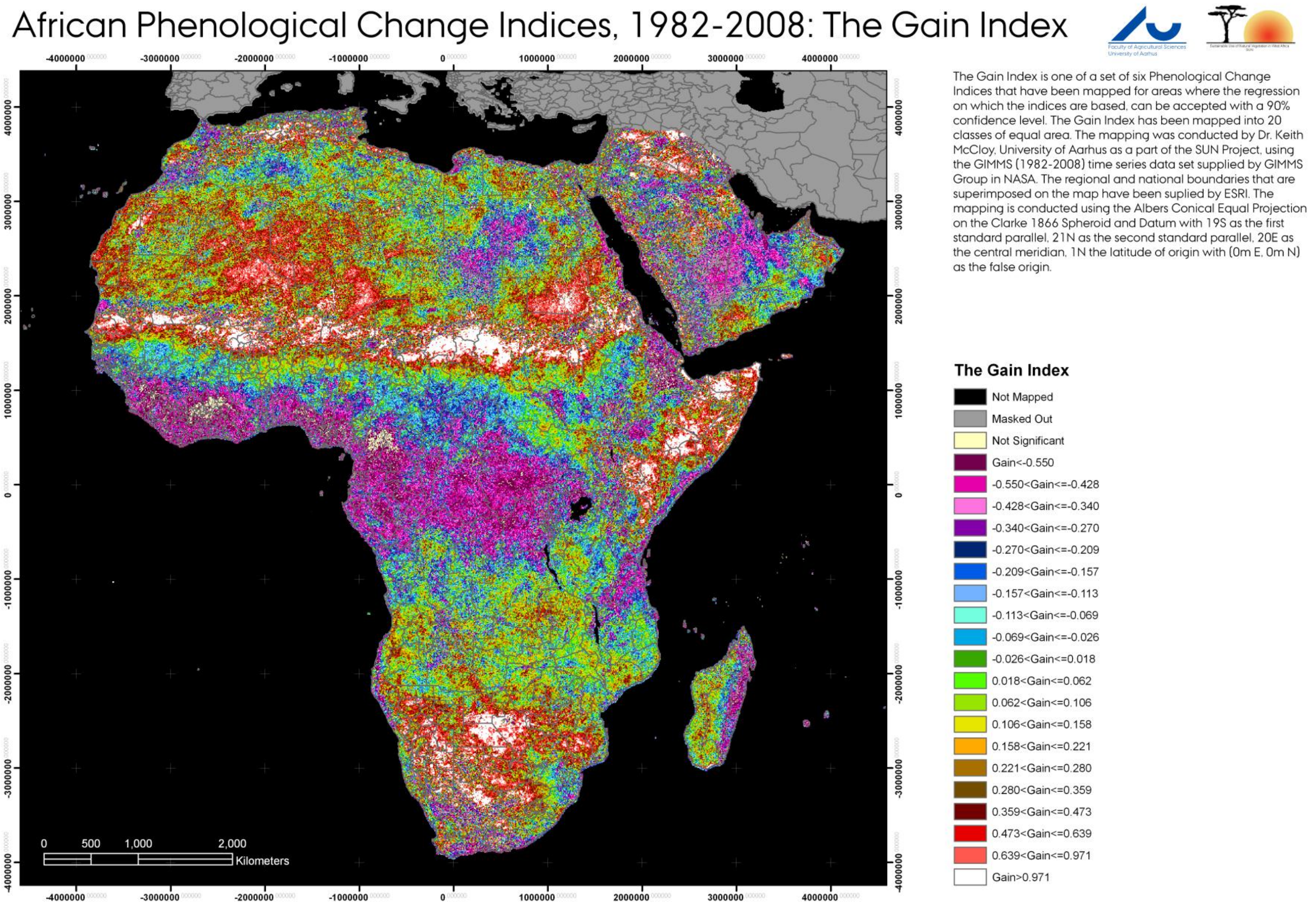

Figure 2.3. The Gain Phenological Change Index for Africa derived using the GIMMS dataset (1982 – 2008), using a second order polynomial for the fitting and 90% Confidence Level as the threshold for acceptance of the regression.

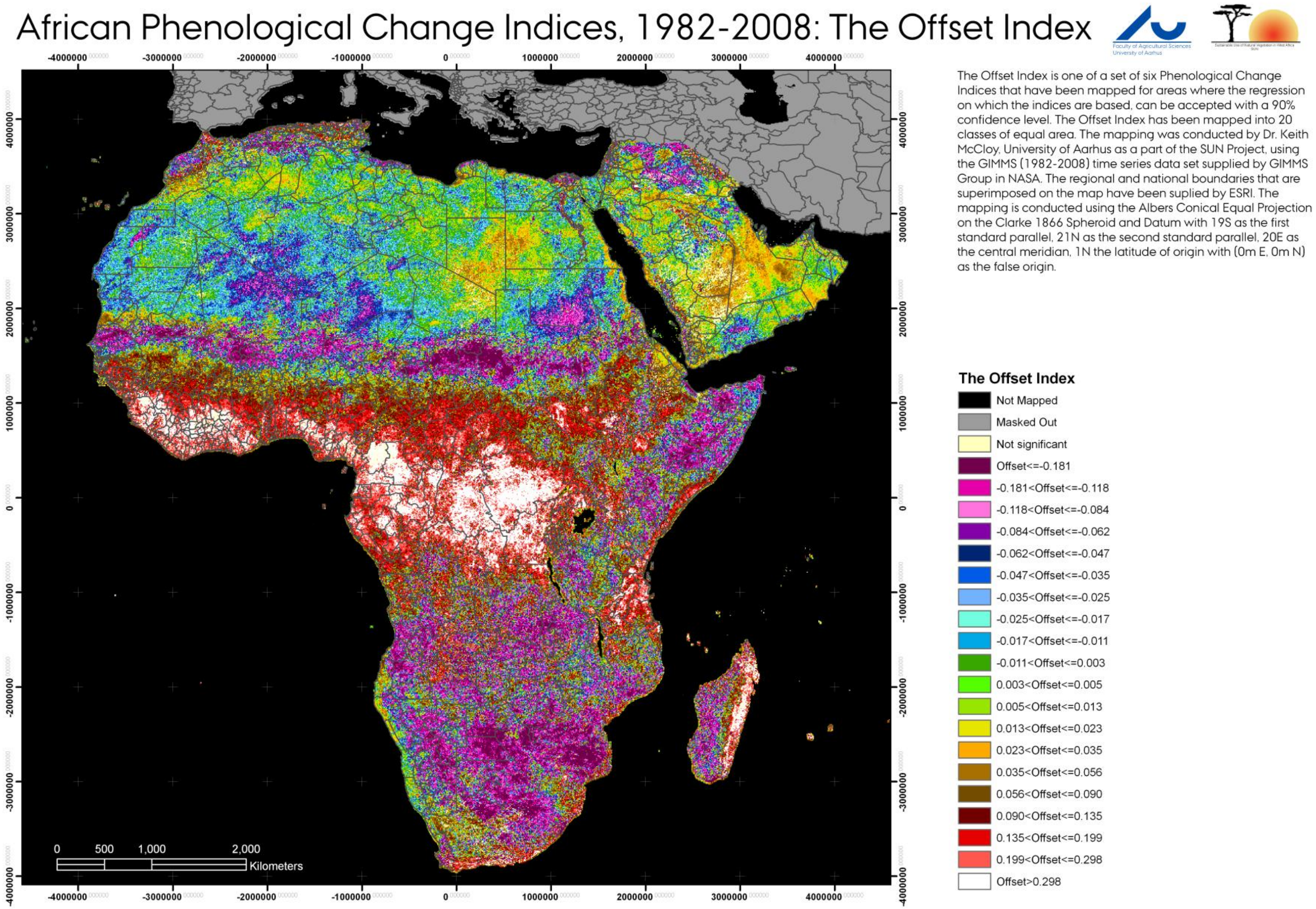

Figure 2.4. The Offset Phenological Change Index for Africa derived using the GIMMS dataset (1982 – 2008), using a second order polynomial for the fitting and 90% Confidence Level as the threshold for acceptance of the regression.

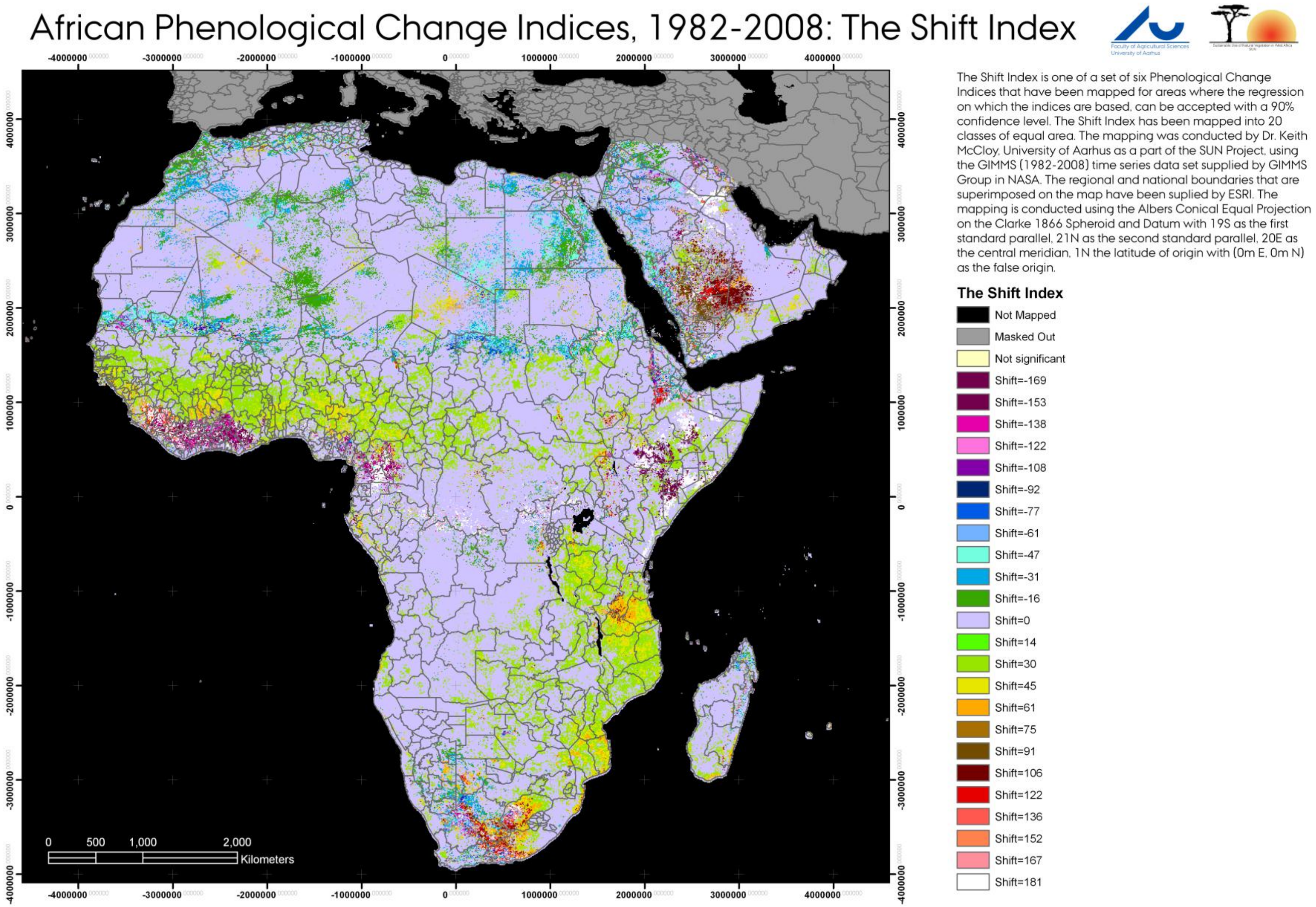

Figure 2.5. The Shift Phenological Change Index for Africa derived using the GIMMS dataset (1982 – 2008), using a second order polynomial for the fitting and 90% Confidence Level as the threshold for acceptance of the regression.

