

## **Supplementary Figures for “Wetland fragmentation associated with large populations across Africa”**

**Sani Idris Garba<sup>\*1</sup>, Susanna K. Ebmeier<sup>2</sup>, Jean-François Bastin<sup>3</sup>, Danilo Mollicone<sup>4</sup>, Joseph Holden<sup>1</sup>**

**<sup>1</sup>water@leeds, School of Geography, University of Leeds, Leeds, LS2 9JT, UK;**

**<sup>2</sup>School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK;**

**<sup>3</sup>TERRA, Teaching and Research Centre, Gembloux Agro Bio-Tech, Université de Liège, Belgium.**

**<sup>4</sup>Food and Agriculture Organization of the United Nations, Rome, Italy.**

**\*Corresponding author: idrisgarbasani@gmail.com**

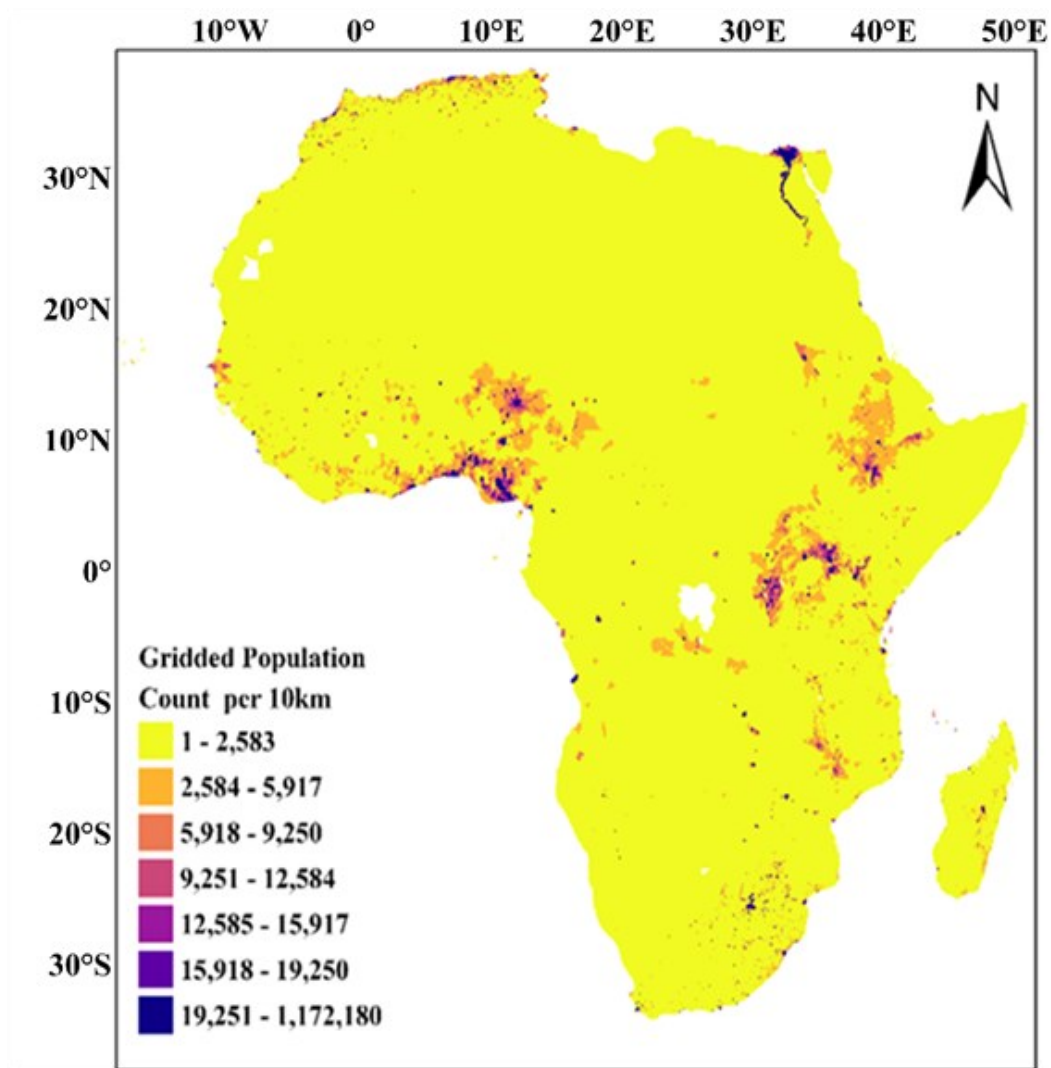


