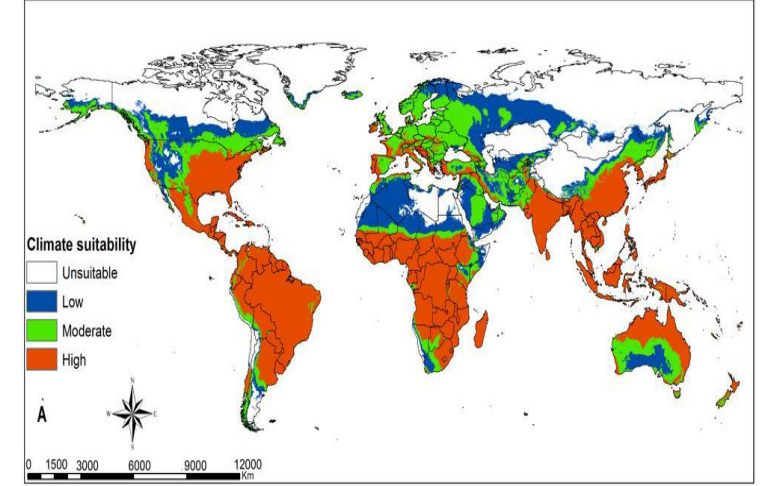
# Modelling scenario I



Climate suitability of FAW at a global scale



Climate suitability of *Telenomus remus* at a global scale



Climate suitability of *Trichogramma pretiosum* at a global scale

3 other parasitoids

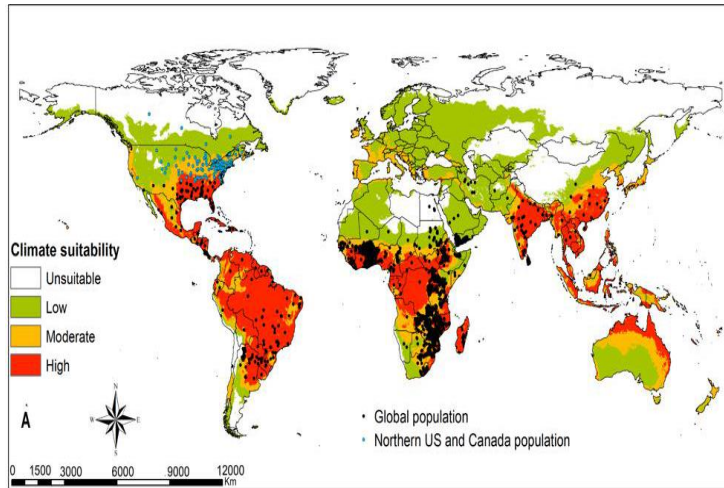


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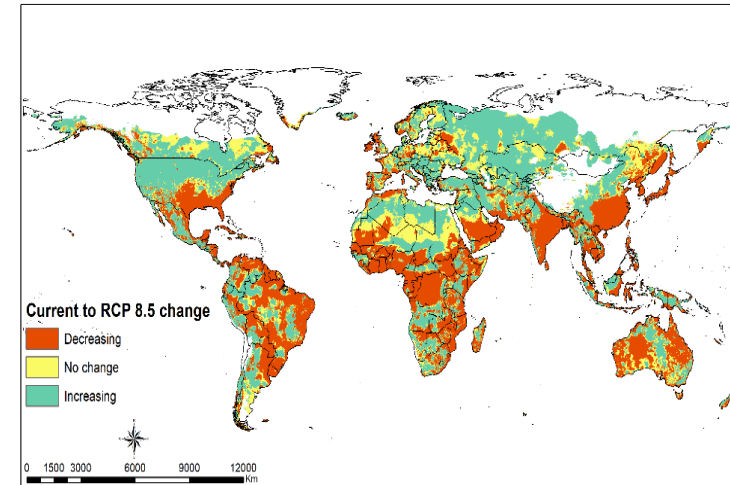