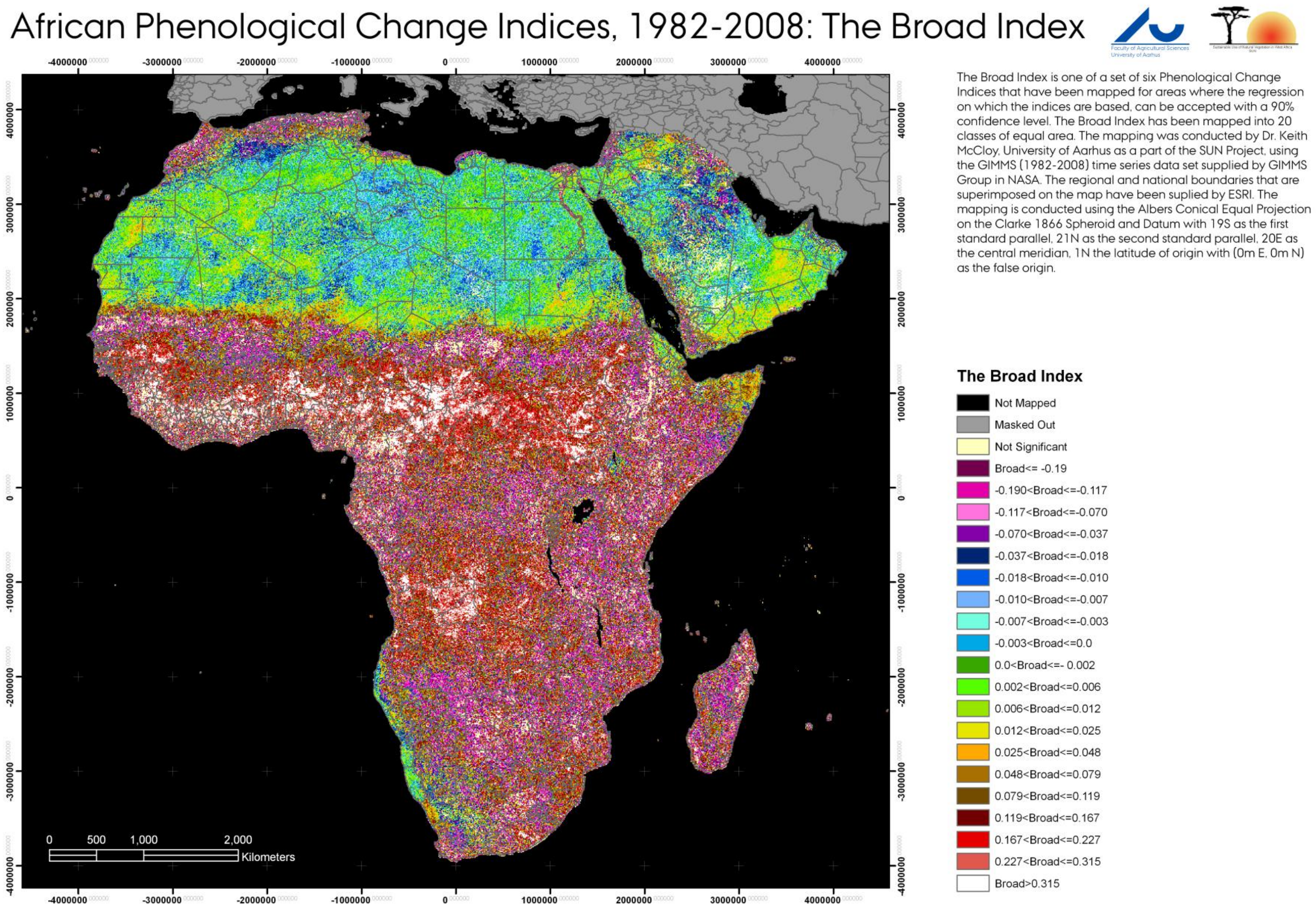

Figure 2.6. The Broad Phenological Change Index for Africa derived using the GIMMS dataset (1982 – 2008), using a second order polynomial for the fitting and 90% Confidence Level as the threshold for acceptance of the regression.

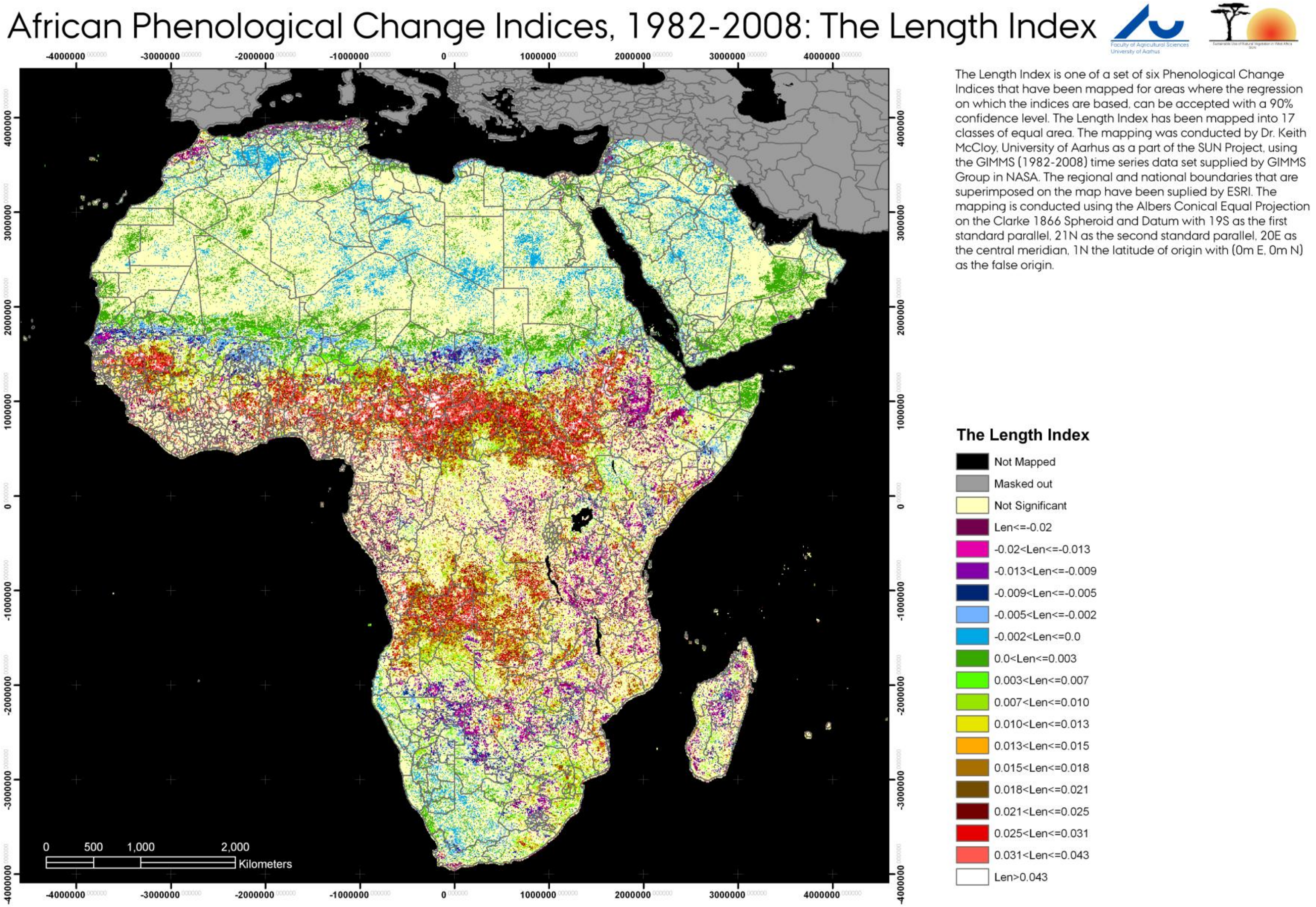

Figure 2.7. The Length Phenological Change Index for Africa derived using the GIMMS dataset (1982 – 2008), using a second order polynomial for the fitting and 90% Confidence Level as the threshold for acceptance of the regression.

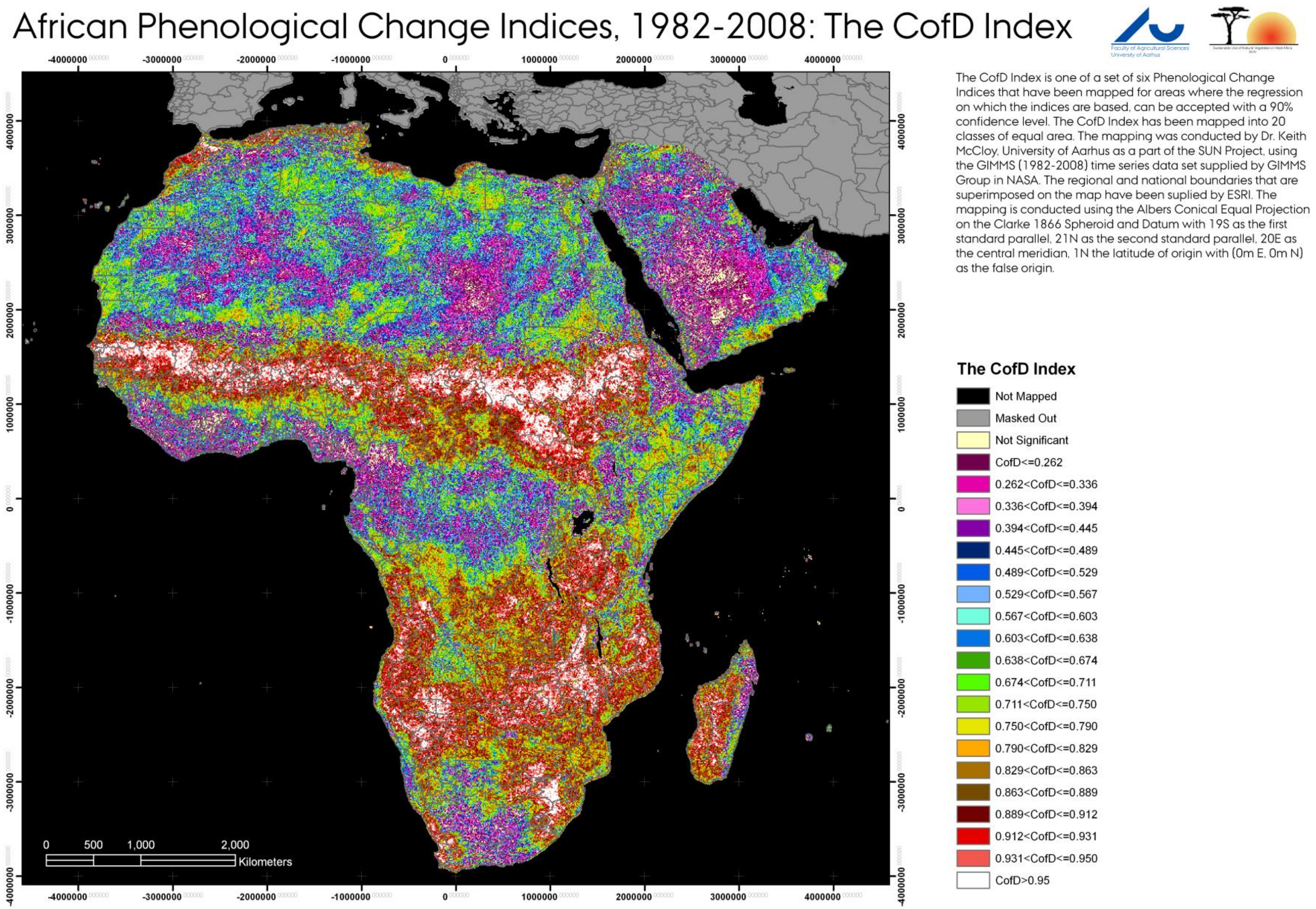

Figure 2.8. The CofD Phenological Change Index for Africa derived using the GIMMS dataset (1982 – 2008), using a second order polynomial for the fitting and 90% Confidence Level as the threshold for acceptance of the regression.