**Figure S1.** The 10-kilometer square gridded layer of population count of Africa. The yellow regions indicate grids with lowest population count (maximum count of 2,583 persons per 10 km<sup>2</sup>), while the ultra blue colored region represents grids with a population count greater than 19,250 persons per 10 km<sup>2</sup>. White patches have no data.

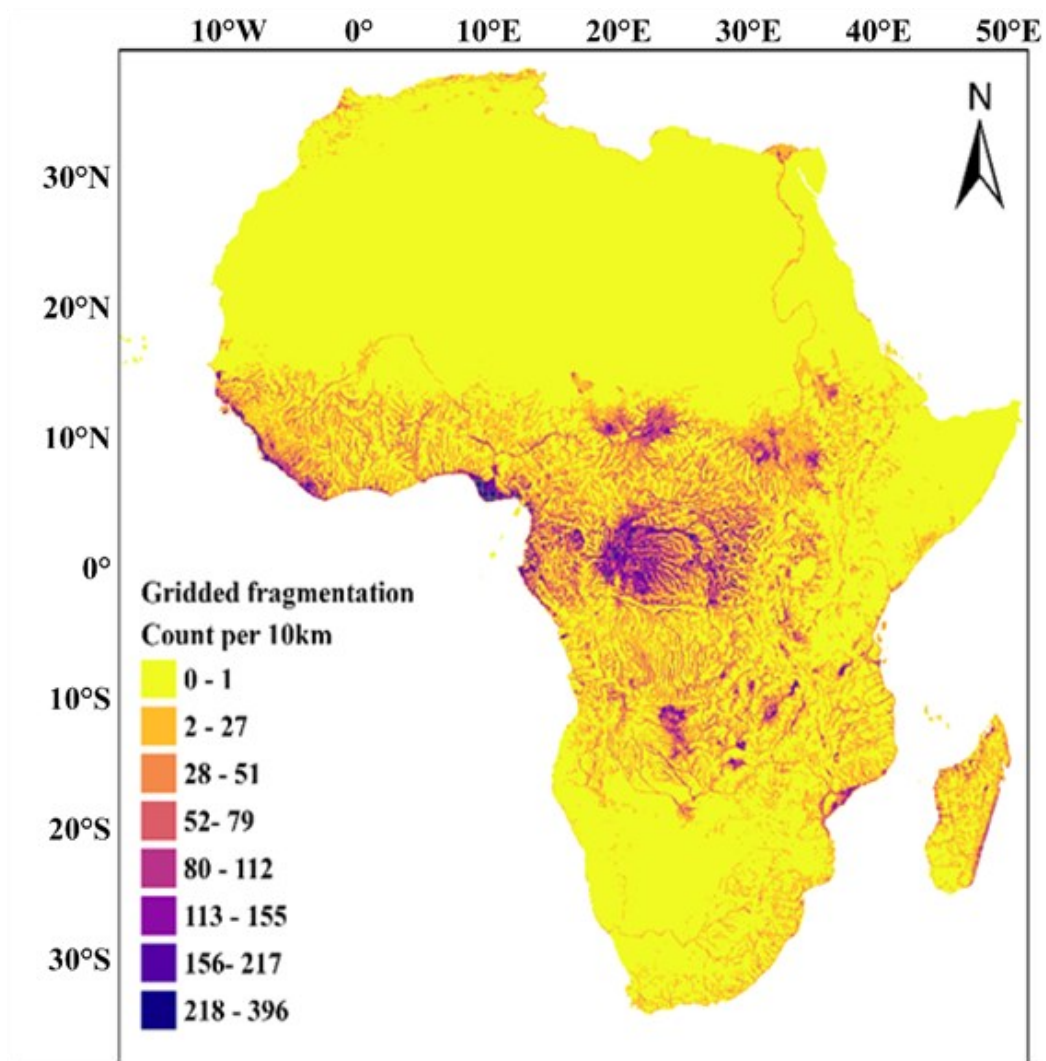


Figure S2. The 10-kilometer square gridded layer of wetland fragmentation in Africa. The yellow regions indicate a non fragmented grid (fragment  $\leq 1$ ), while the ultra blue represents a highly fragmented grid.

