CONFLICT AND COMMUNITY COOPERATION IN AFRICA

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Introduction:

The purpose of the following analysis is to determine if there is any correlation between community cooperation and conflict events in Africa. Community cooperation is difficult to measure so a proxy variable, irrigation, is used to measure this. The methods used evaluates major crop types within grid points across Africa and the amount and type of conflict along with the level of irrigation used, if any. The dataset is often updated, so a system which can be replicated quickly and applied to new data is essential.

Background:

This project is based on the conjecture that irrigation practices can reduce the likelihood of conflict in Africa. This conjecture stems from the "rice theory of agriculture" (Talhelm et al 2014) in which communities which grow rice require cyclical irrigation and community cooperation. Irrigation is a process which requires planning, many workhands, and careful allocation of resources, especially water. Farmers are required to coordinate with each other to ensure a successful harvest later in the year. The rice theory of agriculture proposes that people raised in a culture of cooperativeness will be less likely to host civil conflict events.

Data:

Data was retrieved from the Armed Conflict Location and Event Data Project (ACLED) compiled informatics. The table contains data points for all of Africa separated into grid points and contains 20 years of data from 1997 to 2016. The data includes major crop type, total harvested area, irrigation fraction, technology usage, and 8 types of conflict event as well as a sum of conflict events across the 20 years for each grid point. See figure 1 for an example of the

data table. Supplementary data includes an average annual rainfall map from ATLAS of African Agriculture Research and Development (see Appendices).

The crop types found in the table included: wheat, rice, maize, pearl millet, sorghum, cassava, and other (tropical fruit, vegetables, sugar cane, groundnut, cowpea, rapeseed). The conflict event types included:

E1: Battle with no change of territory

E2: Battle where a non-state-actor overtakes the territory

E3: Battle where the government regains territory

E4: Headquarters or base is established

E5: Strategic development

E6: Riots and Protests by civilians

E7: Violence against civilians

E8: Remote violence (bombings)

For the purpose of this project, only E4 and E6 conflict events were studied individually, although a column for **total conflict events** including counts for all conflict types was used to count conflict in general . The irrigation fraction is a measure of total area irrigated divided by the total area harvested within a grid point. As such, the irrigation fraction is not a measure of total land area of a grid point that has been irrigated, but only from that which has been harvested.

Methods:

All created maps and extracted data were saved into a geodatabase for the benefit of future students. This also made finding necessary layers easy to find and share. Statistical data

was saved into an Excel spreadsheet (figure 3) to summarize data. Many elements were added to **Model Builder** to replicate processes quickly, see figure 2.

1.) Table data was displayed as XY points

2.) XY point feature was converted to raster using Point to Raster tool and displayed conflict events with the following parameters: Pixel size = 0.53, cell assignment= most frequent value. The resulting raster table has **value** and **count** columns. These columns were multiplied to obtain a **totals** column. Using **statistics,** a sum of these **totals** was obtained for conflict events.

    * The Point to Raster tool was utilized as a means to isolate data. The original data set contained 20 lines of data from 1997 to 2016 for each point. The cell assignment feature simplified the data effectively and emphasizes high data points.

    ** All sum data exported to Excel was verified to be proportional to original table data. For example, raster sums and point sums are not equal, but ultimately proportional. This can be seen in the Excel table in figure 3.

3.) XY point feature -> Point to Raster -> Parameters: value field = crops, pixel size = 0.53, cell assignment = most frequent -> Reclassify (1 = wheat, 0 = all other crops). Use Zonal Statistics to see sum values.

4.) Step 3 is repeated for each crop type creating a total of 7 crop rasters.

5.) XY point feature -> Point to Raster -> Parameters: value field = irrigation_fraction, cell assignment= maximum of points, pixel size = 0.53 -> Reclassify (0 = value is 0, 1 = value > 0). Use **Zonal Statistics** to see sum values.

6.) Using Map Algebra tool, use expression: wheat_reclass = 1, conflict > 0. This will output a map showing areas where conflict exists coincident with wheat. Use Zonal statistics to see sum values.

7.) Using Map Algebra tool, use expression: wheat_reclass = 1, irrigation_fraction > 0). This will output a map showing areas where irrigation exists coincident with wheat. Use Zonal Statics to see sum values.

8.) Steps 6 and 7 are repeated for each crop type

9.) XY point feature – select for E4 conflict type -> export selected data to new table -> display as XY point feature (HQ/Base Established) -> Symbolize as graduated symbols based on number of E4 events in any given year.

10.) Repeat step 9 for E6 events for Riots and Protests by Civilians.

Results:

Statistical results show that wheat occupies the highest total area at about 44% (figure 4). This only indicates that 44% of grid points have wheat as the primary crop. This is followed by maize at 14.5%, maize at 14.4%, cassava and sorghum at nearly 9% each, and pearl millet and rice as the least percentage (figure 4).

Wheat has the lowest number of grid points which have an irrigation fraction greater than zero. This is optimal for areas of drought and makes sense. Total conflict for these grid points is lower than 3 other crop types. This does not indicate an inverse correlation between irrigation and conflict. Rice has the highest irrigation rate which seems correct as rice is produced in flooded conditions. Rice has the smallest total area at 3.6% of grid points, but has 5.7% of all conflict (figures 5 and 6). Maize has the second highest irrigation rate as well as the

second highest conflict rate. The category for "other" crops has the highest conflict rate at 24.5% and irrigation fraction at a medium of 8.9%.

The map of Conflict Distribution Across Africa (figure 7) shows higher concentrations of conflict near coastal areas and water bodies. The crop distribution map (figure 8)does not show clear crop regions of conflict or a clear correlation between conflict and crop type (figure 9).

The map of irrigation fractions (figure 10) shows the highest fraction in South Africa and Madagascar. After inverting the map colors to accent areas with a lack of irrigation, there is a clear depiction that areas near the Sahara Desert and inland areas do not have a high irrigation fraction. The map of average annual rainfall across Africa from ATLAS (Figure 11) indicates higher rainfall in areas nearest to the equator especially central Africa in the Democratic Republic of the Congo (DRC), the coasts of Cameroon and Nigeria, and the coasts of Liberia, Sierra Leone, Guinea, and Guinea Bissau as well as the north and east coasts of Madagascar.

The map of riots and protests (Figure 12) as well as establishment of headquarters (figure 13) indicate a high concentration near the coasts of Liberia, Sierra Leone, Guinea, and Guinea Bissau, as well as near Lake Tanganyika and Lake Victoria at the eastern border of the DRC. There is also a concentration of mixed events in Somalia, many riots in Angola, and a high number of bases established in Zimbabwe. There is also a small cluster of events near Lake Chad.