D2.3 The Relationship between plant communities, remotely sensed data and their drivers.

The detection and attribution of changes in vegetation to climate change and other forcing mechanisms continues to involve considerable scientific effort. Detection is defined as the process of demonstrating that an observed change is statistically significantly different from natural internal variability. Attribution is taken to mean a demonstration that the detected change can be explained by the impact of identified external forcing mechanisms, including natural and anthropogenic forcing mechanisms. In addition to the impact of these forcing mechanisms on the analysis and, hence, the deductions made, an important source of noise in the system arises due to errors in the data used in the analysis. Not only do such errors affect the general reliability of the results as assessed using standard statistical techniques, but such errors change over time, through changes in the data collection techniques amongst other reasons, and as such they may lead to trends that can lead to erroneous conclusions.

Considerable differences exist in the results reported in the literature. Part of the explanation for these differences arises because of the different response characteristics of different species to changes in the climate parameters as for example have been reported by Miller-Rushing and Inouye (2009) as well as by others. Another part is due to the regional differences in climate on the impact of the forcing mechanisms, such as those reported in Shutova et al., 2006 and others. Some of the remainder should be explained by other natural and anthropogenic forcing mechanism, but part of the residual must be due to errors that arise in the datasets that are used in the study.

To derive a general understanding of the relationship between changes in vegetation and changes in its forcing mechanisms is still a demanding task. Remotely sensed data provides the best promise of being able to address this need, due in part to the nature of the problem and in part due to the characteristics of the image data itself. The problem is spatially extensive, and with temporal variations imposed on top of the spatial variation, where both the spatial and temporal dimensions can vary from the biome and regional scale right through to the continental scale.

Each pixel in each satellite image in a time series of images covers a defined area on the earth's surface, recording the aggregated radiance from within the field of view for that pixel. Since each pixel area is covered by many to very many plants, and their background, it follows that the pixel records the aggregated radiance from all of the plants and their background. This mix can change over time, just as the response of the plants change over time and the mix of plants and their response values change spatially, so that the radiance recorded by a pixel will change over time, and the response for one pixel will differ from the response of other pixels covering the same biome, and certainly from pixels covering other biomes.

Seaquist et al (2009) found good agreement estimates of LAI derived by a process based model that models the evolution of natural vegetation and the satellite based estimates of NDVI, and from this they deduced that most of the changes detected in the vegetation in the Sahel are driven by the climate forcing mechanism of precipitation. This finding is in contrast to that of Brink and Eva (2009) who used extensive sampling of satellite images in 1975 and 2000 to map the images into four major land cover classes of forest, natural non-forest, agriculture and bare areas. They found that agriculture and barren areas had increased by 57% and 15%, respectively, over the 25 year period, at the expense of forests and non-forest natural areas which had shrunk by 16% and 5% respectively. An explanation for this apparent anomaly is embedded in Seaquist et al. (2009), since they also found that the correspondence of the model and image results were improved with increasing pasture areas. In semi-arid country, grasslands typically brown off in the dry season, and as a consequence the phenology of grasslands is very similar to that of crops. It is possible that Seaquist et al. (2009) in fact found that the correspondence between the model and NDVI was improved with increasing crops and grasslands, so that his results actually may be supporting the conclusion that anthropogenic forcing mechanisms are the primary driver for vegetation change in the Sahel.

This issue was addressed in the SUN Project by relating the vegetation based PCI's to PCI's derived for precipitation and temperature data. The individual vegetation based PCI's were regressed against the climate PCI's using a model of the form;-

$$\beta 0+\beta 1 * p+\beta 2 * p^2+\beta 3 * t+\beta 4 * t^2+\beta 5 * p * t=n$$

where βi are the regression coefficients to be found and *p, t* and *n* are the selected PCI for precipitation, temperature and NDVI respectively. Since most of the PCI's in a set of PCI's derived from a time series of image data are correlated, only one PCI can be used from each dataset in the regression. A second order model like this was chosen because plots of the PCI's for precipitation and temperature against NDVI showed non-linear characteristics for some pixel samples. The regressions were implemented for a 5 by 5 window about each pixel, so that the regressions represented 2.5^o of latitude and longitude, and with significant correlation between adjacent pixel results because of the overlaps in the used data. The fitting was only accepted if there were 19 or more satisfactory values in all three datasets in the 25 possible locations about the central pixel, and if the F-test showed that the regression was statistically significant at the 90% confidence level. From the regressions, the Coefficient of Determination showed the percentage of the variation that was explained by the independent parameters of precipitation and temperature. Beta values were derived from the regression coefficients and these were used to derive the proportion of this variation explained that was due to precipitation, temperature and both, derived from the sum of the beta values from $(\beta 1+\beta 2)$, $(\beta 3+\beta 4)$ and □*5* respectively. These results are shown using the Gain and Offset PCIs in Figures 2.10 to 2.13.

Figures 2.10 and 2.12 show the proportion of the variation in the NDVI Gain and Offset PCIs that is explained by the climate Gain and Offset PCIs respectively, not excluding areas that were not statistically significant in the regression at the 90% Confidence Level, so as to show the distribution of the Coefficient of Determination. These areas that were not statistically significant are mapped as purple on Figures 2.11 and 2.13. In all four Figures, a total of 3562 pixels or 33.76% of the African continent had regressions that were statistically significant. In the comparison of the variation in the amplitude of the peak of the Growth season or the Gain Index, the mean proportion of the variation explained was 0.4592, with a maximum of 0.9473 and a minimum of 0.3331, skewed to lower values so that only 1150 pixels or 9.95% of the African continent had more than 50% of the variation explained by the climate variables. Similar results were found with the analysis of the relationship between the changes in the average value or the Offset Index. In this analysis, the mean proportion of the variation explained was 0.4573, with a maximum of 0.9290 and a minimum of 0.3002, again skewed so that only 1083 pixels or 10.26% of the African continent had more than 50% of the variation explained by the climate variables.

Figures 2.10 and 2.11 show that there are regional areas in Africa where the proportion of the variation explained is quite high, all occurring in the Sahelian zone in Africa, but these are isolations amongst a generally low level of proportion explained. These values also compare poorly with similar figures for Eurasia where on average about 56% of the variation is explained by these climate parameters and the proportion with a statistically acceptable regression is above 50% of the continental area.

These figures for Africa support the findings of Brink and Eva, 2009 and Wittig et al., 2007 that anthropogenic factors are the dominant drivers for vegetation change in Africa. The low level of acceptable fittings in the regression of 33.76% compared to greater than 50% for Eurasia may also support this conclusion that the effects of other drivers may appear as quasi-random noise in the dataset and thus reduce the possibility of the F-Test being met.

Figures 2.11 and 2.13 show the relative contributions of precipitation, temperature and both to the proportion of the variation that is explained. The images are dominated by the purple of areas that did not have a statistically acceptable fit, but behind this mask one can see that there are patterns, in which temperature dominates the relationship between the Gain Indices in West Africa and precipitation in East Africa. The Offset comparison shows a very different picture. Here temperature dominates in the arid Sahelian and Saharan regions, but precipitation dominates in the moister regions.

One of the significant problems with this analysis is that significant levels of error exist in all three datasets. This means that Ordinary least Squares regression will under-estimate the Coefficient of Determination, and so using Total Least squares, one can expect somewhat higher values of the Coefficient of Determination.

In addition, the patchy nature of the image makes it difficult to see trends across Africa. The approach taken to deal with this issue was to map Africa into regions that were similar in the PCI's and then mean values for these regions were used in the regressions to derive regional Coefficients of Determination and regional models. This analysis shows that the correlation between precipitation and vegetative response is higher than between temperature and vegetative response and that the level of correlation varies significantly across the continent, with the average level of correlation with precipitation being about 35% whilst it is about 21% with temperature.

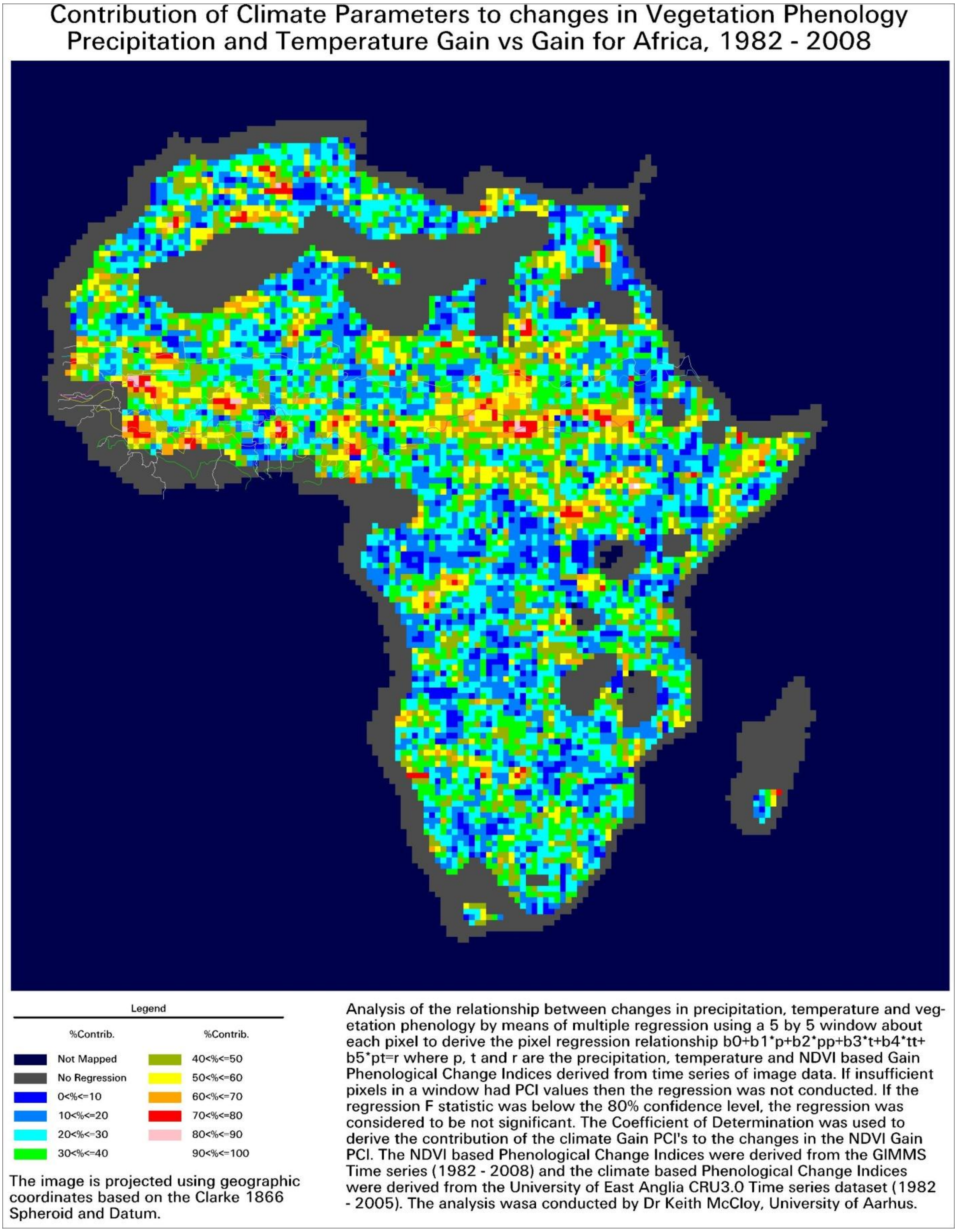

Figure 2.9: The proportion of the variation in the NDVI Gain PCI explained by the climate gain PCIs.