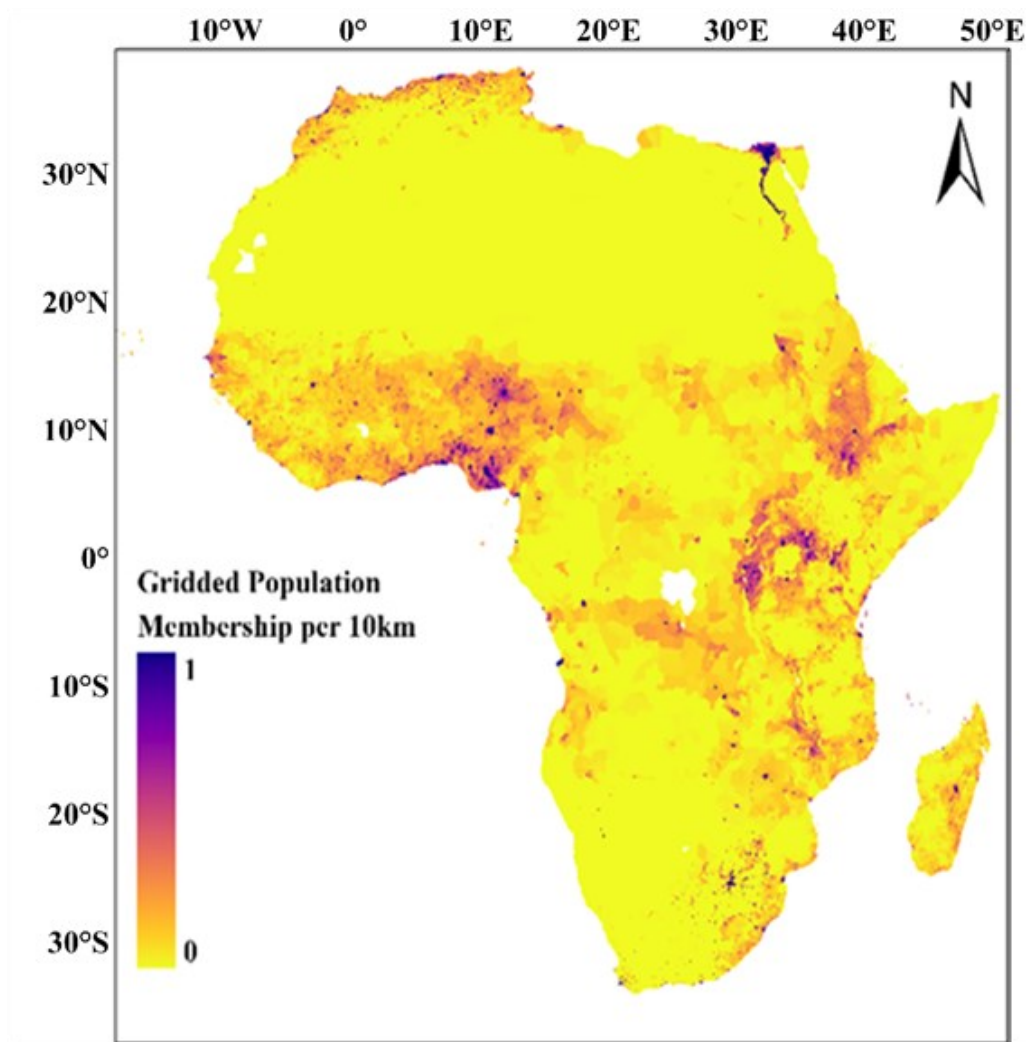


**Figure S3. Fuzzy membership showing the distribution from lowest to highest members of the population grid from 0 to 1 in an increasing order. 0 label represents the lowest membership which indicates sparsely populated grids, while the label 1 indicates densely populated grids assigned to the highest membership group.**