# Modelling scenario I



Locations of FAW and habitat suitability of its parasitoids



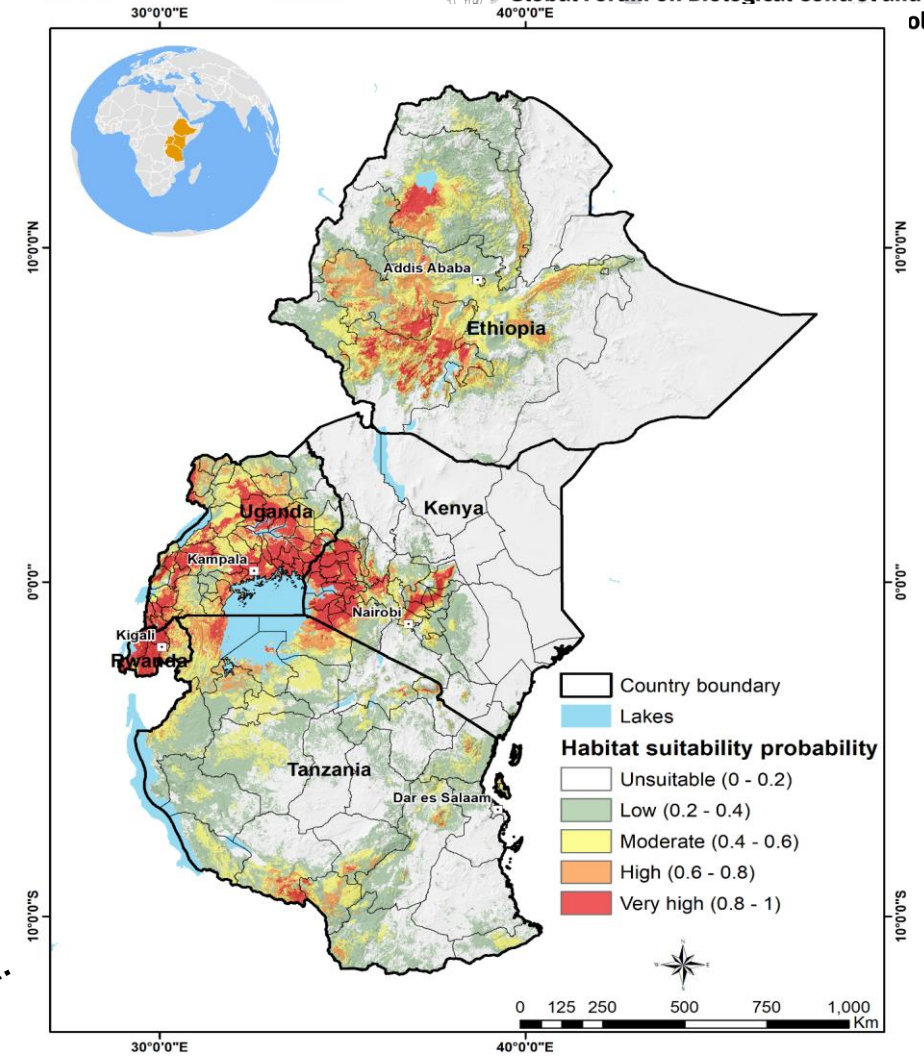
Habitat suitability range shift for 5 parasitoids from current to 2050

# Modelling scenario I

**Area** coverage (km<sup>2</sup>) of the predicted habitat suitability

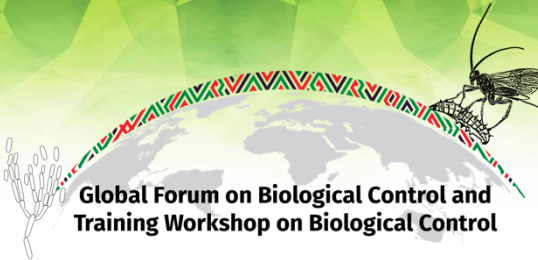
Habitat suitability	Ethiopia	Kenya	Rwanda	Uganda	Tanzania
<b>Very low (0 - 0.2)</b>	900,302 (68%)	566,847 (83%)	1,739 (6%)	72,506 (26%)	782,289 (71%)
<b>Low (0.2 - 0.4)</b>	254,795 (19%)	43,076 (6%)	4,462 (15%)	75,979 (27%)	236,885 (21.5%)
<b>Moderate (0.4 - 0.6)</b>	110,444 (8%)	20,378 (3%)	4,811 (17%)	38,834 (14%)	58,288 (5.3%)
<b>High (0.6 - 0.8)</b>	38,785 (3%)	19,626 (3%)	5,358 (19%)	63,822 (23%)	18,920 (1.7%)
<b>Very high (0.8 - 1)</b>	22,127 (2%)	34,998 (5%)	12,557 (43%)	28,501 (10%)	4,771 (0.4%)