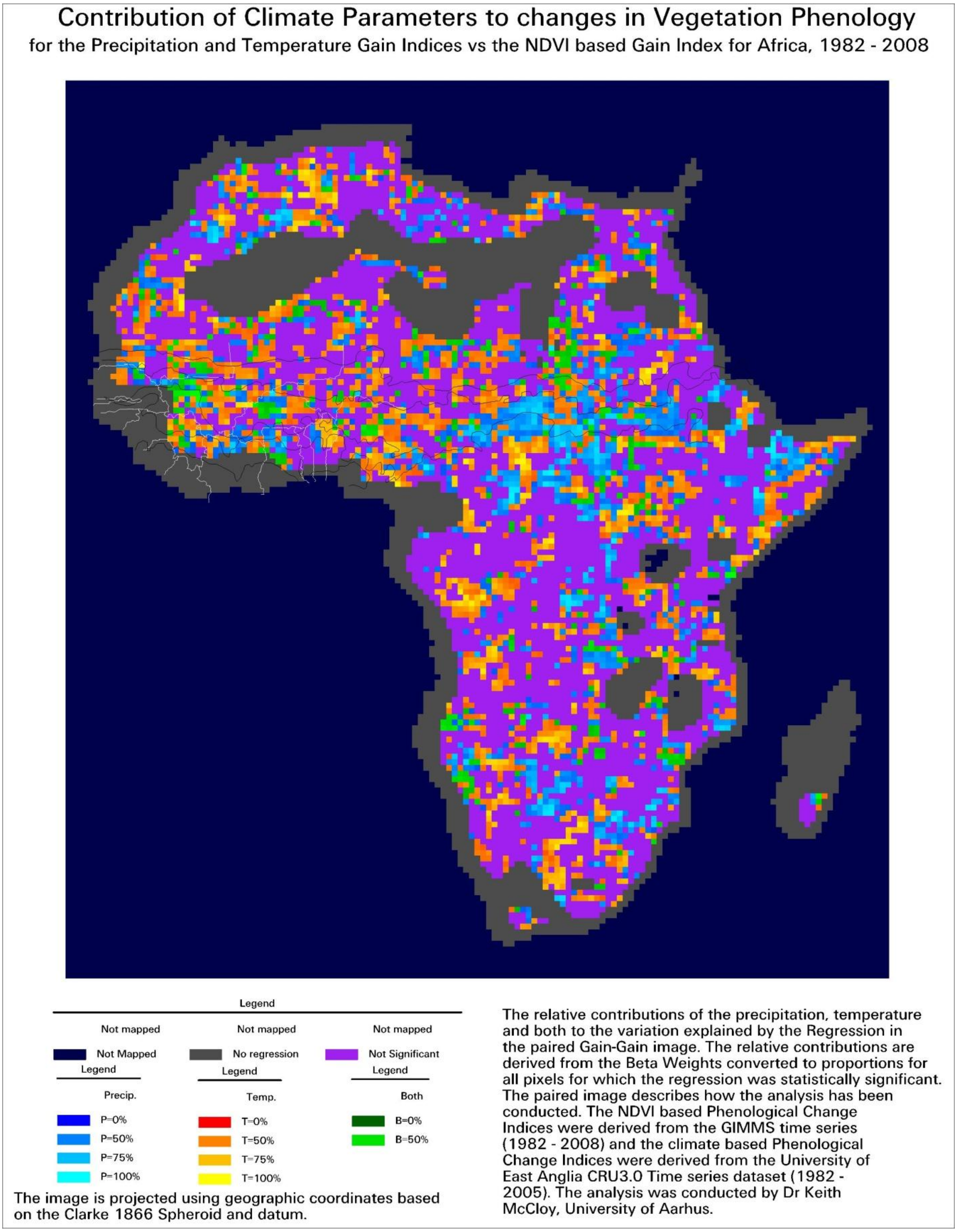

Figure 2.10: Relative Contributions of Precipitation, Temperature and both to the variation explained.

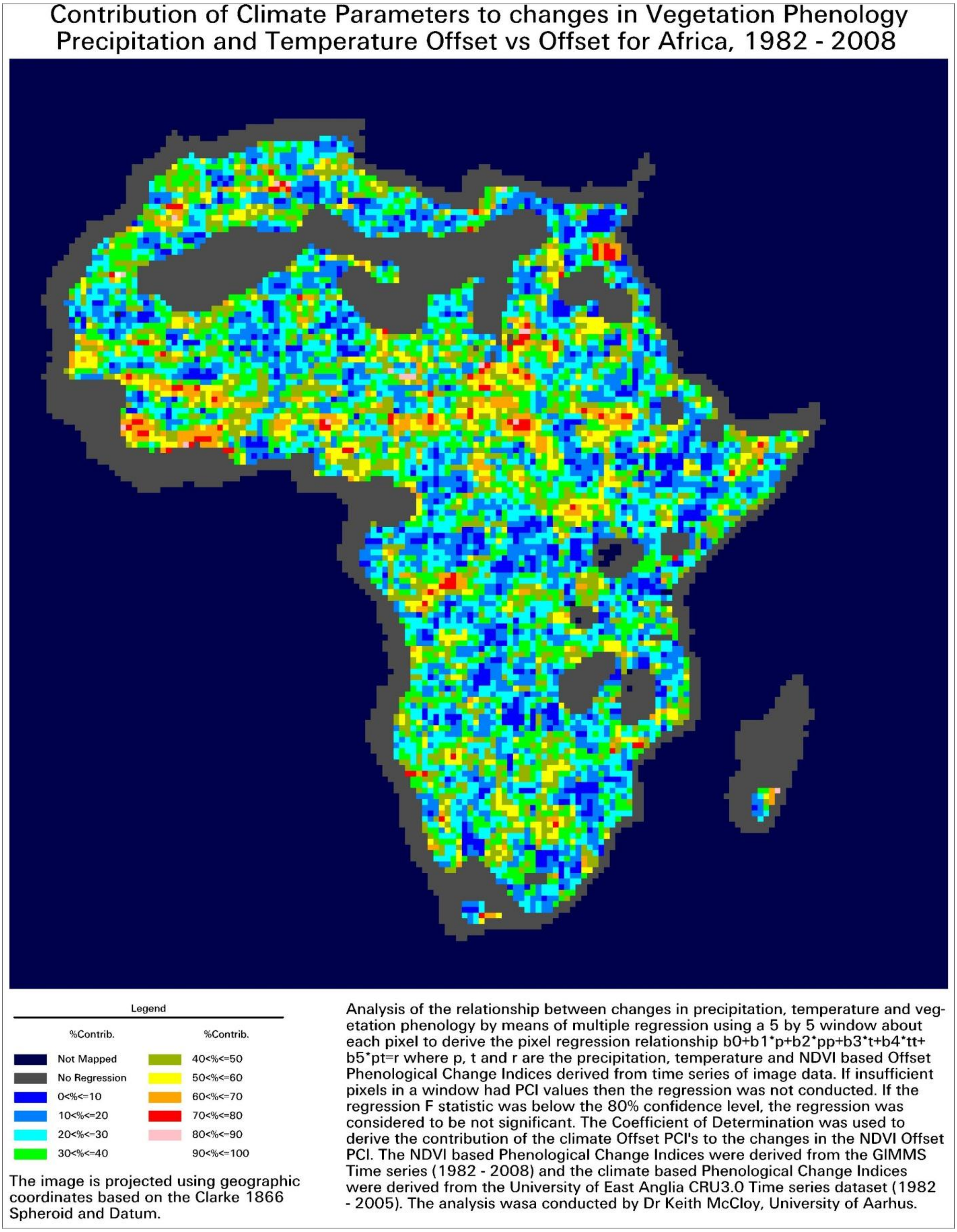

Figure 2.11: The proportion of the variation in the NDVI Offset PCI explained by the climate Offset PCIs.

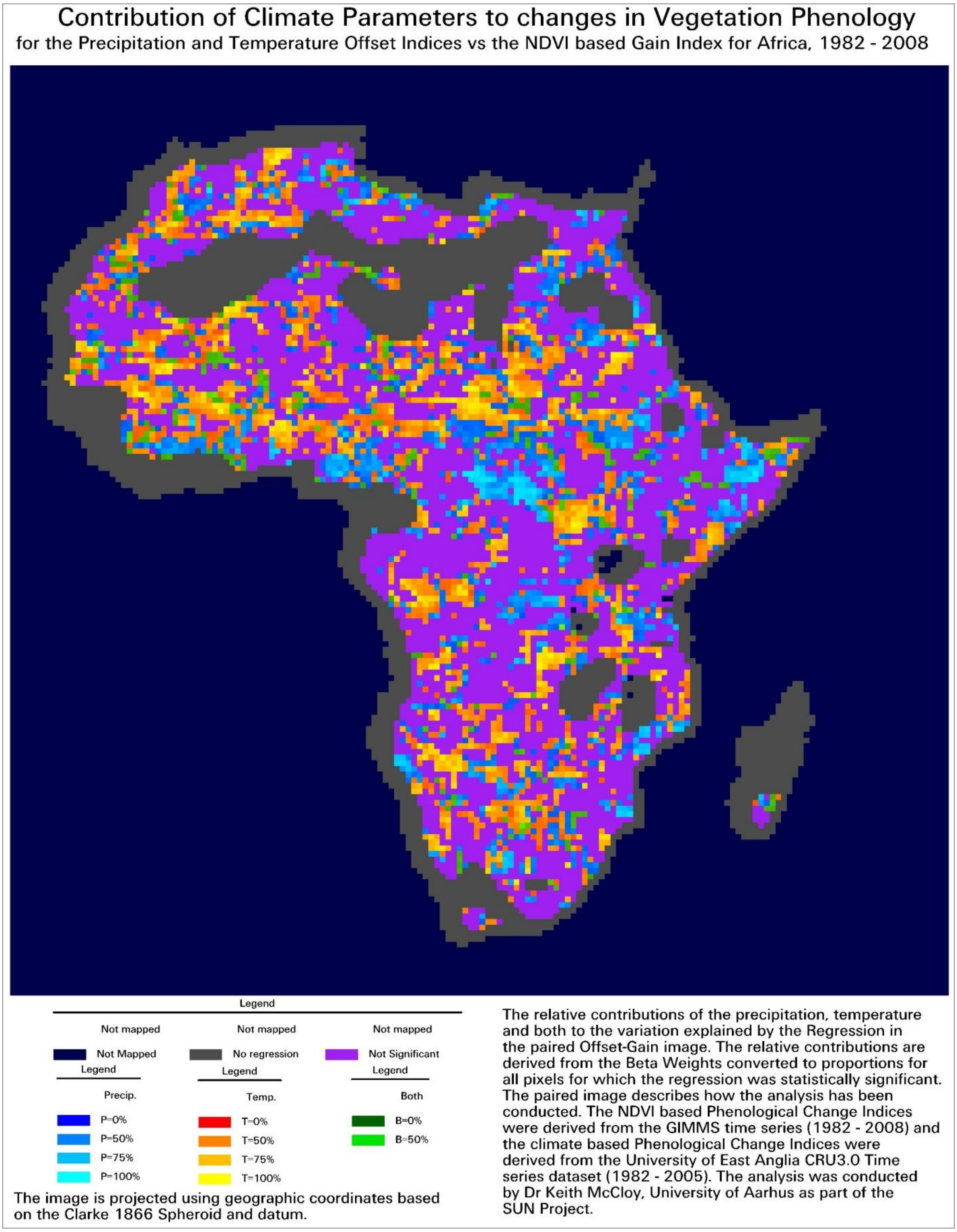

Figure 2.12: Relative Contributions of Precipitation, Temperature and both to the variation explained.

The relation between vegetation, carbon and climate in Africa

The relation between vegetation, carbon and climate in Africa has been investigated in order to determine how climate and other environmental factors influence the distribution of vegetation types across Africa. The purpose of this study was to use vegetation classification based on remote sensing data to assess how successfully vegetation distributions in Africa can be explained by climate and also, which environmental factors are most important for each of the different vegetation types. This forms the first such study at large geographic scale. In addition, we wanted to determine to what extent vegetation has the potential to increase carbon storage in Africa, and in which areas across the continent this would be particularly beneficial.