Discussion:

Results did not indicate that irrigation was negatively correlated with conflict. Based on the location and clustering of E4(HQ/Base Established) events and an image of rainfall distribution across Africa, it is possible other factors have a much higher influence on conflict events such as water seen as a limited resource to be hoarded or fought for. This analysis was

limited in that irrigation values were used as binary and does not account for total area irrigated. The reality is that the total fraction of area being irrigated is very small and there are very few areas which have an irrigation fraction greater than 0. The data shows very low irrigation fractions in each grid and this may be negligible and thus uninfluential. Further, the data shows conflict events as part of insurgent group activities and major battles. Irrigation may influence at a community level and prevent minor crimes such as theft, but may not have a significant influence on conflict events.

Further analysis may include political data, population counts, religious areas, and cultural islands. I think this analysis would benefit by using a different variable to measure community cooperation or involvement as the total irrigation fraction of harvested area is very low. It would also be useful to eliminate areas which do not have any harvests from these statistics as the Sahara Desert is currently included, but does allow for widespread agriculture.

Other limitations to this project includes ArcMap's capacity for raster clipping/mask. Throughout the methods, I attempted to clip to rater as well as mask one raster to another. For example, find crops in areas of conflict by using areas of conflict > 0 as a mask. This did not generate the correct output. The software consistently missed several data points.

Conclusion:

This project sought to find a correlation, if any, between conflict events and irrigation in Africa. The results from the analyses did not indicate a correlation either positive or negative. There is a higher correlation between climate conditions and conflict events based on a simple visual evaluation. Conflict events were also coincident with fresh water body locations and major ports. This analysis requires further study which includes more in-depth variables regarding each grid point including major religious views, cultural practices, terrain, and population count

References:

Armed Conflict Location and Event Data Project (ACLED). (2016). Data from Data Export Tool. https://www.acleddata.com/data/

Talhelm, T., Zhang, X., Oishi, S., Shimin, C., Duan, D., Lan, X., & Kitayama, S. (2014). Large-scale psychological differences within China explained by rice versus wheat agriculture. Science, 344(6184), 603-608.

Thornton, P. (2014). Rainfall and rainfall variability in Africa. The Atlas of African Agriculture Research and Development. IFPRI. https://news.ilri.org/2014/07/23/new-map-average-annual-rainfall-in-africa

Tsusaka, T. W., Kajisa, K., Pede, V. O., & Aoyagi, K. (2015). Neighborhood effects and social behavior: The case of irrigated and rainfed farmers in Bohol, the Philippines. Journal of Economic Behavior & Organization, 118, 227-246.

Appendices

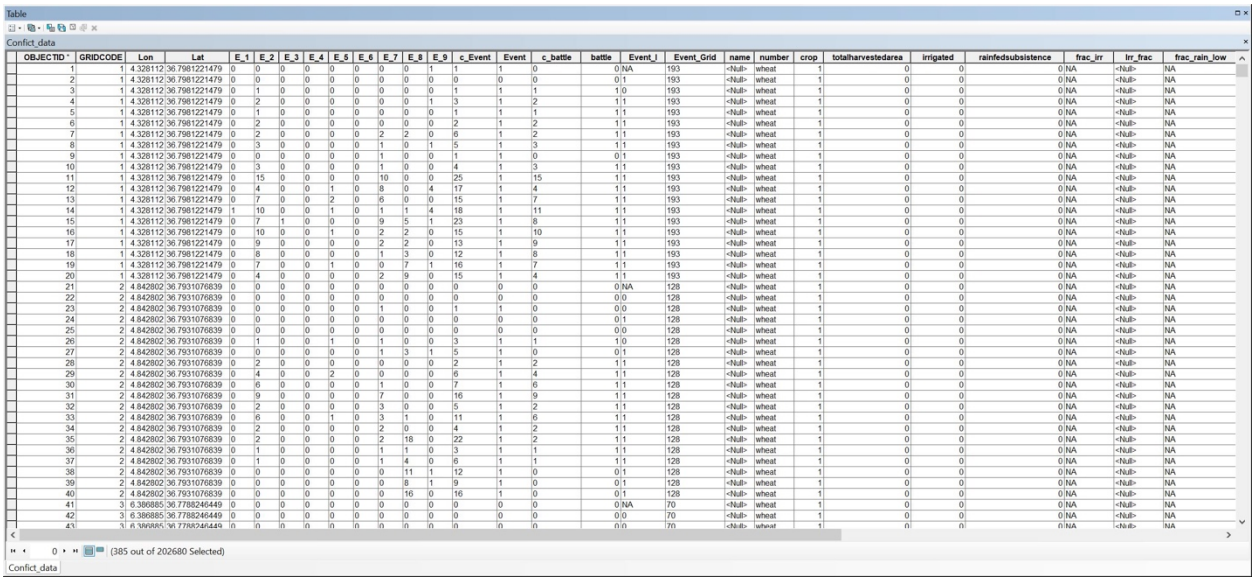

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Figure 1: Example of Table Data,(left to right) code for each grid point, latitude and longitude, E1 to E8 conflict events, total conflict events per grid point, major crop type, and irrigation fraction.