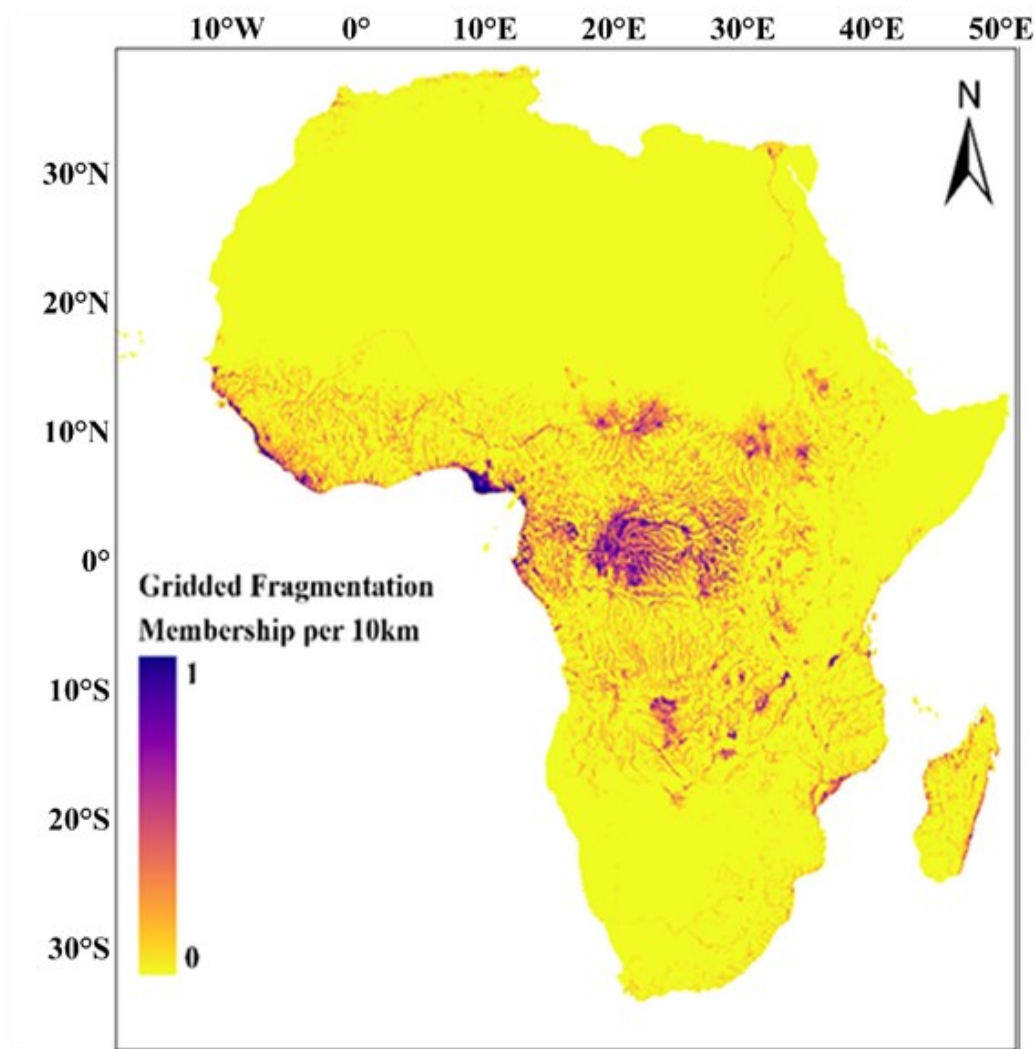


**Figure S4.** Fuzzy membership showing the distribution from lowest to highest members of the fragmentation grid from 0 to 1 in an increasing order. 0 label represents the lowest membership which indicates sparsely populated grids, while the label 1 indicates densely fragmented grids assigned to the highest membership group.