The drivers of vegetation distribution were assessed for the entire continent. Because the vegetation map that was used was obtained from remote sensed data, it was possible to ascertain how both environmental and anthropogenic factors may have driven the distribution of vegetation. Amongst environmental factors, annual rainfall always emerged as the most important determinant of vegetation distribution. Deserts and evergreen forests were best predicted by environmental factors. This work has been submitted to Global Ecology and Biogeography for review.
The potential for carbon sequestration projects in West Africa was also assessed. A carbon storage map based on remote sensing data was used to quantify the relationship between maximum potential carbon storage the environment, and this relationship was used to calculate the potential carbon sequestration across the region and identify areas of high potential for sequestration, and also quantify the possible potential of these projects.

Investigation into the relationship between the vegetation of the PATAKO area and its driving forces

This synthesis summarizes the different impacts of stresses factors in vulnerable ecosystem spots due to the combination of natural and human influence in Patako and around. Despite its enormous potential, Patako is becoming increasingly fragile due to the degradation of natural resources as a result of numerous constraints: environmental, social and economic.

The main problems in place are degradation of vegetation, erosion, bush fires, development of plant parasites and salinity. All these factors are interrelated to climate trend and human livelihoods.

The vegetation of the area has undergone various forms of degradation due to human activities such as bush fires, shifting cultivation, extraction of firewood and the use of wood for various purposes (medicines, food, construction of traditional houses, crafts). Degradation of vegetation is seen as the downturn of the ecological balances in that the area. The environmental consequences of deforestation have serious implication on ecosystems equilibrium and ecosystem services. They include spatial and temporal changes of cropland, deforestation of valuables vegetation stands, pasture expansion, etc.

The clearing of natural vegetation exposes soil to erosion risk. Analysis of satellite images shows an increasing change in the land processes which resulted in an expansion of cropping areas at the expense of natural vegetative cover that could protect the soil against erosion. Soil erosion has become a major factor in degradation of ecosystems in the area. The soil erosion has taken on considerable areas, due to the combined action of deforestation, improper agricultural practices. Land degradation has impacts on the physical and socio-economic consequences.

Bush fires, especially those occurring during the last months of the dry season just before the rains, have severe impacts on remaining vegetation. The grass is very dry at that time, fire destroyed the stems and the aerial parts of trees. The land is virtually naked and remains poorly protected for at least a year. As bush fires are repeated every year in many parts of the area, soils are dry and become very vulnerable to erosion. Therefore, heavy rains alter the surface, which becomes an outcrop with very low permeability resulting in an abundant runoff.

The advent of the drought of 1970 has greatly reduced agricultural production and exacerbated the damage caused by weeds and making people's lives very precarious. Production systems are undergoing major changes: intensification of land use, reduction or sometimes abandonment of fallow and changing farming systems. Indeed, the occupation of arable land by a population increasingly growing together with the practice of monoculture, the reduction or abandonment of fallow, and lack of maintenance of soil fertility, has promoted the colonization cultivated area by certain plants, including parasites *Striga hermonthica* and consequently greater vulnerability of crop yield.

In the valleys, we have identified two major constraints: salinization and proliferation of invasive aquatic plants, especially *Typha domingensis*.

The phenomenon of salinization that now prevails in the area is the result of several factors: the worsening climate change (drying), undercover of fossil salts, low slopes and the influence of tidal waves. All components of the natural environment have been profoundly affected by salinity in recent years, and result mainly in soil degradation, contamination of the groundwater and degradation of biodiversity. Salinization formerly confined to mangroves is now expanding in the gallery forest and arboreal and horticultural areas, especially in the northern part (see map).

The alteration of the ecological balance of wetlands has led to a rapid proliferation and excessive aquatic vegetation, including *Typha domingensis* which is a major concern that eventually may cause eutrophication. Stands of *Typha sp*. have large extent in the southern parts of the gallery forest. Sediments are transported in the shallow depressions with several impacts on productive systems. This siltation of water disrupts the flow of water and creates a sort of dam that holds some water upstream, while little water arrives in other sectors. This stagnant water causes the disruption of ecological conditions.

The intersection of these different stress factors enabled us to develop a vulnerability map of the area.

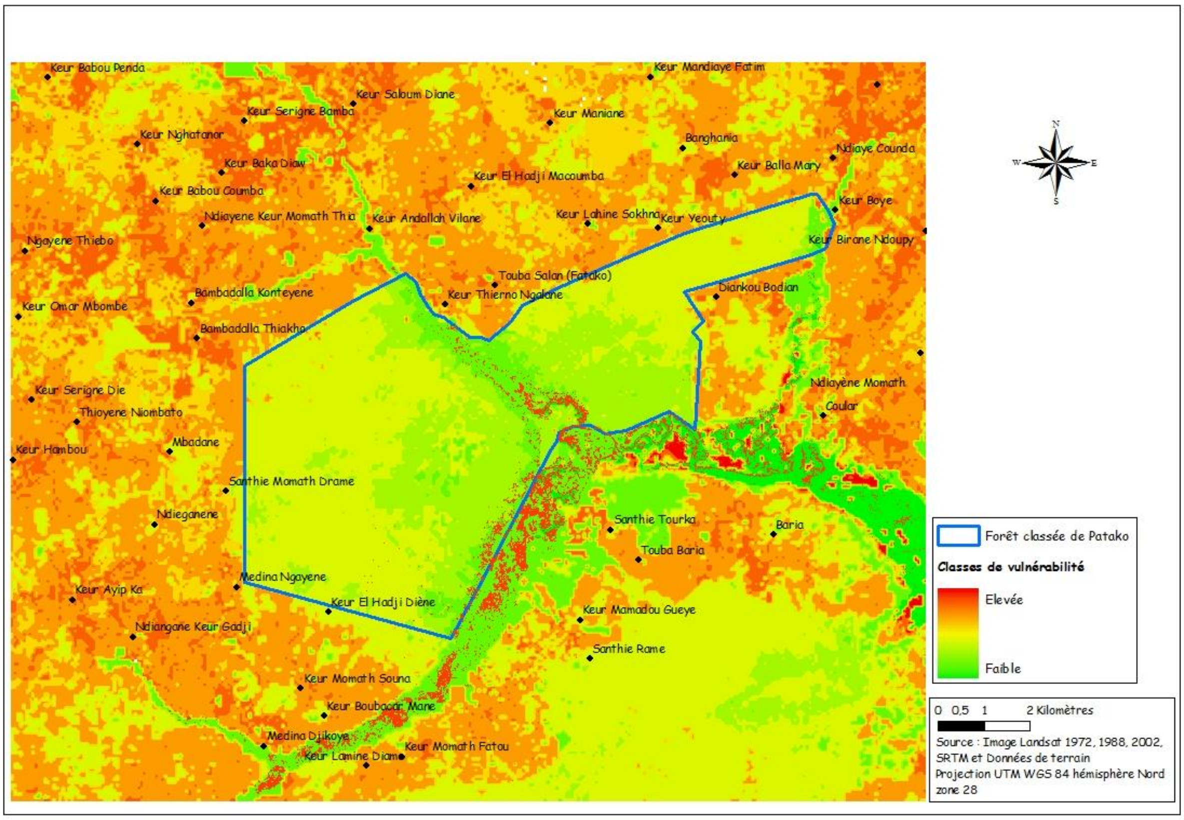

Figure 2.13: Map of Vulnerability Zones in the Patako Area (Red is high, Green is low)

D2.4 Numeric models to predict vulnerable areas

Numerical modelling work has now been done to indicate those areas that are vulnerable to changes in climate, and maps of such areas will be produced over the next three months. However, the analysis work being conducted shows that climate is not the dominant driver for changes in vegetation, but that rather the dominant drivers are probably related to the activities of man. So far, no adequate datasets have been found that can be used to test this hypothesis.

Partner 5 (Senckenburg) used grasses (Poaceae) as a dominant component of sub-Saharan savanna ecosystems to show that the predictive power of modeling approaches improves with the geographical coverage and density of the dataset available. This project is a cooperation of CIRAD, Montpellier, University of Ougadougou and Senckenberg Research Institute and largely based on vegetation data extracted from the vegetation database established during the SUN project. Thanks to the availability of 16.062 individual records as a result of data pooling in order to facilitate analyses with a regional scope – a major aim of SUN-WP 4 – distribution areas for 471 grass species have been modelled and combined to analyse overall grass diversity in West Africa as well as the distribution of plant functional, physiological and morphological types.

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WP3 Local and socio-economic aspects

Dr. Mipro Hien, Partner 7
Participants: P1 (Aarhus), P3 (Dakar), P6 (Ouagadougou), P7 (Bobo-Dioulasso), P8 (Cotonou), P10 (Niamey)

WP objectives:
In the context of widespread poverty among natural resource-dependent people, the prime concern of WP3 is to investigate local and socioeconomic aspects of environmental management. The overall objective is to identify local needs and preferences and best overall natural resource policies for enhancing sustainable economic growth in the local area.

The specific objectives are:
To identify local preferences and needs in relation to vegetation use.
To analyse what types of economic instruments, such as subsidies, taxation, quotas or other property right institutions may be politically feasible.
To identify and redress cultural and socio-economic impediments to sustainable use.
To analyse socio-economic information at regional scale in relation to remote sensing maps and vegetation dynamics.

Deliverables

D3.1 Analysis of local needs and preferences

- **Patako Core Area:**

Master student Steen N. Christensen, Aarhus University (P1), worked on the "Socio-economic and ecological determinants of local scale tree distribution, diversity and dynamics in agroecosystems in West-Central Senegal". His work highlights some important problems in relation to local knowledge and preferences in relation to tree planting:

- Only 36% of the informants think that soil enhancing plants exist, and among these *Faidherbia albida* was the most mentioned.
- When informants were asked which tree species they would like to have on their land, more than 50% mentioned mango (*Mangifera indica*), orange (*Citrus sinensis*) and cashew (*Anarcardium occidentalis*). There was very little awareness about the possibility of planting native fruit trees.
- All informants would like more trees. On average, they were ready to allocate 19% (2 ha) of their land for the desired trees, with a range of 0.1 – 10 ha.
- Out of 366 trees recorded, 25 tree species were found with an average height of 11.0 m and a range from 2.0-22.5 m, an average dbh of 62 cm and a range from 5-256 cm.
- *Cordylla pinnata* was the dominating tree species, comprising 50% of all trees.

For the Patako forest, all data regarding local needs and preferences are already collected. Data have been analysed and a chapter has already been written. A manuscript will be submitted this year. The results of the study show that 34 species from 73 listed woody species have been selected as the most important by local populations. For men, wood was the major criteria of species preferences. Medicinal use of plants comes in second position followed by animal feeding and human consumption. For women, the preferences are fruits and fuel wood. The same level of species preferences has been noted for pregnancy problems, infant diseases, malaria and arterial high blood pressure. *Cordyla pinnata* and *Parkia biglobosa* are two species of great preference in this southern part of Saloum, despite the significant regression of their population.