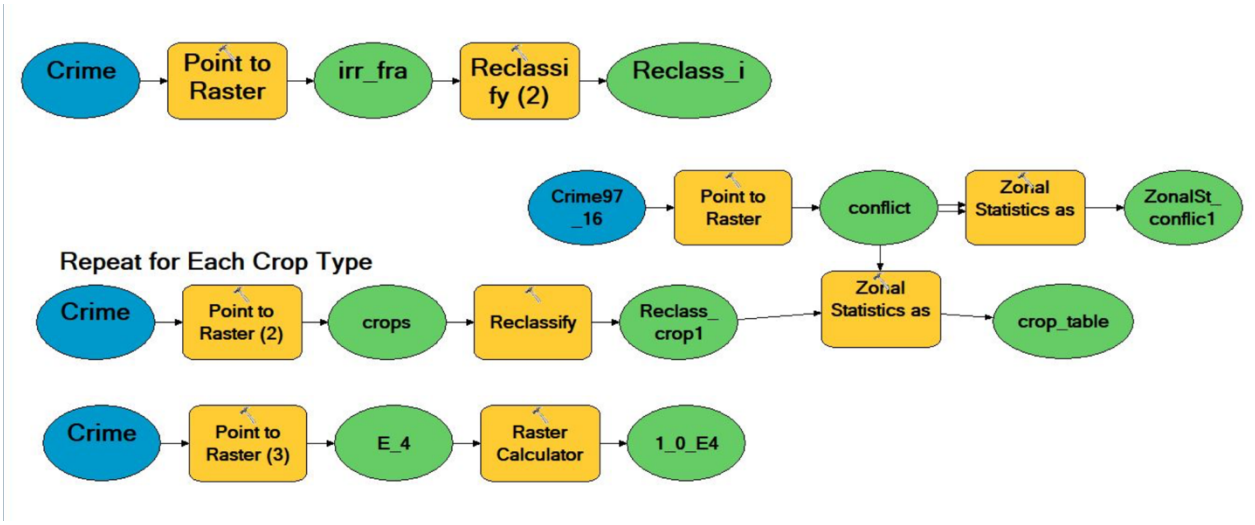


Figure 2: Model of raster creation and reclassification in Model Builder

Category	Pt_Crimes	% Pt_AllCrime	Ct_Crimes_>0_pix	% of All Crime	Pixel_count_Area	% Total Area	Irr_Cr_pixels	%CropArea_Irrigated
Wheat	19614	15.50097207	722	15.50097207	4013	44.20090318	47	1.171193621
Rice	7159	5.657767873	198	5.657767873	328	3.61273268	114	34.75609756
Maize	30431	24.04966254	733	24.04966254	1315	14.48397401	314	23.878327
Pearl Millet	5767	4.557668295	242	4.557668295	500	5.507214451	16	3.2
Sorghum	20345	16.07868241	527	16.07868241	808	8.899658553	86	10.64356436
Cassava	12239	9.672499091	382	9.672499091	812	8.943716268	53	6.527093596
Other	30979	24.48274772	751	24.48274772	1303	14.35180086	116	8.902532617
Conflict Raster	126534	100	3555	100	9079	100	746	8.216763961

Figure 3: Excel Table of summarized data from method calculations.

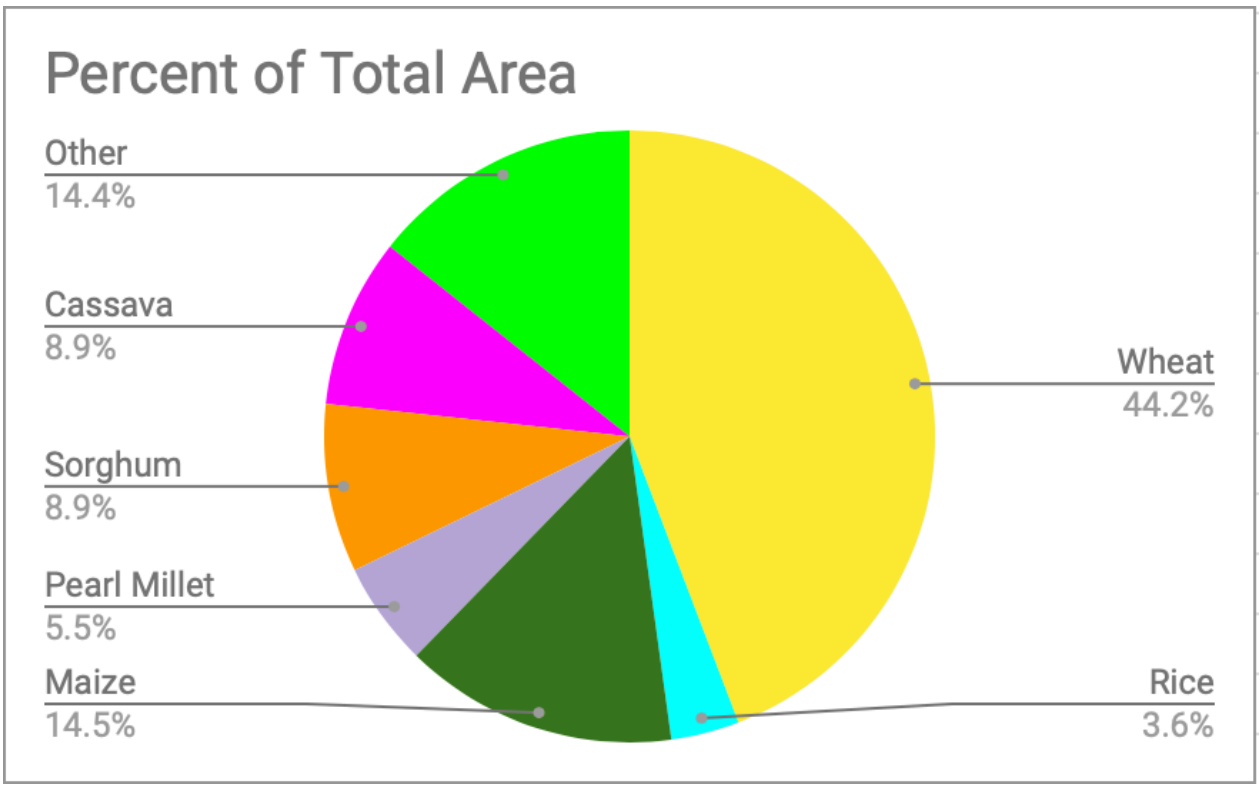


Figure 4: Percent of Total Area pie chart, calculated as percent of total pixels which are designated by category.