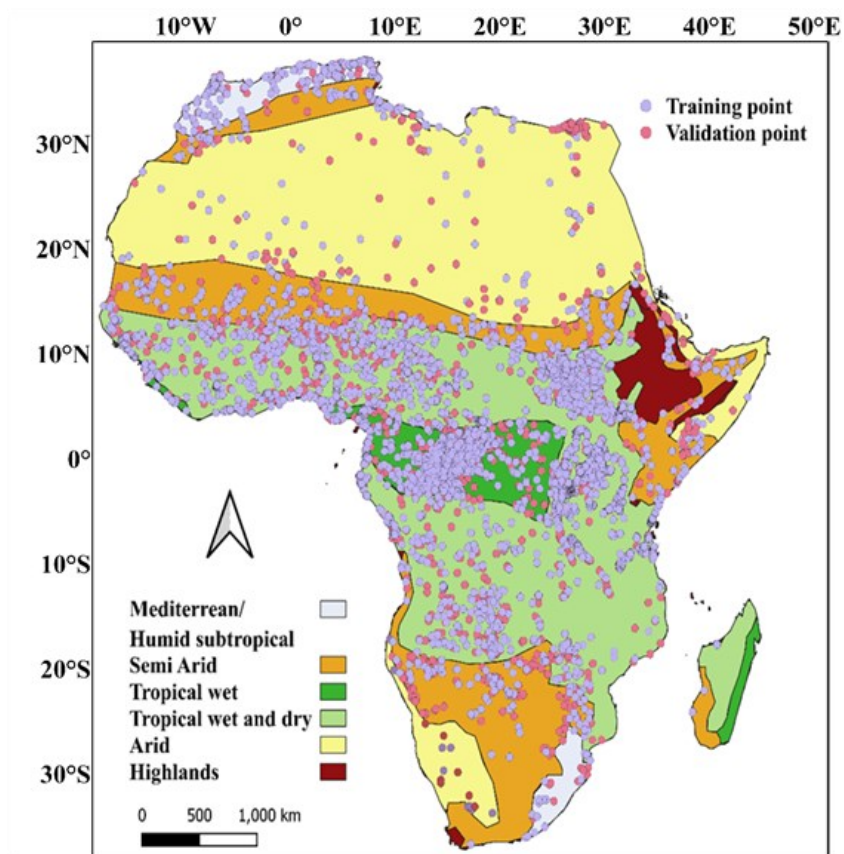


**Figure S5. Distribution of training and validation across the different climate zones in Africa. Tropical wet (3,218 points), Tropical wet and dry (2,550 points), Semi-arid (1,144 points), Arid (536) and Mediterranean/humid subtropical (846 points).**