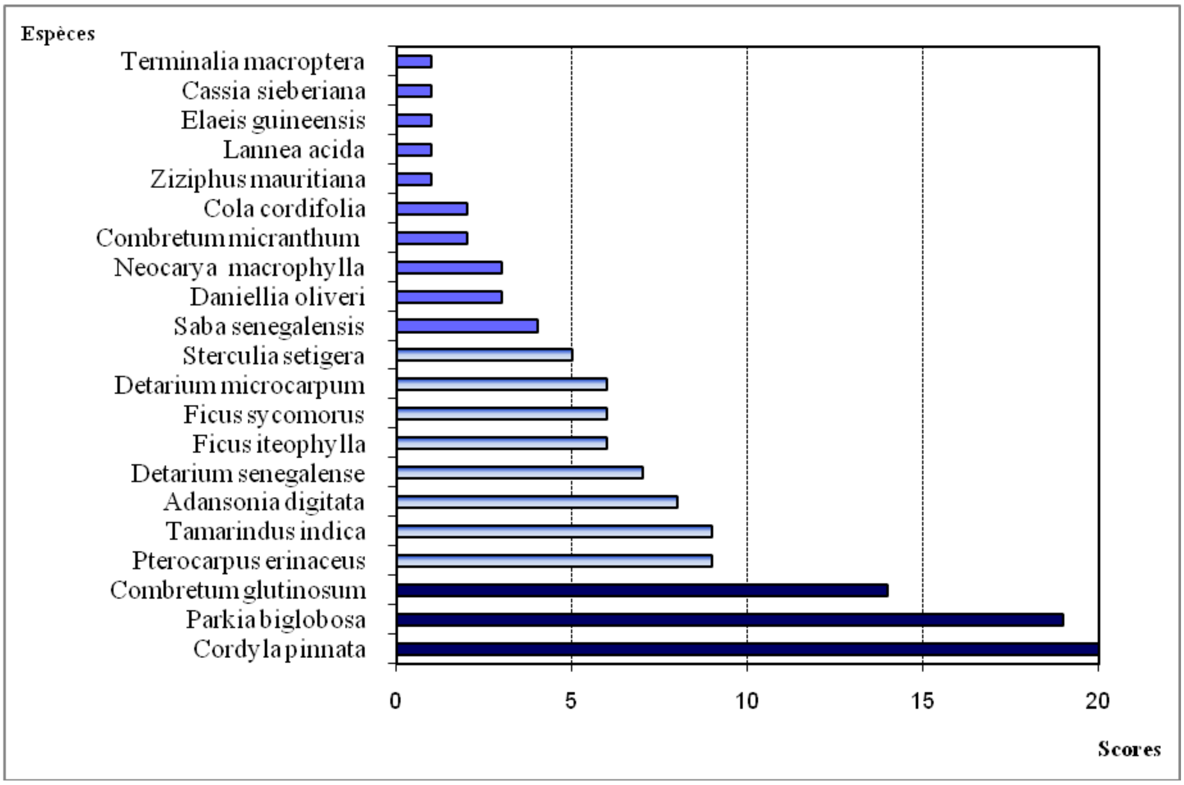

Figure 3.1: Species preferences of women

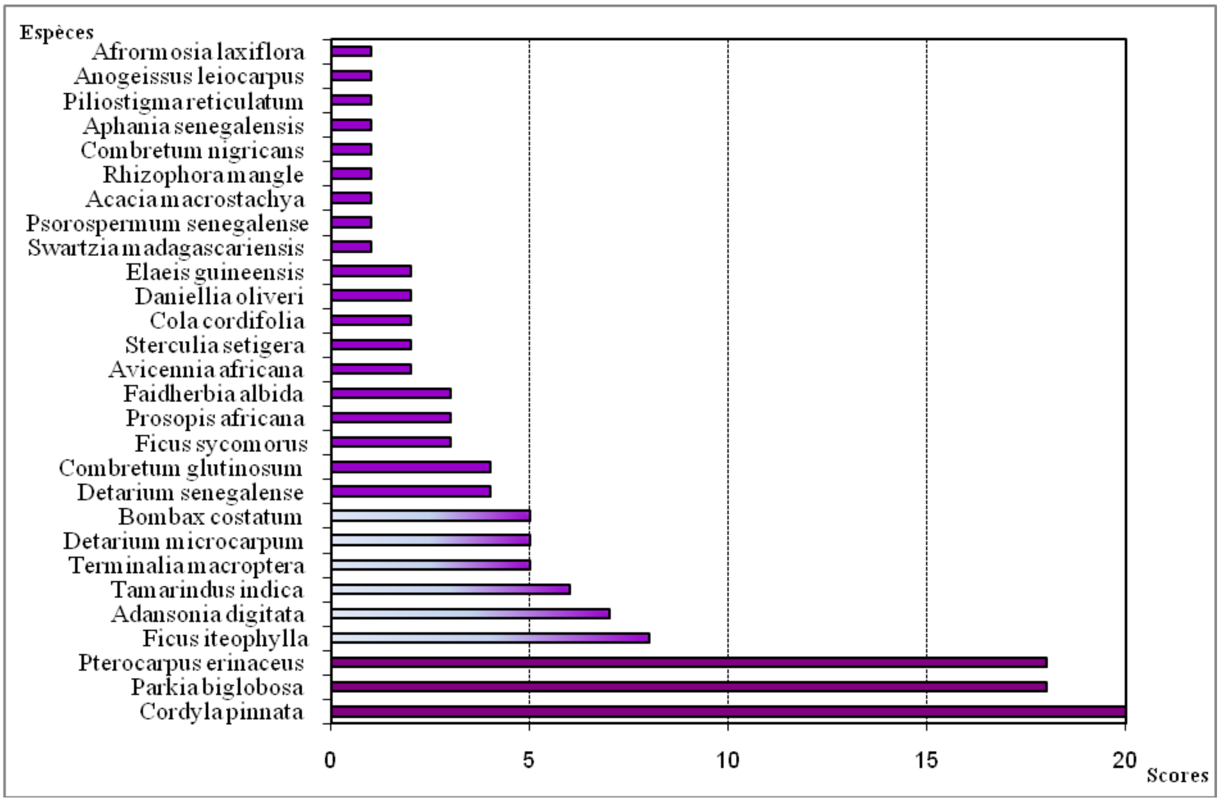

Figure 3.2: species preferences of men

Many other socio-economic data have been collected. They are related to the main socio-economic problem of natural resources management, the management methods and the best practices in terms of forest resources management. These results will be presented in the management plan (WP7).

One of the constraints that has affected the progress of the work is the change in the rural community leadership after local elections.

- **W Park Core Area:**

The main conclusions about socioeconomic aspects of Parc W, Burkina Faso, have been summarised in the work of several PhD students from Ouagadougou University (P6)

- The main needs for the populations bordering the Parc W regarding woody species, as shown by the data of our investigation among the population, are food (40%), firewood (20%), pharmacopoeia (20%), fodder (10%), timber (5%) and crafts (5%).
- According to the local people, the most preferred woody species come by order: the shea tree (*Vitellaria Paradoxa*) for food (60%), firewood (28%) and timber (12%), locust (*Parkia biglobosa*) for food (67%) and for pharmacopeia (33%), the baobab tree (*Adansonia digitata*) for food (94%), sawlog (5%) and epicarp for heating (1%), Kapoquier (*Bombax costatum*) for food (65%), sawlog (25%), and crafts (10%), the caïlcédrat (*Khaya senegalensis*) for timber (64%) and firewood (36%), Balanites (*Balanites aegyptiaca*) for food (75%), sawlog (20%) and firewood (5%), the raisinier (*Lannea microcarpa*) for food (80%) and firewood (20%), the gardenia (*Gardenia spp.*) for food (60%) of wood heating (40%) The eucalyptus (*Eucalyptus camadulensis*) for sawlog (80%) and firewood (20%), the Neem tree (*Azadirachta indica*) for wood for heating (66%) and the pharmacopoeia (34%), Pterocarpus erinaceus for fodder (80%) and sawlog (10%) firewood (10%), Afzelia africana fodder for (75%); sawlog (20%) and firewood (5%), the other woody species for various uses.

The main conclusions about socioeconomic aspects of Parc W, Benin, have been summarised in the work of several PhD students from the University of Abomey Calavi (P6).

- Five high valued species around W National Park in Benin were under investigation regarding their dynamics. These species were *Sclerocarya birrea, Prosopis africana, Parkia biglobosa, Afzelia africana and Daniellia oliveri*.

Assessment of NTFP extraction and utilization

- 172 species of NTFP were used and played an important role in local communities' livelihoods as food, medicine, fuelwood, and for handwork.
- Extraction of NTFP was a seasonal activity and engaged mostly women.
- *Anogeissus leiocarpa* and *Crossopteryx febrifuga* (as fuelwood), *Vitellaria paradoxa*, *Parkia biglobosa* & *Adansonia* digitata (as food & medicine) were the most used.
- These plants should be taken into account to define community priorities for scientific study in relation to forest resources management.

Assessment of NTFP economic value and contribution to household revenues

- Results showed that 11.45 % of the total annual revenue per household, representing **255,484 CFA,** was provided by NTFP commercialization.
- When including self-consumption of marketed NTFP, this revenue reached **303,657F CFA**.
- Valuation of self-consumption NTFP revealed that they generate up to 1,488,000 CFA.

Assessment of competitive time allocation between NTFP collection and agriculture (case of cotton culture)

Cultivating cotton and harvesting NTFP were found to be competitive activities as far as labour allocation was concerned.

Estimate of Demand for NTFP

- NTFPs are normal goods.
- Own-price elasticity is consistently inelastic.
- As indicated by the inelastic response, pricing policies may not be very useful in manipulating NTFP extraction.

Local needs and preferences in Karmama district have been specified:

Table 3.1: Ranking of spared species for soil fertility restoration and improvement of farmers' incomes

Ranking	Restoration of soil fertility	Economic value
1	*Vitellaria paradoxa*	*Vitellaria paradoxa*
2	*Piliostigma reticulatum*	*Tamarindus indica*
3	*Borassus aethiopum*	*Parkia biglobosa*
4	*Parkia biglobosa*	*Balanites aegyptiaca*
5	*Tamarindus indica*	*Adansonia digitata*
6	*Balanites aegyptiaca*	*Vitex doniana*
7	*Adansonia digitata*	*Borassus aethiopum*
8	*Vitex doniana*	*Sclerocarya birrea*
9	*Ficus sycomorus*	*Mangifera indica*

Main spared species:

- ✓ For restoring soil fertility: *Vitellaria paradoxa, Piliostigma reticulatum, Borassus aethiopum, Parkia biglobosa.*
- ✓ For improving farmers'income: *Vitellaria paradoxa,Tamarindus indica, Parkia biglobosa.*
- ✓ For animal feed: *Pterocarpus erinaceus, Sclerocarya birrea, Ficus sycomosus, Khaya senegalensis, Albizia chevalieri, Guiera senegalensis* and *Acacia seyal.*

➢ **Boulon-Koflandé Core Area**

Based on 97 interviews conducted during field work in the forest area of Boloun-Koflandé by Aarhus University (P1), the following conclusions have been drawn:

- The PAGEN project, the aim of which was to protect the forest of Boulon-Koflandé, has succeeded in terms of reducing illegal trespassing into the forest. Local rangers are engaged in the protection of the forest and have been paid by the PAGEN project. The impression of rangers and villagers, who have been working in the forest since the project started, is that the wildlife and fauna has improved since the implementation of the project.
- The PAGEN project has put high restrictions on local use of natural resources (plants, nuts, dry wood) inside the forest of Boloun-Koflandé. These are resources which local villagers previously have relied on to ensure basic needs, such as food, fuel and medicine. Many villagers explained that the restrictions have had a negative impact on their livelihoods. Women reported that they have lost access to important income generating sources, such as shea nuts, due to the protection of the forest.
- The PAGEN project has extended the forest border so that water points previously accessible to the villagers are now annexed to the forest. Villagers report that no efficient alternative water sources have been provided, resulting in increased water shortage to villagers and their cattle. Some villagers report that this has also caused an increase of water fights and tensions between farmers and herders.
- There seems to be quite some confusion as to what the villagers actually are allowed to do and not to do in the forest. This confusion persists both among villagers themselves as well as officials (i.e. the Forest Service). Lack of information seems to be a general problem.
- Despite the problems caused by the PAGEN project, the village people seem to show a genuine interest in protecting the forest. Most villagers believe that they can benefit from the forest in the future through revenues such as safari tourism.

- The future of the PAGEN project had yet to be confirmed at the time of the field work. Finances seem to be a pressing problem.
- Greater attention to the basic needs of the villagers is necessary to ensure the success of the project.