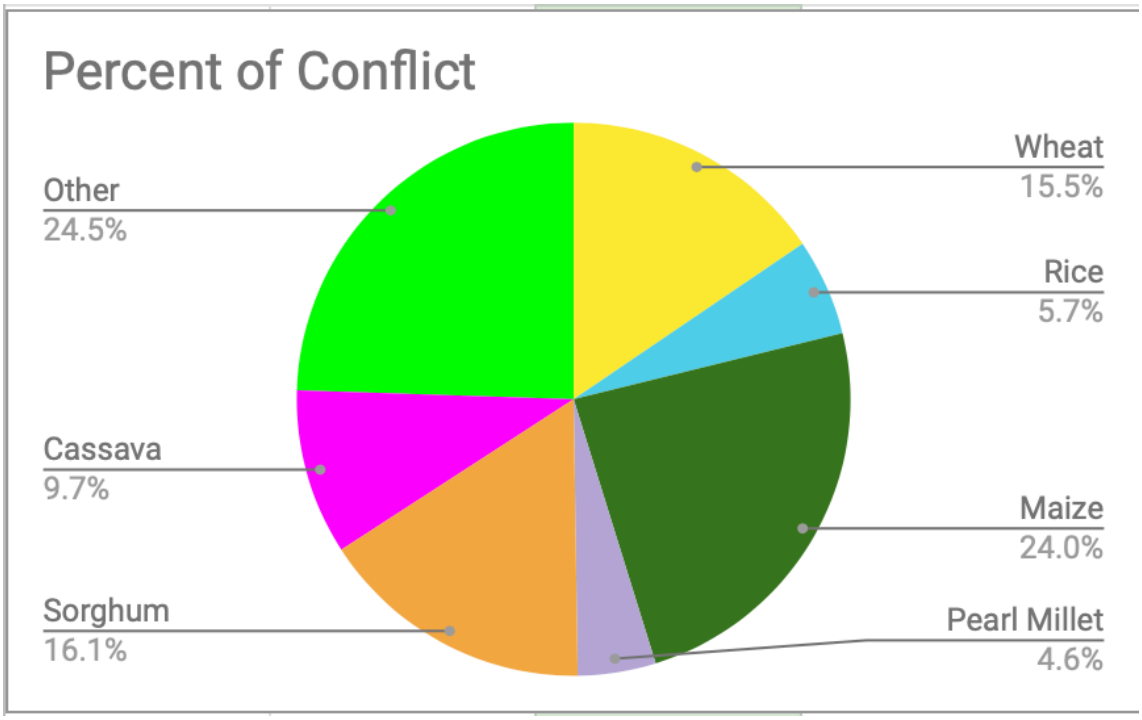


Figure 5: Percent of Conflict pie chart, calculated as percentage of total conflict events within each category of crop.

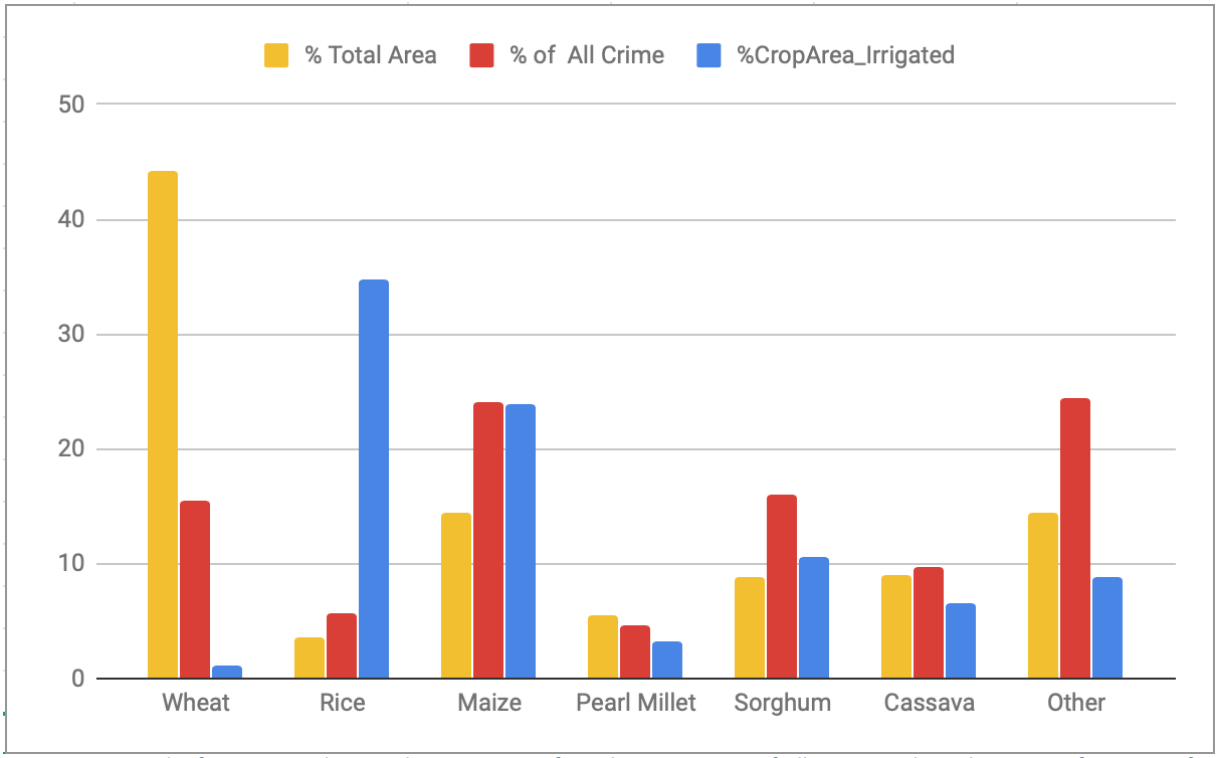
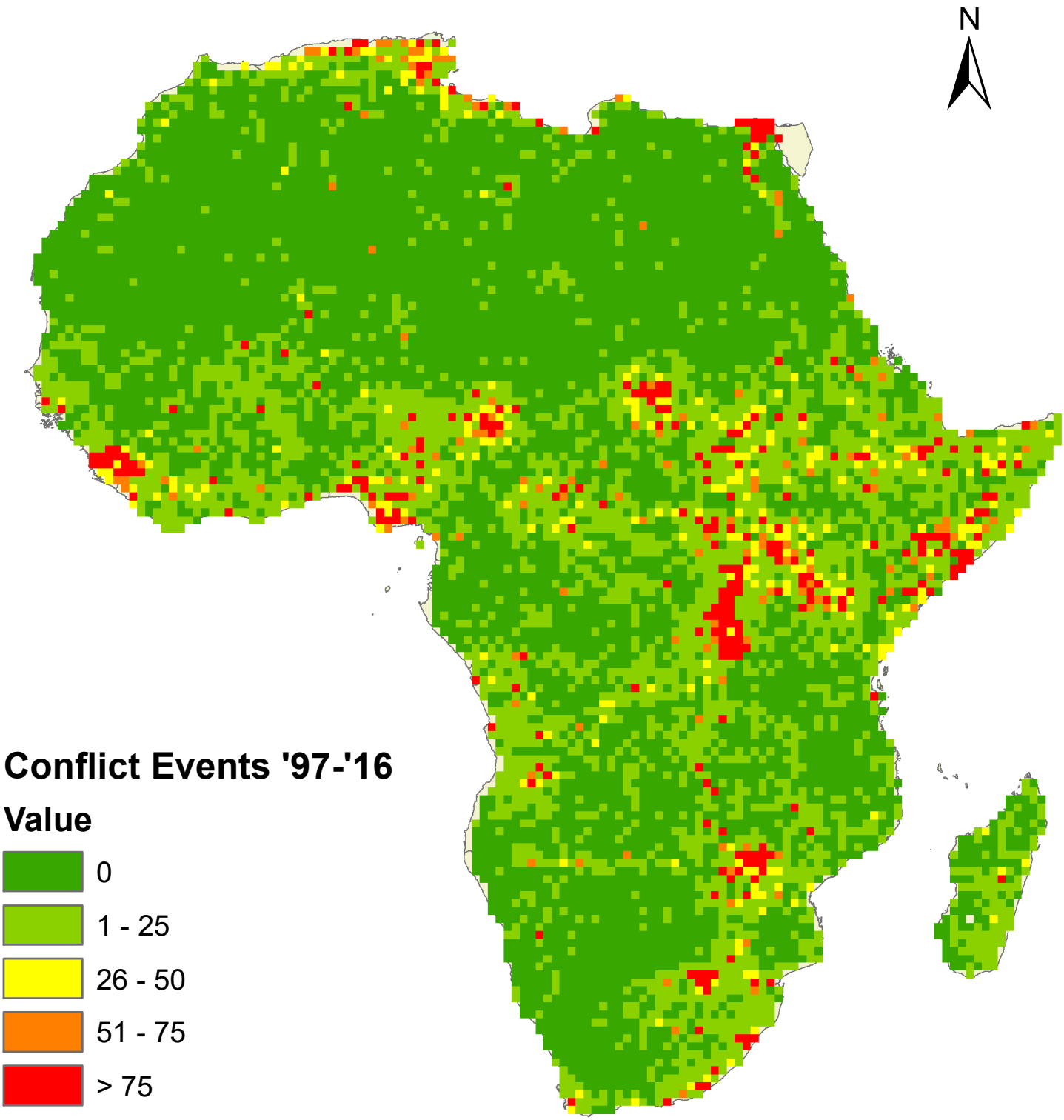