**27%** of eastern Africa  
is currently at risk of  
FAW establishment.

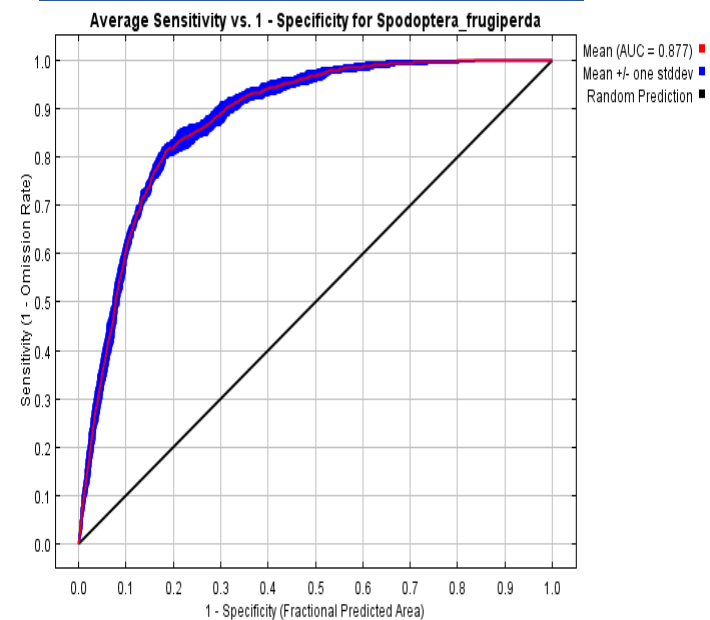




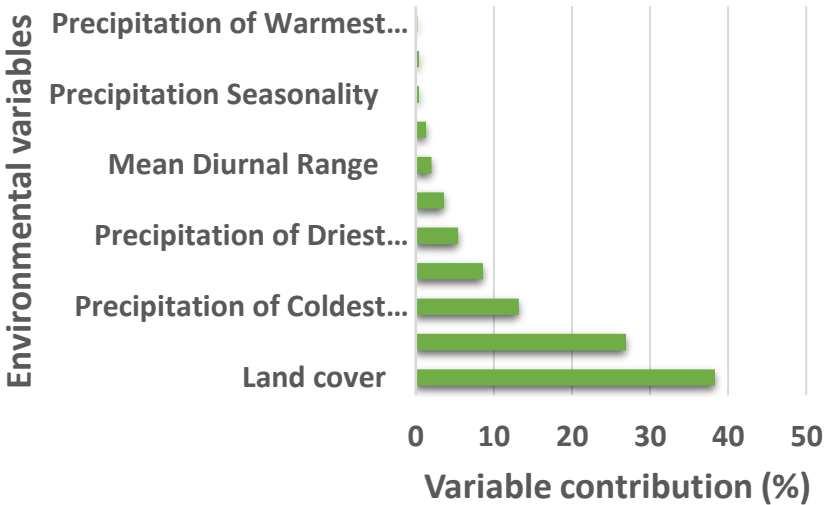
# Modelling scenario I



## Area under curve



## Variable contribution



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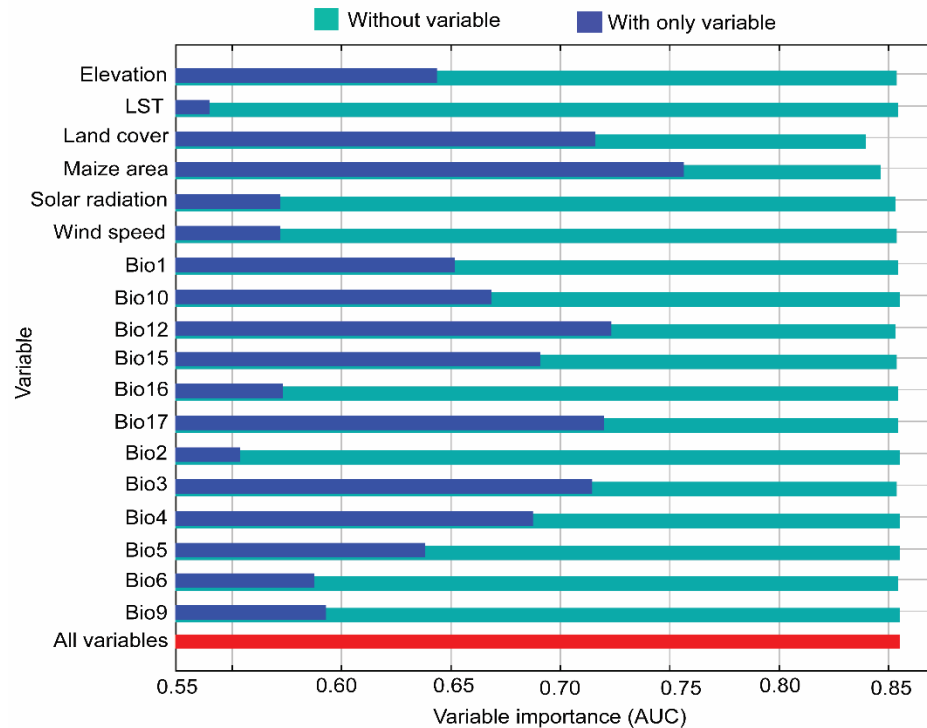