Ethnobotanical studies on five economically useful tree species showed:

- All five plant species are known by all informants and have multiple uses. All informants (100%) use at least some of the species for food, and they all use the fruits to eat and to make juice, porridge, beer and tô, a local dish based on a porridge of maize or millet.
- Fruits from *Saba senegalensis* and *Tamarindus indica* can also be dried for conservation and stored until the next season.
- Leaves from *Tamarindus indica* and *Vitex doniana* are used by 87.7% informants for sauce.
- Stems from *Saba senegalensis* and *Diospyros mespiliformis* were used for construction by 31.5% informants as cords and boards for roof construction.
- At least one of the species was used for tools/utensils by 97.7% informants, all species and all parts of the plant were used for this category.
- The stem is, obviously, most important, and the liana *Saba senegalensis* is used to make plaited baskets for a lot of different purposes.
- The other species are especially used for firewood, but also charcoal, axe handles, mortars and pounders, catapults and ploughs, toothbrushes, etc.
- Furthermore, all informants use the plants for medicine and all the parts are used to treat diseases such as wounds, fever, malaria, meningitis, ulcer, diarrhoea, dysentery, haemorrhoids etc. A total of 40.
- 77% of informants use at least some of the plants for handicrafts/rituals and all parts, except flowers, are used.
- Some ethnic groups, villages etc. never burn a particular species as firewood in the house because of religious importance and custom.
- Leaves or fruits used for fodder were mentioned by 5, 38% of the informants. All species were used except *Tamarindus indica*.
- Fruits were mentioned by different ethnic groups as eaten by animals in the bush and as fodder for pigs. Leaves were only used by Fulanies as fodder for their cattle.

A thorough investigation of the highly important species Parkia Biglobosa has drawn the conclusions below:

- Indications observed during fieldwork and preliminary results point towards the fact that *Parkia biglobosa* does, indeed, have a potential of empowering women through improved sale of the specific natural resource.
- The occupation of selling products of *Parkia biglobosa* seems to be mainly occupied by women, and the women who sell *Parkia biglobosa* appear to have a higher yearly income than those who do not sell products from *Parkia biglobosa* or those selling nothing at all.
- Furthermore, it has been possible to make a characterization of the *Parkia biglobosa*-selling women. This has enabled us to propose solutions for how to optimize these specific factors correlating to sales, which hopefully will create opportunities for more women to exploit the resource sustainably and thereby improve their own wealth.
- Additionally, results show that the current management practiced is sustainable, although not necessarily the practice bringing the greatest profit to the harvesters.
- Finally, we intend to propound what we believe is the most correct, sustainable and economically productive management initiatives for the natural resource *Parkia biglobosa*.
- As a result of fieldwork and subsequent analyses and discussion of the data collected, a scientific article is currently under preparation for the journal Ecological Economics, with the running title: *"The potential of Parkia biglobosa as a natural resource to improve the*

economic situation of rural women in Southwest Burkina Faso – A field study from the Province of Comoé, Burkina Faso".

The results on *Parkia biglobosa* proved to be highly interesting, and funding for a PhD was received from Danida in order to continue investigations of this species by Mette Kronborg under supervision of Anne Mette Lykke.

University of Bobo-Dioulasso (P7) conducted a study with a sample of 583 households from 14 villages around the Boulon-Koflande forest. The study describes the socioeconomic characteristics of the households, identifies the main vegetal species used by households, assesses the household income by sources and the importance of forest income in the households and identifies the factors affecting the NTFP income and economic dependence on NTFP.

- ***Socioeconomic characteristics of households of the study sample***

- Main results showed that most households are lead by men, six major ethnic groups and the main activity is agriculture.

- ***Household income***

- Data analysis showed that the households around the Boulon-Koflande forest draw income from many sources which we classified into four categories as follows: (i) crop income, (ii) livestock income, (iii) no-timber forest product income (NTFP) and (iv) the income from other sources such as commerce, rent of field, rent of animal labour, rent of agricultural machineries, fishing and hunting, gift from another person, etc.

- ***Importance of NTPF income***

- The households living near of the forest of Boulon-Koflande used many NTFP (fruits, nuts, seeds, leaves and flowers) from about twenty species of natural plants. The common used species were: *Vitellaria paradoxa, Parkia biglobosa, Tamarindus indica, Saba senegalensis, Adansonia digitata, Detarium microcarpum, Bombax costatum, Diospyros mespiliformis, Vitex doniana, Pilostigma thonningi, Gardenia erubessens, Pterocarpus sp., Nauclea latifolia, Manilkara multinervis, Ficus gnaphalocarpa, Daniellia oliveri,* etc. The three species used most were *Vitellaria paradoxa, Parkia biglobosa,* and *Tamarindus indica,* which were been used by 92.8%, 70.15% and 20.58% of the households, respectively. The species that provided income trough non timber products were *Vitellaria paradoxa, Parkia biglobosa, Tamarindus indica, Bombax costatum, Saba senegalensis and Adansonia digitata*. *Vitellaria paradoxa* provided 64 625 F CFA per year to 87.5% of the survey sample of households. *Parkia biglobosa* generated 21 095 F CFA per year to 65.9% of the survey sample. *Tamarindus indica* provided 8 699 F CFA to 17.2% of the sample of households during the year 2008.

- ***Determinants of NTFP income***

- Determinants of NTFP income were analysed by using a linear model of the logarithm of the total income with the OLS method. The dependence value was the NTFP income per capita. The results show that *having* a *male head of household, marital status (married), household size, the number of month of food insecurity, the distance to forest, and the number of cattle,* have negative effect on NTFP income per capita. The *origin of the head household, the total income, the cropped area, the distance from the market, the forest area of district, and the density of the population of district* affect the NTFP per capita positively.

- ***Determinants of household dependence on forest incomes***

- Determinants of household dependence on forest income were analysed by using a linear model with the OLS method. The dependence value was the share of the NTFP income on total income. Three models have been conducted for (i) all the households, (ii) poor households and (iii) non-poor households, respectively.

A paper on: ***«*Assessing the economic dependence on non-timber forest products: case of households living near the forests of Boulon and Koflandé, in the south-western of Burkina Faso *»*** is in preparation. This paper is submitted to *BASE* for publication.

D3.2 Analysis of economic instruments

There are different types of instruments to achieve the objectives of management and environmental policy. Ideally, these instruments include regulatory instruments, economic instruments and financial incentive instruments.

- The regulatory instruments are means of ensuring respect for the environment by setting standards that apply to all citizens under the jurisdiction of a State. These rules usually take the form of standards.
- The economic and financial instruments are mainly royalties and taxes. In general, there are three kinds of tax policies for the environment (emission taxes are established by the government based on the quality and / or quantity of pollutants discharged or emitted, taxes on products that add to the price of goods or inputs that are polluting the stage of manufacture or consumption or which require special equipment evacuation, administrative charges are those paid to such authorities that the registration of chemicals or the preparation and implementation of regulations concerning the environment).
- The incentive instruments may be creating a market in pollution rights, where the State gives or offers for sale pollution permits for an amount corresponding to the maximum level of acceptable pollution. It differs in the market (nowadays called carbon market) with two types of instruments (tradable permits where each license or permit issued shall specify the amount of pollutants that the holder is authorized to discharge or emit and liability insurance that allows a private company or a public body to transfer to an insurance company risk penalty for damage). Financial incentives in the environment may also be consequences of an economic choice between two options (compliance rewarded with subsidies and non-compliance punishable by positive tax differential).
- In this case, it is on the one hand an environment, where industrial activity is almost nonexistent, and on the other of a particular type of natural resource (woody species). Therefore, all economic instruments cited above should not be applied systematically in environmental policies.
- The regulatory tool best suited in this context, is the distribution of property rights through the erection of village areas in hunting concession or agri-business. This option is a reality in Burkina Faso since 1996, and the policy management of natural resources could be applied in this case, but its acceptability by the population may be problematic.
- The tax on the use of woody species could help reduce human pressure on woody species. However, the contexts of poverty in the midst render ineffective such an instrument.
- The best environmental policy instrument in this case remains the carbon market, given the vastness of the park, and especially its floristic diversity. However, awareness among people to better conserve woody species outside the park to prevent intrusions inside would make for a more efficient instrument.

D3.3 Analysis of socio-economic impediments to sustainable use.

The main impediments to sustainable use are listed below:

- **Patako Core Area:**
  - A deforestation rate of 14% over a five-year period was estimated.
  - The main reason for felling trees was found to be the need for firewood by 72% of informants.
  - The main reason for not planting more trees was lack of fencing materials and money.
  - Surveys related to the identification of socio-economic problems were done, and the results showed that poverty and decrease of livelihood conditions due to land degradation were the most important factors that worsen the sustainable use of forest resources. Poor gathering practices, low commodity price and low organisational dynamics and public health issues were the main limitation for best natural resources management.

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- **W Park Core Area:**
  - The abundance and species structure, forms of levy and other threats have been the criteria used to assess the sustainability of exploitation.
  - The 4 species (*Adansonia digitata. Vitellaria paradoxa , Tamarindus indica. Parkia biglobosa*) showed very low density and all lacked possibility of regeneration. The organs most used were seeds, fruits, almonds, bark and roots for multiple uses. The seeds and / or fruits were generally harvested before maturity, while systematically collecting the bark was often done on older subjects by pulling on one side or on small surface areas of the trunk. The removal of the root was done by uprooting the tree. These results indicate high pressure, with predatory practices resulting in the elimination of individuals, and long-term depletion of the resource.

- **Boulon-Koflandé Core Area:**
  - This research activity assessed the degree of deforestation and identifid the socioeconomic factors of deforestation. It modeled the choice of household to clear new agricultural land with socioeconomic characteristics of household, institutional and physical environment characteristics of the study villages, by using the probit model.
  - The area cleared per year by farmers to grow new crop was used as the deforestation index proxy.
  - The study showed that 27.10% of the households had cleared forest to grow crops during the year 2008. The average area cleared by household during this year was 1.52 ha and varied from 0.25 to 9 hectares. The total area cleared through the sample from 2002 to 2008 was 992 hectares. The deforestation rate was about 13.67% per year within the sample of households.
  - The main crops grown by farmers were maize (93%), groundnut (57%), cotton (42%), cowpea (40%), cashew tree (39%), sorghum (35%), sesame (23), vouandzou (17%), millet (16%), rice (15), sweet potato (10%), yam (7%), mango (3) and cassava (1%).
  - *Socioeconomic factors of deforestation:* The practise of cotton, the practise of sorghum, the decrease of crop net revenue per hectare and the household bursting,

affected the deforestation positively. They can be considered as the main socioeconomic factors of deforestation in the Boulon-Koflande zone.

D3.4 Regional scale analysis of relations between vegetation degradation and socio-economic factors.

Constraints

The major constraint in WP3 during the 3rd year of implementation of the project was that the PhD students Issa ZONGO (Partner 6) and Alice BONOU (Partner 8) stopped their participation due to illness.

Milestones

Initial data on local preferences and needs (WP1, WP7 and WP8) (month 6).
Achieved

Initial data on traditional practices (WP1, WP7 and WP8) (month 6).
Achieved

Initial data on social, cultural and political impediments to sustainable use (WP1, WP7 and WP8) (month 6).
Achieved

Completion of gathering of regional scale data from international databases (WP2) (month 12).
MIPRO FILL OUT - EXPLAIN

WP4 Vegetation database

Prof. Dr. Georg Zizka, Partner 5

Participants: partners P1 Aarhus, P2 Dias, P3 Dakar (44), P4 Frankfurt (58), P5 Senckenberg (5), P6 Ouagadougou (44), P8 Cotonou (44), P9 JRC (20), P10 Niamey (48), P7 Bobo (44)

WP objectives:

The overall objective is to build a functional vegetation database for arid and semi-arid West Africa and to ensure the accessibility of the data. The major expected result is an improved access to vegetation data for West Africa for all users within the SUN project and for third parties.