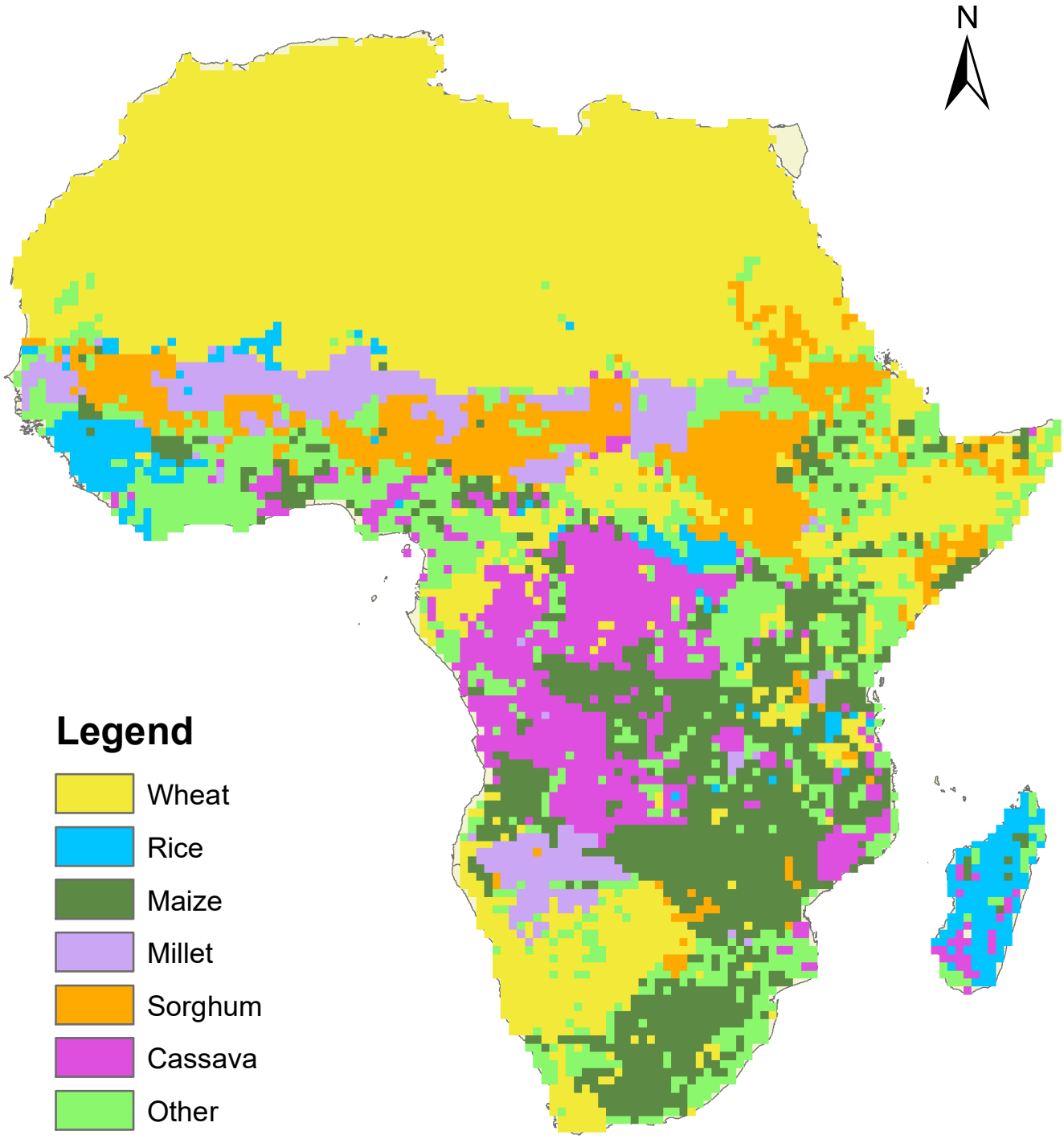
Figure 6: Bar Graph of Summarized Data. Shows Percent of Total Area, Percent of All Crime, and Total Fraction of Irrigation for that crop type.