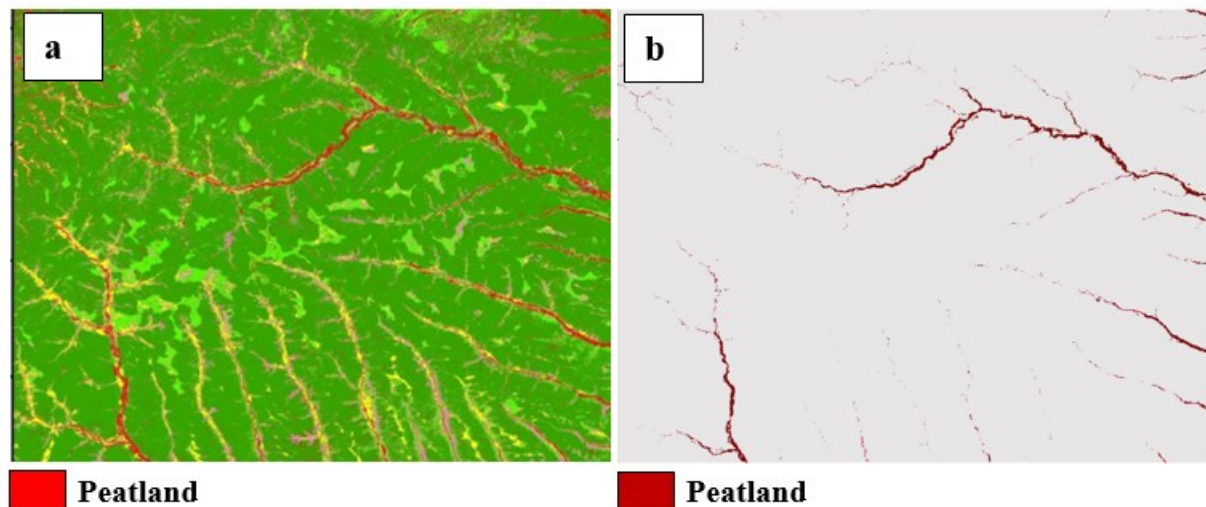


**Figure S6. The Map of Angolan highlands peatlands by (a) Lourenco et al. 2022, (b) This study.**

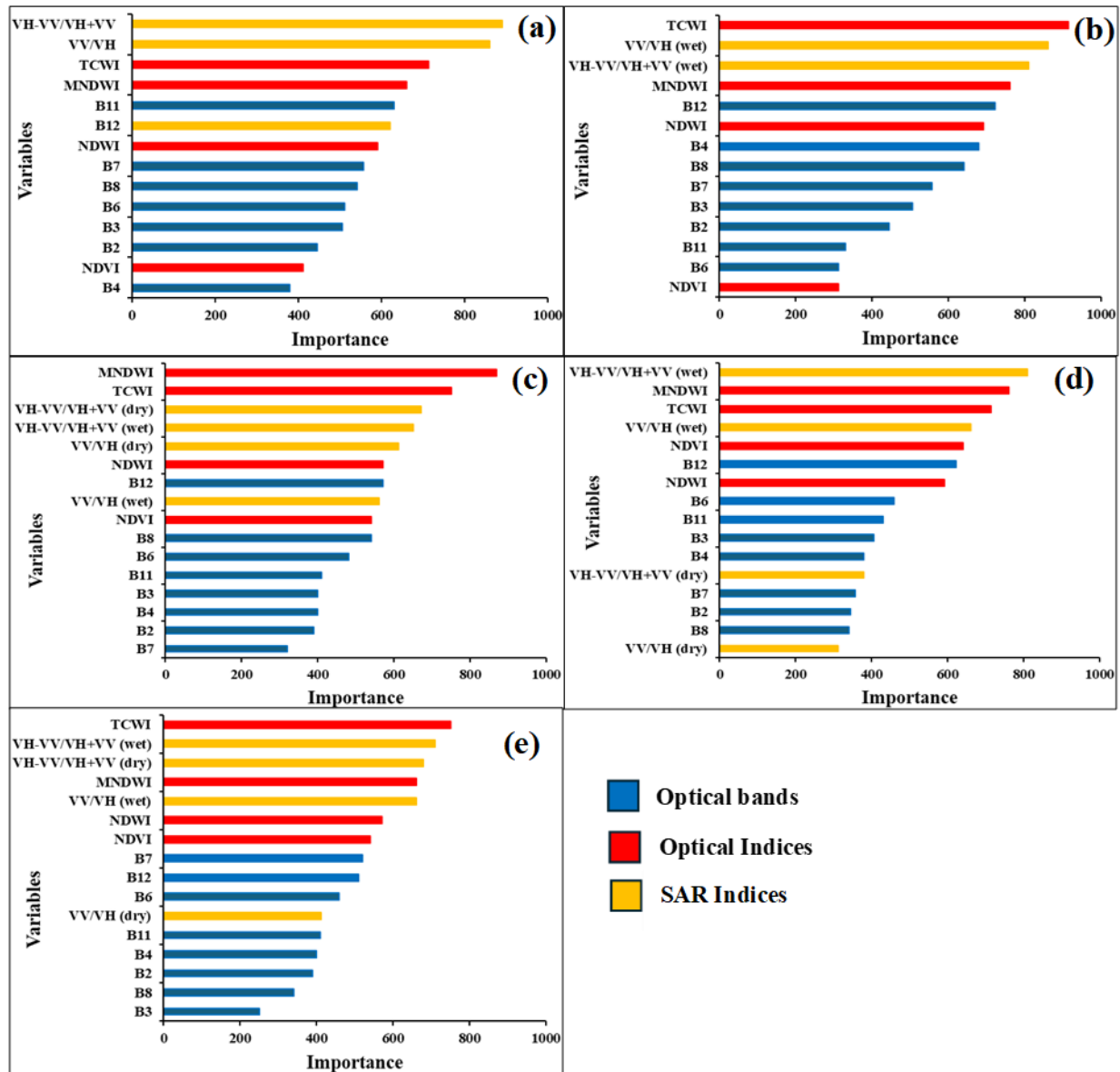


Figure S7. Random Forest variable importance plot extracted from Sentinel-1 and Sentinel-2 features using the training dataset for each climate zone, (a) Tropical wet climate zone, (b) Arid climate zone, (c) Tropical wet and dry climate zone, (d) Semi-Arid climate zone, (e) Mediterranean/Humid subtropical climate zone. The importance of the variable is the sum of decrease impurity each time the variable is selected to be split at the node for the entire trees in the forest and is unitless.

## Supplementary Tables for “Wetland fragmentation associated with large populations across Africa”

**Table S1 The spatial extent of wetland cover in different African climate zones. Classification of satellite imagery was based on training which was independent for each climate zone.**

| Climate zone   | Total area (km <sup>2</sup> ) | Wetland area | Percentage wetland cover |
|----------------|-------------------------------|--------------|--------------------------|
| <b>TW</b>      | 1,948,865                     | 448,210      | 23.0                     |
| <b>TWD</b>     | 11,302,156                    | 362,980      | 3.2                      |
| <b>SARD</b>    | 6,685,370                     | 93811        | 1.4                      |
| <b>ARD/DST</b> | 8,962,030                     | 35,853       | 0.4                      |
| <b>MED/HST</b> | 1,202,970                     | 8,276        | 0.7                      |

**Table S2 The s description of each wetland type used in this study.**

| Wetland class    | Soil systems       | Water sources                                                        | Typical settings and features                                                  | Plant species                           |
|------------------|--------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------------|-----------------------------------------|
| Marsh            | Mineral            | Direct flow from lakes, streams, precipitation                       | Edges of lakes and streams, Coastal zone (salt/tidal marshes)                  | Herbaceous                              |