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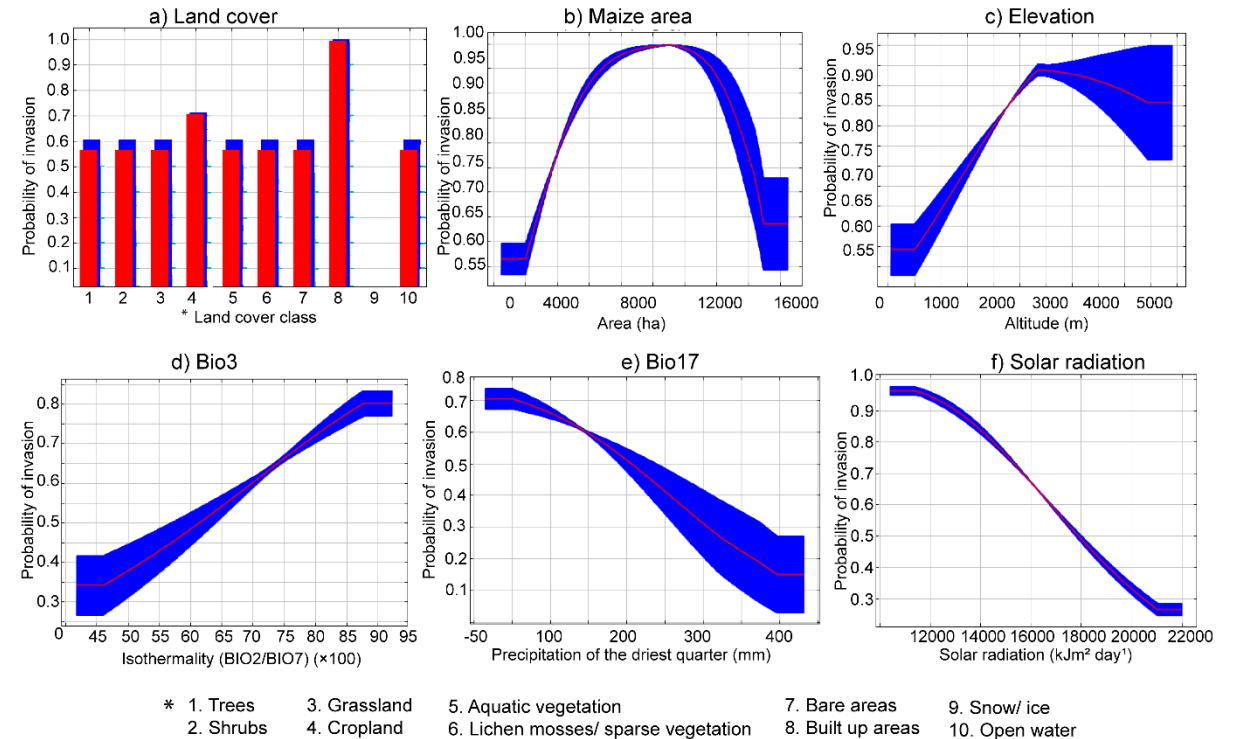
# Modelling scenario I