Figure 7

Conflict Distribution Across Africa for years 1997 - 2016



Crop Distribution Across Africa By Main Type Per Grid



Conflict Events in Africa and Main Crops

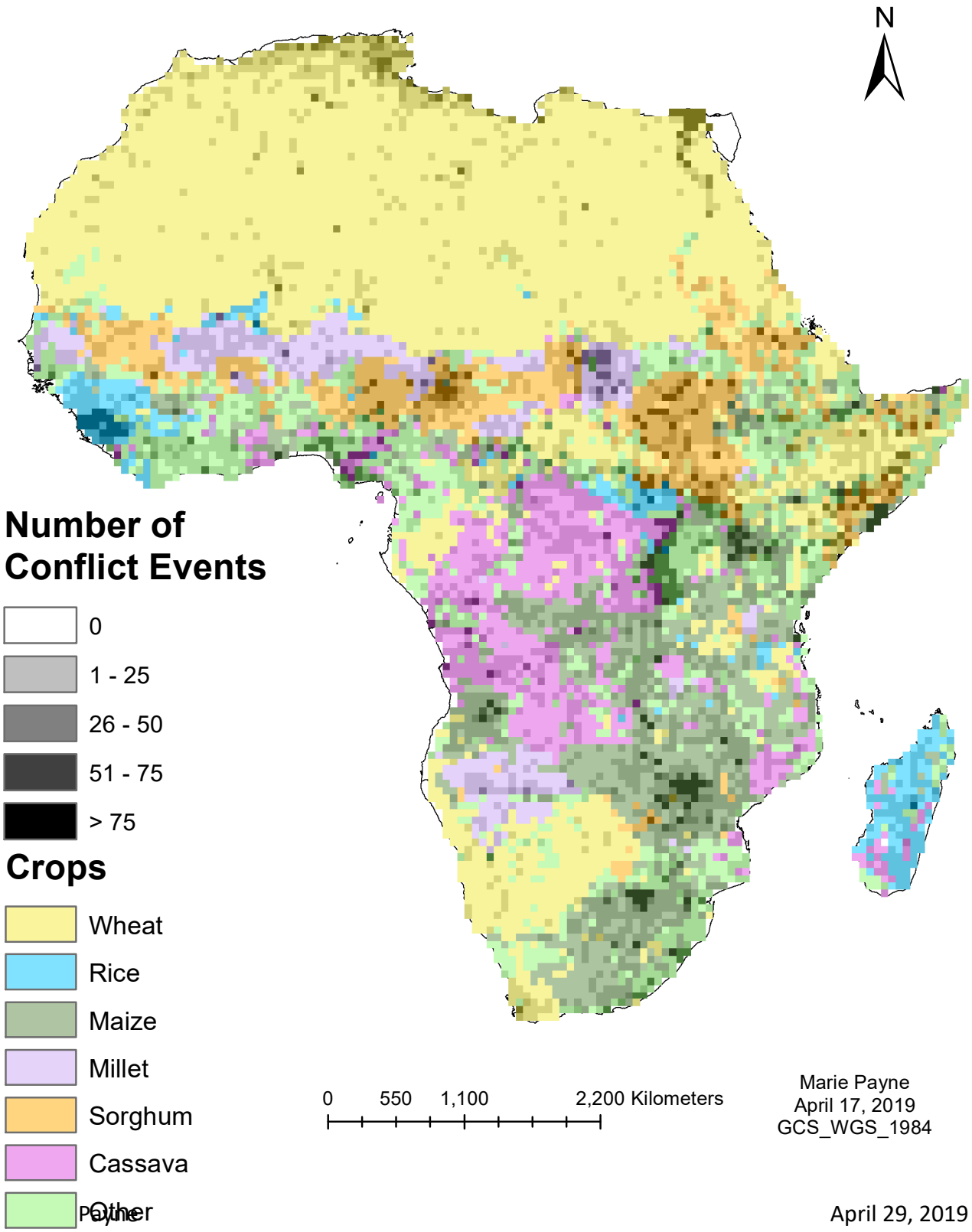


Figure 10

Fraction of Harvested Area in Africa that is Irrigated

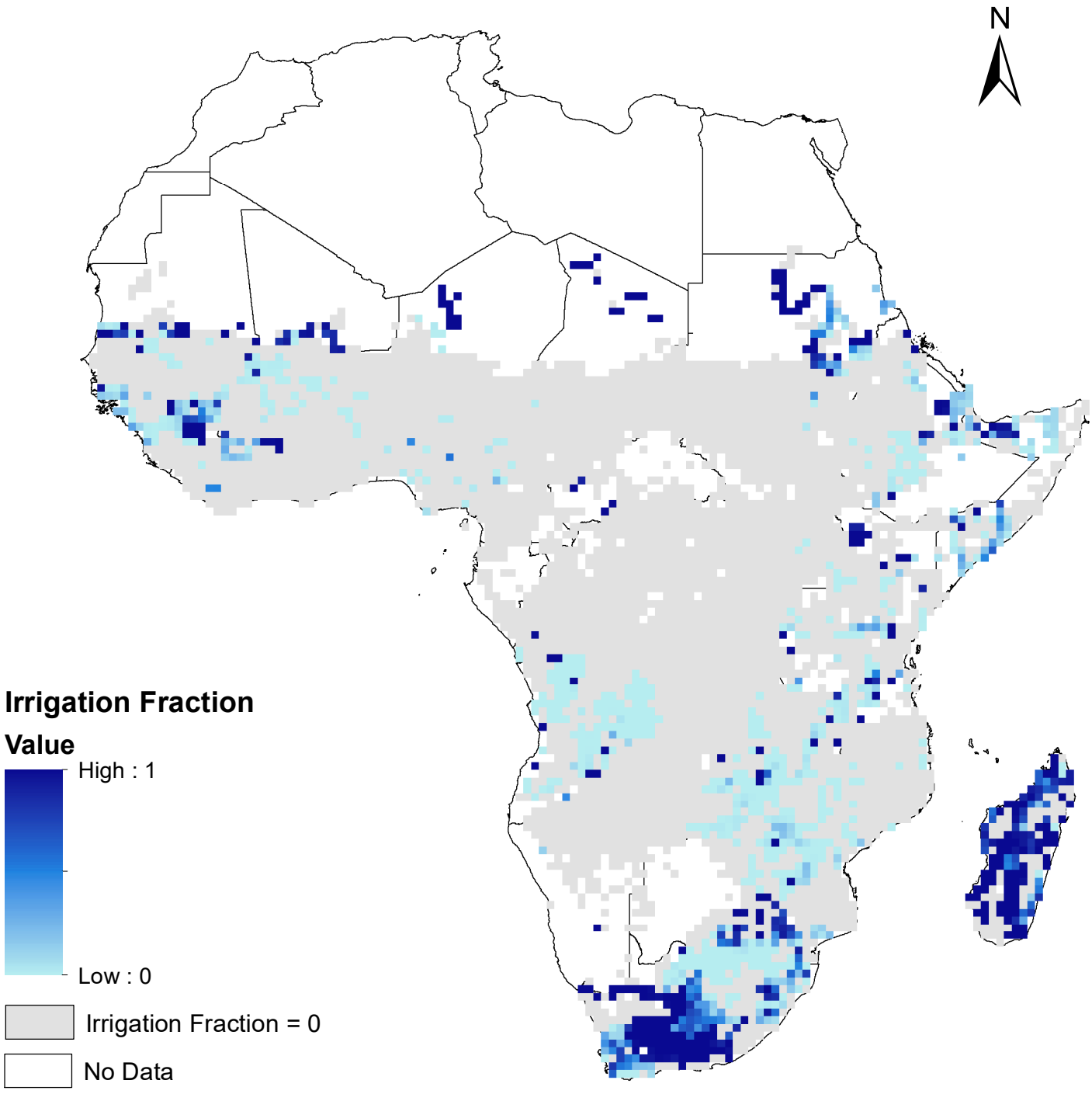
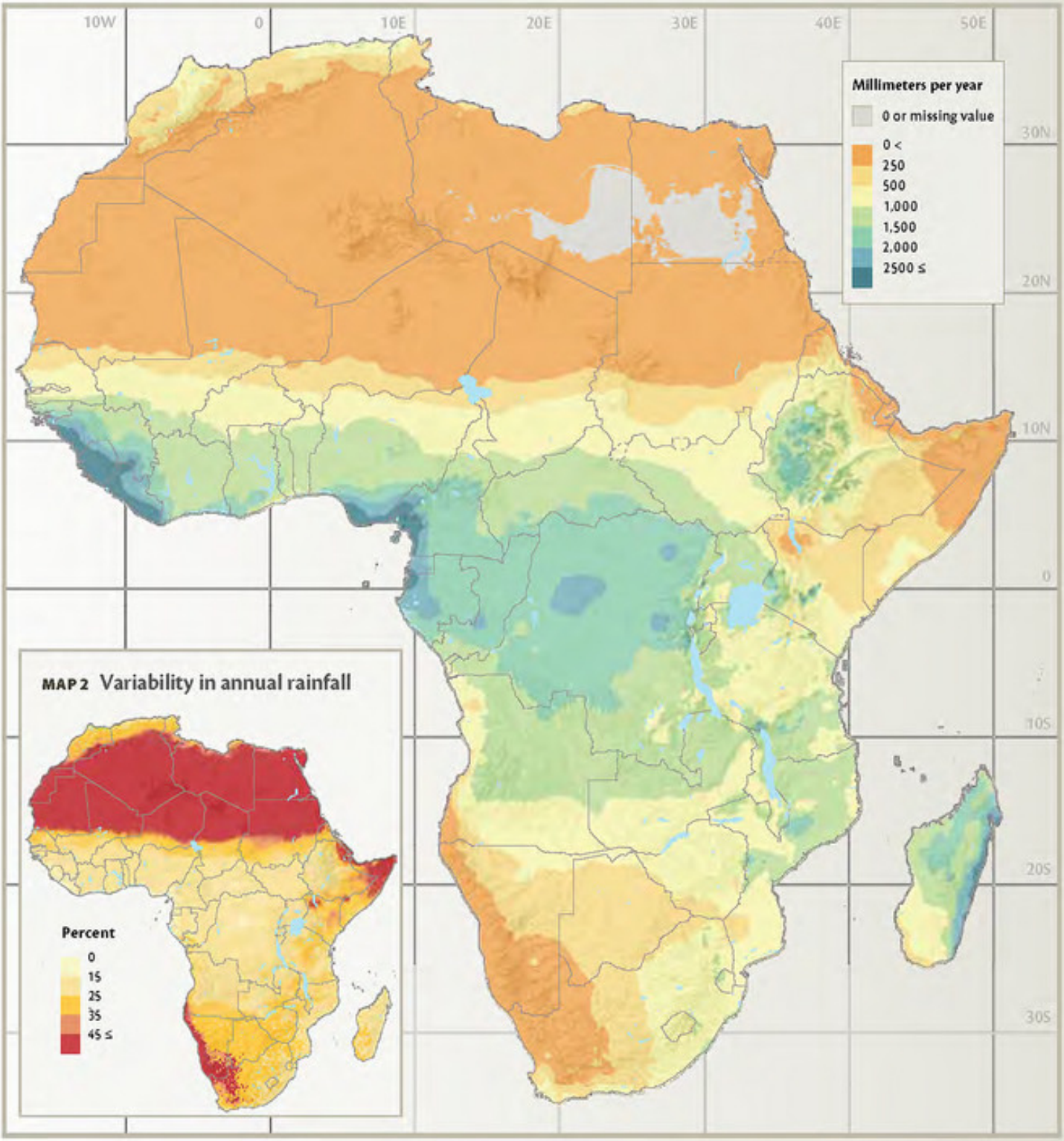


Figure 11

MAP 1 Average annual rainfall



Data source: Map 1—WorldClim (Hijmans et al. 2005); Map 2—MarkSim (Jones and Thornton 2013).

Note: Rainfall variability is represented by the coefficient of variability (CV), calculated as the standard deviation divided by the mean annual rainfall. It is expressed as a percentage and indicates how much rainfall varies from average annual rainfall.