| Swamp            | Mineral or Organic | Precipitation, groundwater, freshwater flooding from rivers or lakes | Along large rivers or on the shores of large lakes                             | Woody, forested                         |
| Mangrove         | Organic            | Precipitation, groundwater and tidal flow.                           | Coastal zone mostly grows in sheltered low lying coasts estuaries, and lagoons | Trees and shrubs                        |
| Peatland         | Organic            | Groundwater inflow or precipitation                                  | Standing water of lakes or margins of slow flowing rivers,                     | Herbaceous plants, Shrubs, small trees. |
| Seasonal wetland | Organic or mineral | Precipitation                                                        | Low lying areas and open fields.                                               | Herbaceous                              |

**Table S3 Confusion matrix for wetlands of Tropical wet and dry (TWD) climate zone after applying RF.**

| <b>Wetland class</b> | Marsh | Mangrove | Swamp | Peatland | Seasonal wetlands | Deep water | Total | User's Accuracy |
|----------------------|-------|----------|-------|----------|-------------------|------------|-------|-----------------|
| Marsh                | 510   | 4        | 2     | 0        | 10                | 0          | 526   | 0.97            |
| Mangrove             | 4     | 171      | 9     | 6        | 0                 | 0          | 190   | 0.90            |
| Swamp                | 9     | 10       | 141   | 36       | 4                 | 0          | 200   | 0.71            |
| Peatland             | 6     | 4        | 23    | 117      | 0                 | 0          | 150   | 0.78            |
| Seasonal wetlands    | 13    | 2        | 2     | 0        | 124               | 6          | 147   | 0.84            |
| Deep water           | 0     | 0        | 0     | 0        | 12                | 384        | 396   | 0.97            |
| Total                | 542   | 191      | 177   | 159      | 153               | 390        | 1609  |                 |
| Producer's Accuracy  | 0.94  | 0.90     | 0.80  | 0.74     | 0.81              | 0.98       |       |                 |
| Overall accuracy (%) |       |          |       |          |                   |            |       | 89              |