## Variable relative relevance



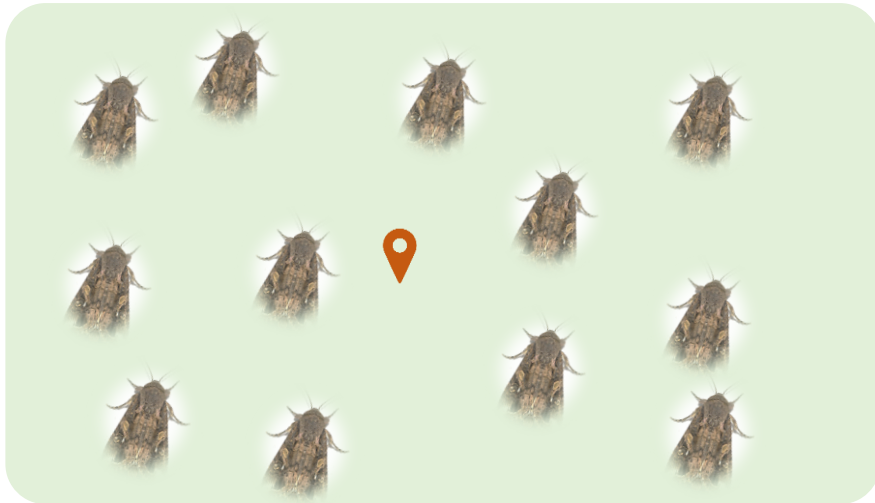
## Response curves



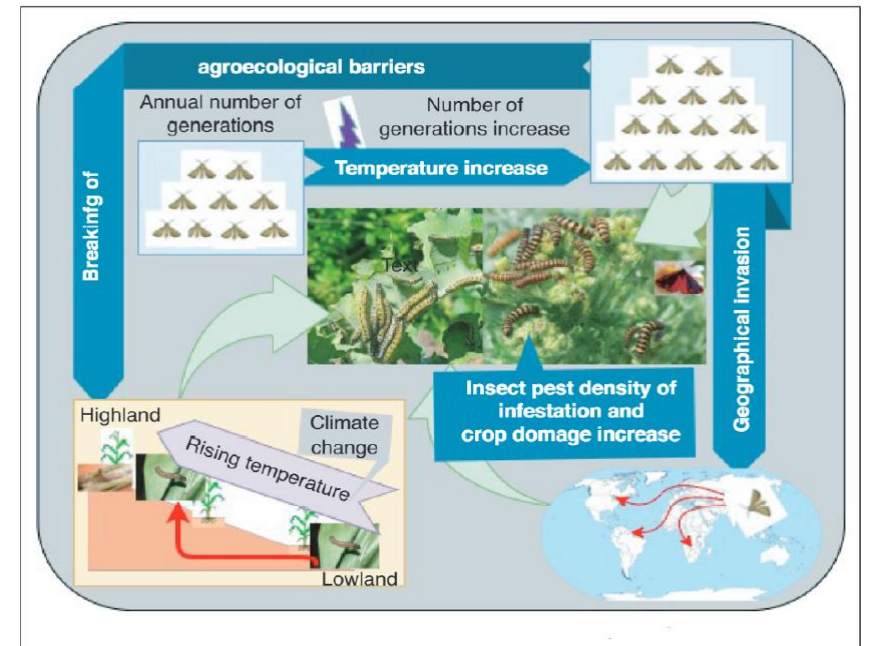


# Modelling scenario II

## II. Abundance (population/ density) data



### Data Science and rule-based models



# Modelling scenario II



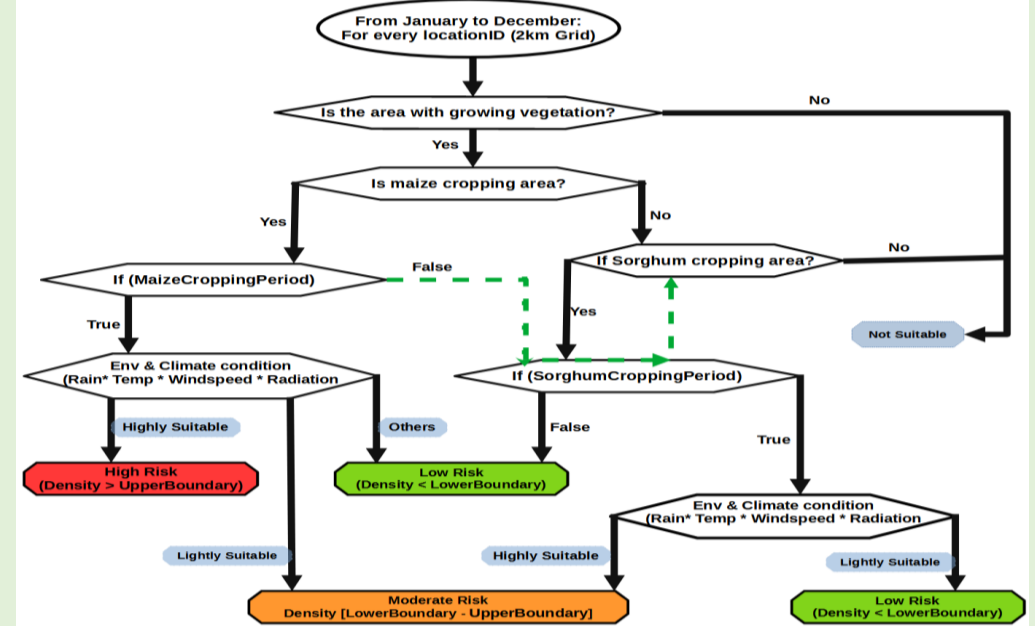
## FAW density (FAMEWS)