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Figure 12

Riots/Protests and Irrigation Fraction

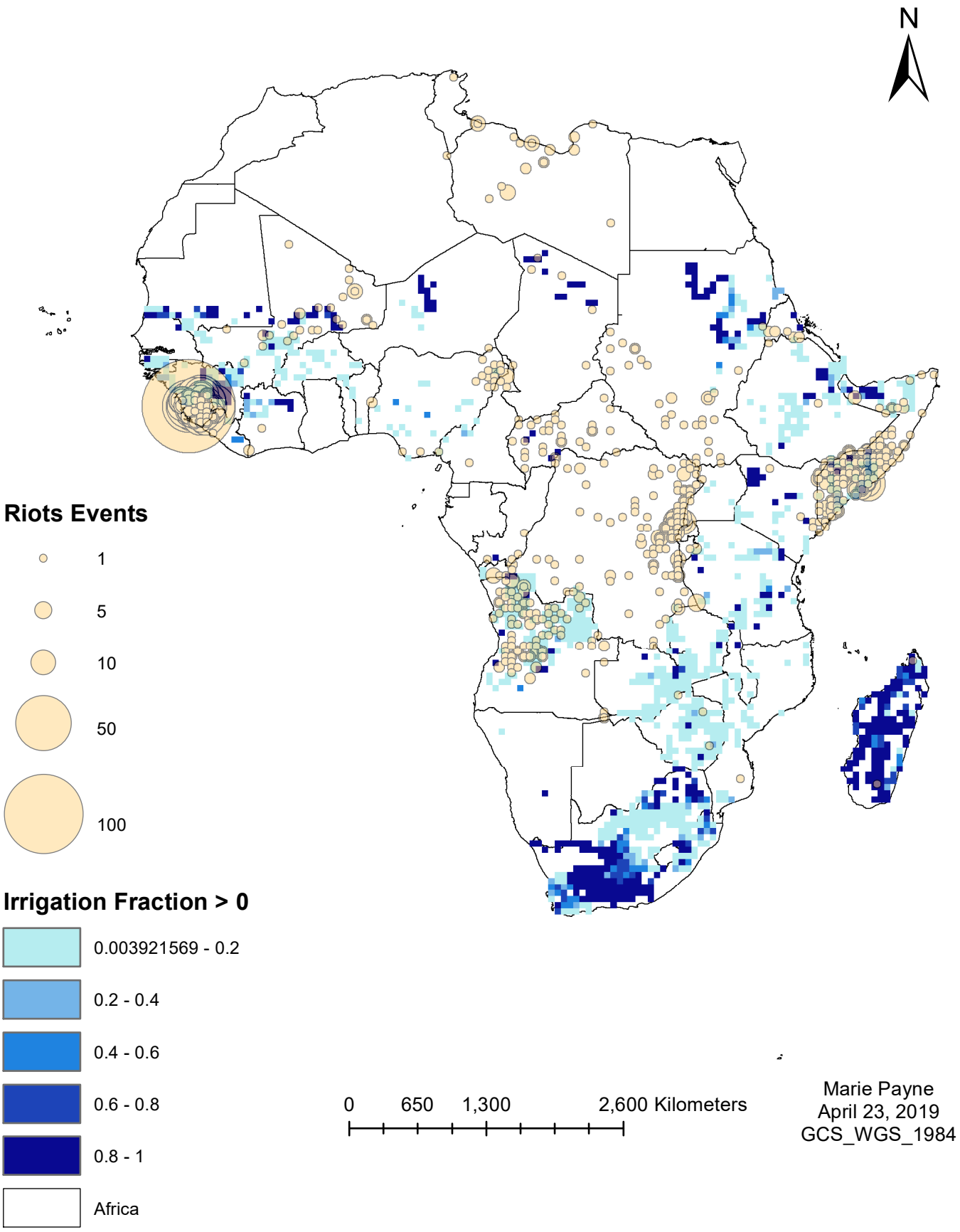
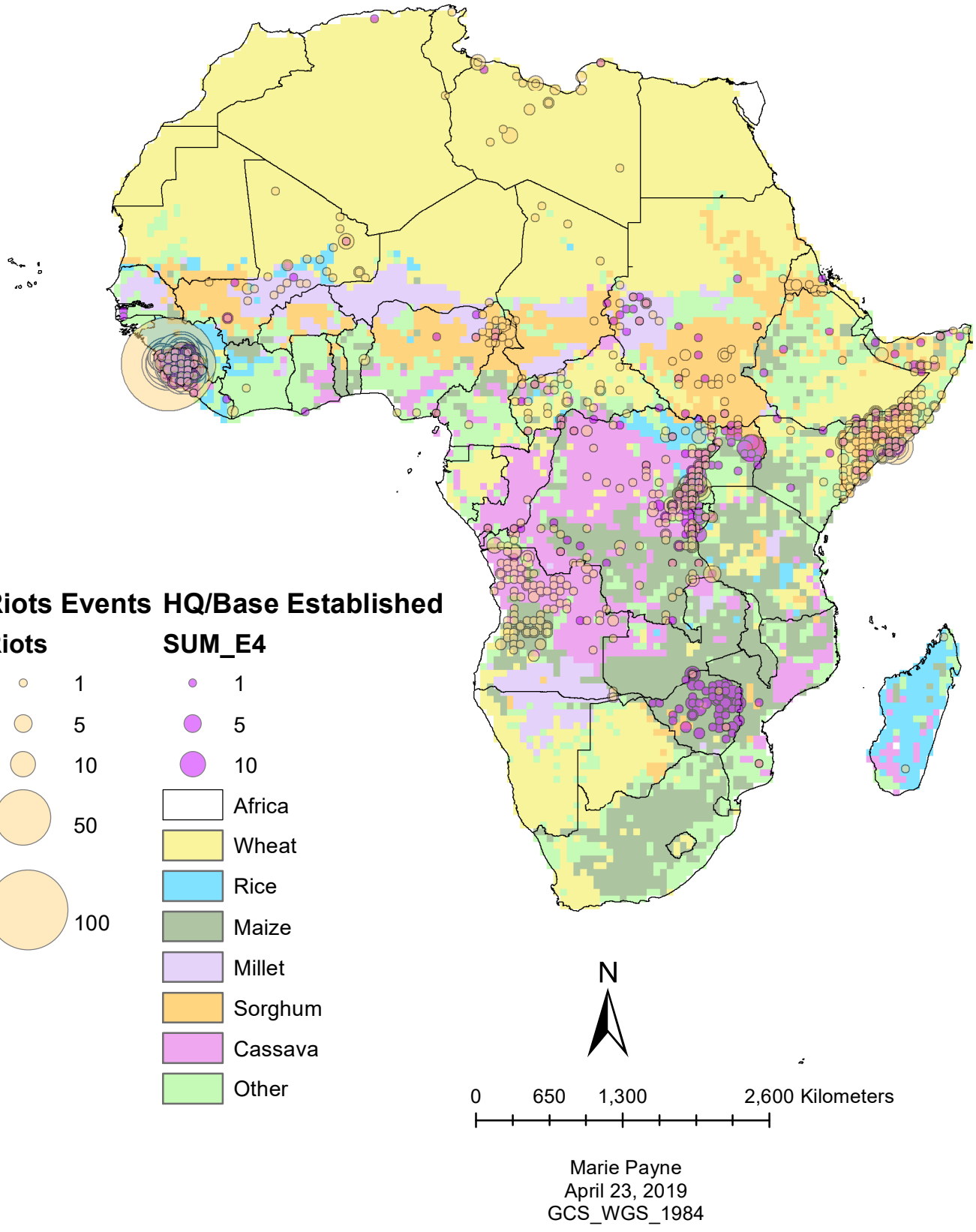


Figure 13

Base Establishment , Riot Conflicts, and Crops in Africa



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April 23, 2019
GCS_WGS_1984