**Table S4 Confusion matrix for wetlands of Tropical wet (TW) climate zone after applying RF**

| <b>Wetland class</b> | Marsh | Mangrove | Swamp | Peatland | Seasonal wetlands | Deep water | Total | User Accuracy |
|----------------------|-------|----------|-------|----------|-------------------|------------|-------|---------------|
| Marsh                | 249   | 0        | 1     | 0        | 5                 | 0          | 255   | 0.97          |
| Mangrove             | 8     | 120      | 10    | 1        | 6                 | 0          | 145   | 0.83          |
| Swamp                | 10    | 9        | 107   | 29       | 6                 | 0          | 161   | 0.66          |
| Peatland             | 18    | 7        | 65    | 347      | 2                 | 0          | 439   | 0.79          |
| Seasonal wetlands    | 26    | 11       | 14    | 14       | 118               | 17         | 200   | 0.59          |
| Deep water           | 0     | 0        | 0     | 0        | 2                 | 73         | 75    | 0.95          |
| Total                | 311   | 147      | 197   | 391      | 139               | 90         | 1275  |               |
| Producer Accuracy    | 0.80  | 0.82     | 0.54  | 0.89     | 0.85              | 0.81       |       |               |
| Overall accuracy     |       |          |       |          |                   |            |       | 84            |

**Table S5 Confusion matrix for wetlands of Semi-Arid climate zone after applying RF**

| Wetland class        | Marsh | Mangrove | Swamp | Peatland | Seasonal wetlands | Deep water | Total | User's Accuracy |
|----------------------|-------|----------|-------|----------|-------------------|------------|-------|-----------------|
| Marsh                | 64    | 3        | 7     | 2        | 4                 | 0          | 80    | 0.80            |
| Mangrove             | 0     | 25       | 4     | 2        | 0                 | 0          | 31    | 0.81            |
| Swamp                | 2     | 3        | 32    | 11       | 2                 | 0          | 48    | 0.64            |
| Peatland             | 2     | 3        | 9     | 34       | 2                 | 0          | 55    | 0.70            |
| Seasonal wetlands    | 15    | 2        | 3     | 4        | 99                | 5          | 128   | 0.90            |
| Deep water           | 0     | 0        | 0     | 0        | 8                 | 75         | 82    | 0.95            |
| Total                | 83    | 36       | 55    | 53       | 115               | 80         | 424   |                 |
| Producer's Accuracy  | 0.77  | 0.69     | 0.58  | 0.64     | 0.86              | 0.94       |       |                 |
| Overall Accuracy (%) |       |          |       |          |                   |            |       | 79              |

**Table S6 Confusion matrix for wetlands of Arid/Desert climate zone after applying RF**

[illegible]

**Table S7 Confusion matrix for wetlands of Mediterranean/Humid subtropical climate zone after applying RF**

| <b>Wetland class</b> | Marsh | Mangrove | Swamp | Peatland | Seasonal wetlands | Deep water | Total | User`s Accuracy |
|----------------------|-------|----------|-------|----------|-------------------|------------|-------|-----------------|
| Marsh                | 31    | 1        | 2     | 2        | 3                 | 0          | 39    | 0.79            |
| Mangrove             | 1     | 17       | 5     | 2        | 0                 | 0          | 25    | 0.68            |
| Swamp                | 1     | 2        | 28    | 10       | 2                 | 0          | 43    | 0.65            |
| Peatland             | 2     | 3        | 11    | 29       | 0                 | 0          | 45    | 0.64            |
| Seasonal wetlands    | 10    | 0        | 2     | 4        | 43                | 4          | 63    | 0.68            |
| Deep water           | 0     | 0        | 0     | 0        | 2                 | 51         | 53    | 0.96            |
| Total                | 45    | 23       | 48    | 47       | 50                | 55         | 268   |                 |
| Producer`s Accuracy  | 0.84  | 0.86     | 0.95  | 0.80     | 0.89              | 0.98       |       | 0.88            |
| Overall Accuracy(%)  |       |          |       |          |                   |            |       | 73              |