### Biotic and abiotic variables:

1. Date of the survey (**Date**)
2. Cropping system (**CropSystem**)
3. Crop stage (**CropStage**)
4. Main crop (**CropMain**)
5. Irrigation, yes or no (**CropIrrigation**)
6. Wind speed (**WindSpeed**)
7. Solar radiation (**Radiation**)
8. **Temperature**
9. Rainfall (**RainValue**)
10. **Elevation**

Multilevel analysis

## methodology



**mixedModel1** ← lme(FawDensity ~ WindSpeed + Radiation+ Temperature + RainValue +Elevation +  
cropSystem +cropStage+ cropMain + monthOfYr + cropIrriga + cropFiel, random = ~1|date, data =  
fawDataAfrica)

(1)

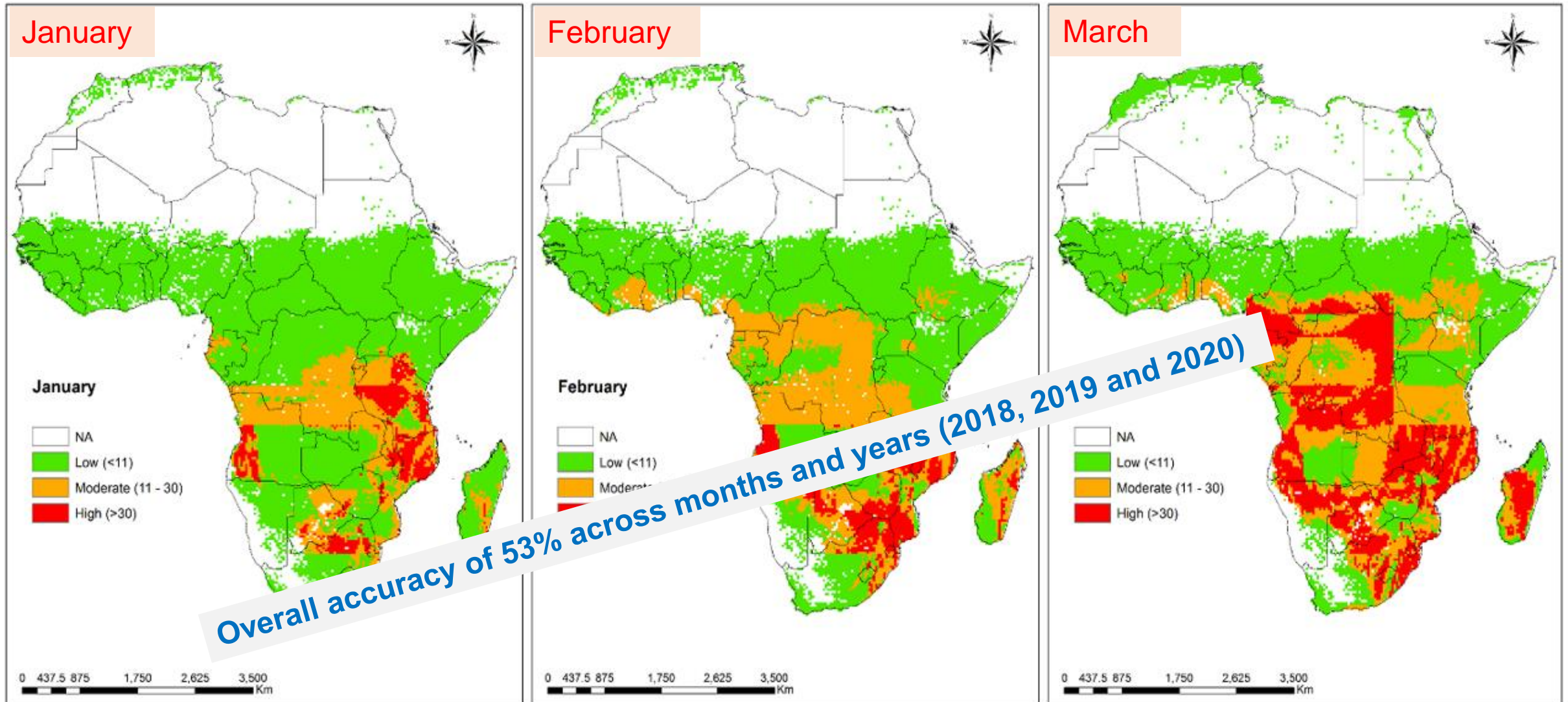


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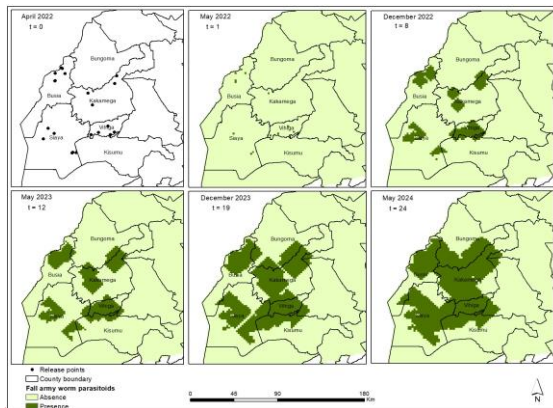
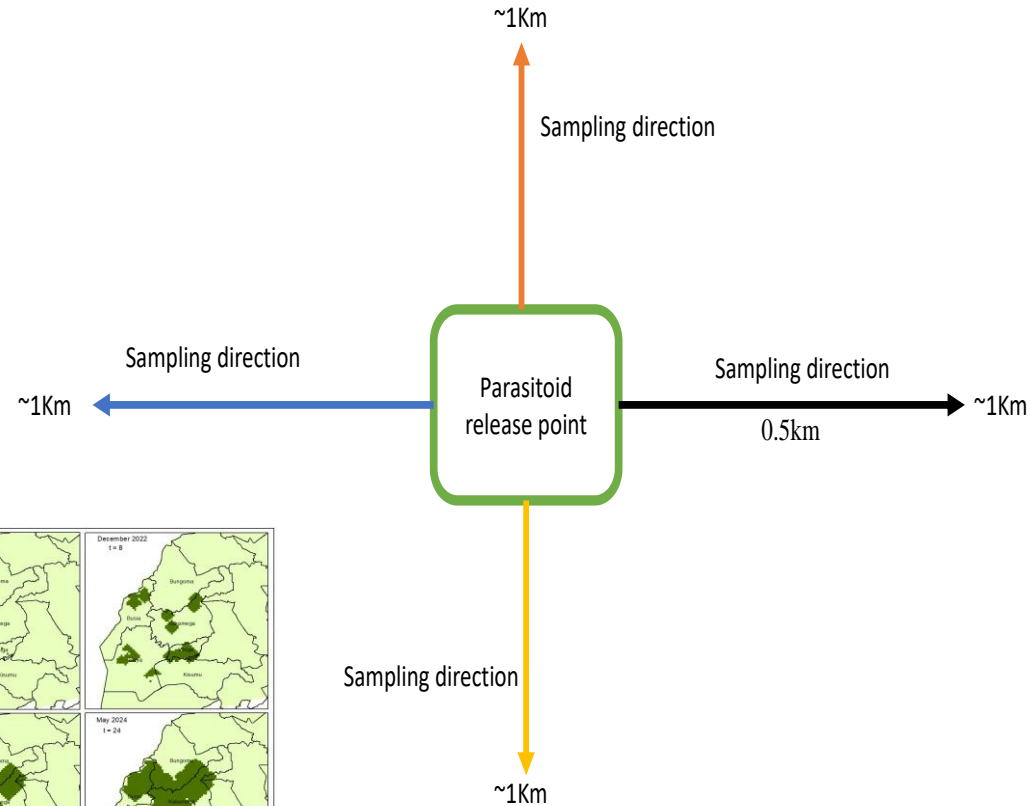
# Modelling scenario II





# Modelling scenarios

## III. Predict parasitoids dispersal at a landscape scale



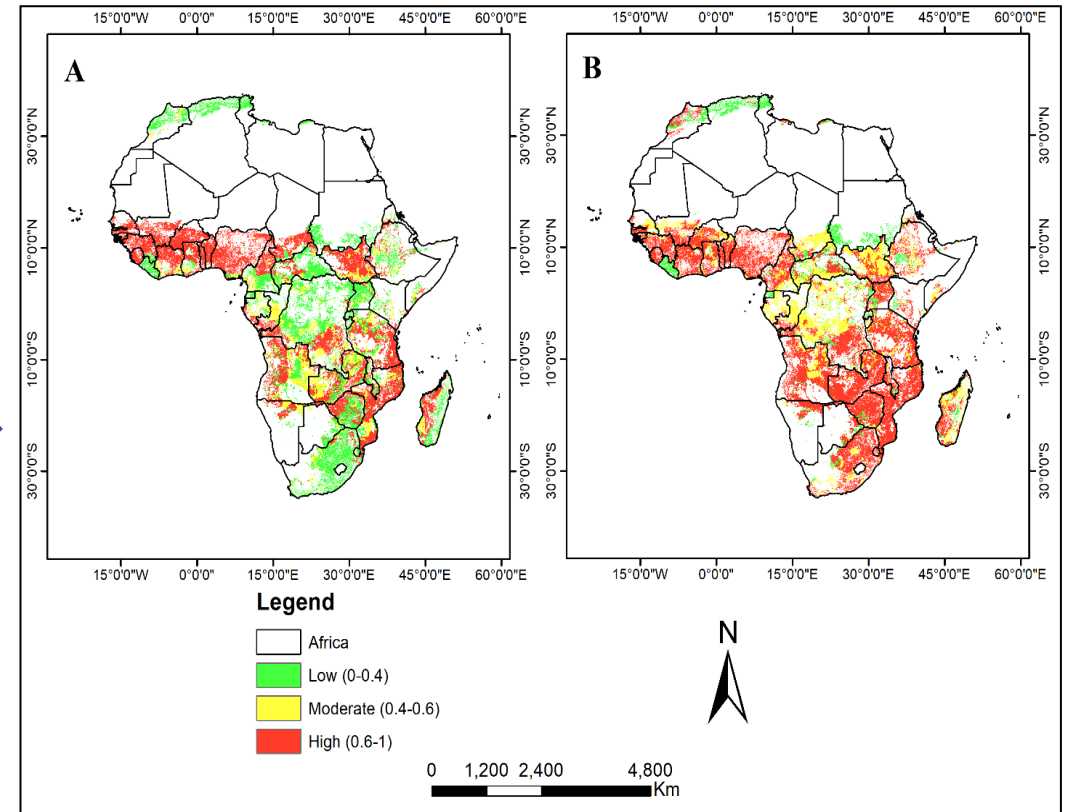
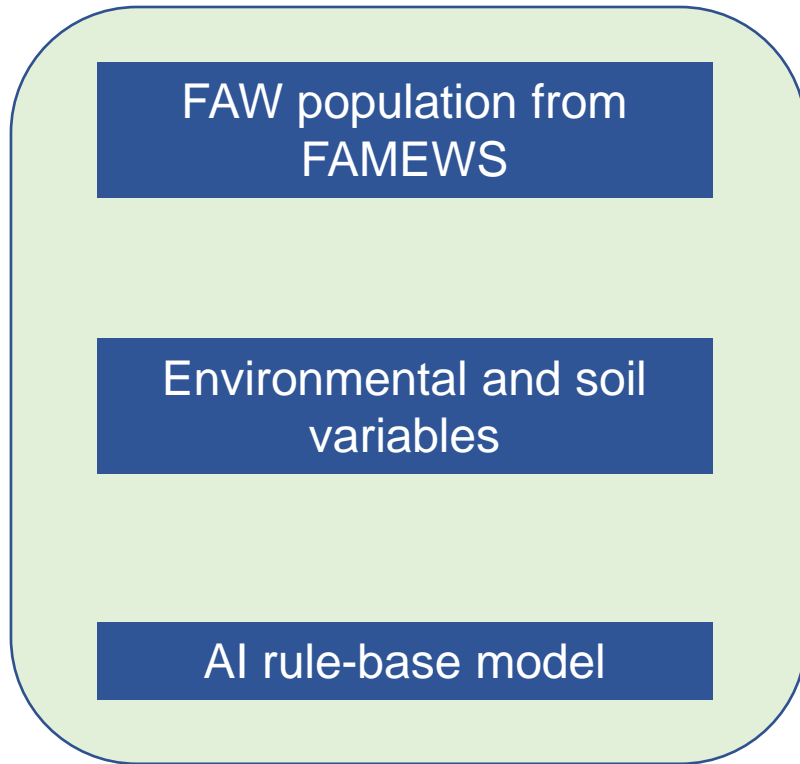
Agent-based model



# Modelling scenarios



## V. Predict suitable sites for deploying biopesticides and releasing parasitoids using a data science AI approach



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