The specific objectives are:

To run the vegetation database, enter data and ensure its functionality. This includes the conception of the structure of an offline database and capacity building activities to promote use of this database. Furthermore, conversion and entry of data existing prior to the start of the project as well as standardisation and continuous entry of new data are integral to this objective.
To ensure data exchange among participants and online accessibility of public data. This includes an adaptation of the offline database structure for the implementation of a web-based solution with an automated link of data to GBIF.
To take care of property rights issues in relation to data owners. This includes development of an IPR strategy including incentives for data contribution and collaboration among contributors. The IPR strategy and a data use agreement shall be published.

Deliverables

D4.1 A functional vegetation database

Work performed:

A **first capacity building workshop,** held in Frankfurt in November 2007, raised awareness of the concept and advantages of a common vegetation database with the project partners and facilitated subsequent data mobilisation (entry or transformation and importation, respectively). The workshop was followed by the signature of a **first memorandum of understanding**, which led the way to the conception of an online solution for a common vegetation database during reporting period 2. An initial version of the **offline** MS Access vegetation database (VegDa, Schmidt 2006) was further developed to **VegDa 2.7**, which has been distributed together with user documentation in May 2008 and is being used for entry of newly acquired data and import of existing data in all partner institutions since that date. Partner 5 continuously provided user assistance to all other partners.
An **online** data platform and data management tool, "**West African Vegetation**", has been established during the second reporting period. A **second capacity building workshop** on biodiversity databases was organized and held in Ouagadougou (Burkina Faso) in November 2008 and followed by the signature of a **second memorandum of understanding** dealing with IPR issues and the commitment of all partners to make use of the online data platform once it is fully functional.
During the third reporting period, the online database "West African Vegetation" has been fully implemented, including powerful data management functions enabling users to search for metadata across all platform users and selectively share their own data. An important aspect worked on during the third reporting period was the interoperability of the offline databases with the online data platform. This task necessitated important changes in the internal structure of VegDa and led to the development of **VegDa 3.0**. Despite major changes to the internal structure and improved efficiency for some calculation routines, VegDa 3.0 allows for bidirectional synchronisation of data

holdings in a user's offline database and in the user account on the online data portal. VegDa 3.0 is currently in the beta testing phase and has not yet been distributed to other partners. All data of partner 5 have been transferred from VegDa 2.7 to VegDa 3.0.
All partners have worked intensively on **data entry and import** to their local VegDa databases, increasing the total number of phytosociological and dendrometric relevés available in a digital format from 6592 at the end of the second reporting period via 10743 at the end of the third period to 17313 at the end of the fourth period (table 4.1), an increase of 162%. Taking into account the African partners only, the number of digitized relevés increased by **381 %** during the last 18 months (from 1479 to 7119), which confirms the efficiency of the capacity building activities carried out by WP 4.
The photo database and determination tool **West African Plants Database** (www.westafricanplants.senckenberg.de) has been developed during the second reporting period as an additional project complementing the functions of the vegetation database by providing vegetation scientists with a determination aid facilitating their work. Thanks to efficient dissemination actions, the data content of this image database could be extended to currently over 7000 pictures with verified determinations representing 1159 species of West African plants.

Work to perform:

The West African Vegetation Database will become fully functional, including interoperability with GBIF, and fully documented. The URL http://www.westafricanvegetation.org has been reserved for the final database, the current version is only accessible from the intranet for test purposes. It will become publicly available before the end of 2010. All currently existing offline databases VegDa2.3 in the partner institutions will be transformed to VegDa3.0 (after resolving remaining IT problems outlined below) and these will all be synchronized with the online database which will make a huge amount of vegetation data for West Africa available online (table 4.1).
A workshop for representatives from all partner institutions took place during the final workshop of the SUN project in Benin in June 2010. This workshop built on the results of the second capacity building workshop held in Ouagadougou (2008) and focused on the functions of the online and offline vegetation data management tools developed in WP4 to the relevant local multiplicators, hence ensuring sustainability of the developments. In addition to introducing the participants to the newly developed tools, it has also been a first field test to African internet realities (at the time, connections in Benin were extremely slow) and revealed the need for further adjustments to online database and synchronization.

Constraints:

Although the online data portal is working, problems with the synchronisation are still not fully resolved. The necessary time budget on the side of Partner 5, as well as on the side of the IT company charged with programming, has been underestimated by far.
Synchronisation of VegDa 3.0 with the online data portal is a feature that will greatly enhance user friendliness and act in favour of a rapid availability of data online. Due to software version conflicts and the complexity of the data structure, this feature was more difficult to implement than expected and caused a delay in the public availability of the online database. Yet, completion of the final product is not endangered, as Partner 5 will continue finishing it beyond the end of the SUN project and expects it to be ready by November 2010.
Although not explicitly included in the initial work package description, capacity building proved to be an essential element necessary to accomplish the goals of WP4, and thus adds to the deliverables of WP4. WP4 also provided continued support to the database contact persons at the African partner institutions, mainly through email communication, which necessitated a significant time budget not accounted for in the project proposal. The impact of these activities is proven by the strong increase in digitized vegetation data at the African partner institutions during the third reporting period.

D4.2 Publication of vegetation data via GBIF.

Work performed:

Technical issues of the mapping of fields of the West African Vegetation Database have been discussed with IT staff. All partners involved with WP4 worked on data digitization in the locally implemented offline vegetation databases (VegDa 2.7).

Work to perform:

As soon as the synchronization problems outlined above have been resolved and no changes to the data field structure are to be expected, data fields will be mapped according to the BioCASE protocol. With the existing GBIF wrapper installation at the IT department of partner 5, all public data transferred to the online data portal will be immediately available to GBIF. The process of linking the data can be quickly completed in a few days.

Constraints:

Delays in the implementation of the synchronisation feature (see above) led to a delay in the availability of the online database on which the implementation of an interaction with GBIF depends.

D4.3 Data sharing protocol dealing with property right issues and sensitive data.

Work performed:

Concerns by data owners (individual researchers and institutions) have been identified and discussed during the workshops in Toubacouta and Frankfurt. A three-step model for the implementation of a common web database providing secure individual accounts has been discussed during the Frankfurt workshop (2007). A strategy to address data property rights concerns and to provide incentives to data contribution to the online database both by researchers from within and outside the SUN project, has been designed during the second reporting period. All project partners endorsed this strategy in a **second memorandum of understanding** (November 2008). The approach is based on individual or institutional user accounts, different data access levels and a distinction between metadata and sensitive data for private data sets. It has been presented and discussed at national and international meetings during the second and third reporting periods.

Work to perform:

A detailed elaboration on IPR management in the online database has been submitted to Applied Vegetation Science in June 2010 and is expected to be published in the first issue of AVS in 2011. The paper is co-authored by all SUN partners. The IPR management in the vegetation database is discussed in the light of a review of the approaches used by other data repositories.

Constraints:

The **second memorandum of understanding** can be considered equivalent to **deliverable D4.3**. However, as dealing with data property rights is an important issue and a frequent cause of non-acceptance of database projects by their potential user community, is has been decided that a better dissemination of the new IPR approach adopted by the West African Vegetation database should be published in a scientific journal rather than in a document with limited readership. In order to substantiate the article, it was necessary to reach a near final database product and conduct first analyses of regional vegetation diversity with the help of data extracted from that database.

Milestones

Initial database structure (month 3).

This milestone has been reached.

Internet portal functioning (month 24).

This milestone has not yet been reached. The structure of the internet portal had been completely conceived at the end of the second reporting period and the offline database (VegDa 2.7) was being used for data entry in all partner institutions. The online portal itself is fully functional, however, the problems with synchronisation outlined above (D4.1) are still an obstacle to its final release and to the upload of the local datasets. However, partner 5 will ensure that this problem will be solved in order to make the database fully functional.

Initial plan for property right issues (month 3).

This milestone has been reached with preliminary principles discussed during the Toubacouta kick-off workshop and consolidated during the second reporting period. All partners agreed on the strategy to be adopted by signing the second memorandum of understanding including the relevant passages (Appendix 1, §4 and Fig. 1).

Database established (month 36).

This milestone has been reached. The structure of the online and offline database is completely established and a significant amount of data is waiting to be transferred to the online data platform. As soon as the remaining problems with synchronisation are resolved (expected by November 2010), the database will become available online.

Expected results

The expected result is an improved access to vegetation data for end-users.
The expected result of WP4 has currently been achieved at the local level and will be achieved at all levels as soon as the Internet data platform will become available online (see above).
Digitization of old and new vegetation data has reached a satisfactory level in all partner institutions making vegetation data in a standardized format and based on a standard list of species names available to all researchers in the partner institutions with the help of the local implementations of the VegDa 2.7 database.
As soon as these locally available data have been transferred to VegDa 3.0 and synchronized with the online data platform, vegetation data for West Africa will be exposed to researchers and all relevant stakeholders (policy makers, conservation planners, interested public etc.) at a global scale. Datasets tagged as public will be viewable and downloadable for all visitors of the website www.westafricanvegetation.org. Datasets tagged as private can be accessed by their respective owners, but the metadata (location and kind of the dataset) can be accessed by all visitors of the website, which can then subsequently contact the data owners to negotiate sharing of potentially interesting datasets. The data owners can then easily activate sharing on the data platform.

First regional analyses based on large datasets gathered with the help of these mechanisms have already been conducted and presented at international meetings: We used grasses (Poaceae) as a dominant component of sub-Saharan savanna ecosystems to show that the predictive power of modeling approaches improves with the geographical coverage and density of the dataset available. The online vegetation database (“West African Vegetation”) will become a valuable tool for research on and conservation of West African vegetation. Being conceived as a data management tool not only protecting IPR, but also integrating with the scientific workflow, it provides incentives to an early contribution of data directly after acquisition and its data holdings should rapidly grow beyond the duration of the SUN project. Partner 5 is committed to ascertain data curation and hosting of the database.

Table 4.1

Partner	**Relevés Phyto**	**Records Phyto**	**Relevés Dendro**	**Records Dendro**	**Relevés Total**	**Records Total**
P1 (Aarhus)	1131	3079	4649	12117	**4210**	15196
P3 (Dakar)	0	0	1231	17951	**1231**	17951
P4 (Frankfurt, University)	817	18711	154	1537	**909**	20248
P5 (Frankfurt, SGN)	5075	121110	0	0	**5075**	121110
P6 (Ouagadougou)	2293	38922	800	40029	**3093**	78951
P7 (Bobo-Dioulasso)	89	692	0	0	**89**	692
P8 (Cotonou)	996	42167	482	17968	**1478**	60135
P10 (Niamey)	1097	21351	131	36740	**1228**	58091
Totals	**11498**	**246032**	**7447**	**126342**	**17313**	**372374**

This table shows the data holdings in the local VegDa 2.7 databases with each partner institution as of June 2010. Total numbers are given including dendrometric and phytosociological relevés. All local VegDa 2.7 holdings will be transferred to the online data platform upon completion of the online database. Each relevé includes several records of species occurrences.

The Data can be used in studies on biogeography, macroecology, phytosociology, analyses of carbon stocks and many others as, e.g., in the FP7 project UNDESERT, or the studies on land cover changes, socioeconomically important species and grasses within the newly established Biodiversity and Climate Center (BiK-F) Frankfurt. The regional extent makes it an important data base for regional and cross-border studies in West Africa. In the long term, we aim at closing gaps in spatial and temporal coverage.

WP5 Indicators of sustainability

Participants: Partner 8 (Cotonou-Benin) (34)**,** Partner 3 (Dakar-Senegal) (5), Partner 4 (Franckfurt-Germany) (11), Partner 5 (Senchenberg-Germany) (2), Partner 6 (Ouagadougou-Burkina Faso) (39), Partner 7 (Bobo Dioulasso-Burkina Faso) (8), P9 JRC (4) and Partner 10 (Niamey-Niger) (48).

WP objectives
The overall objective of this workpackage is to identify indicators of sustainability at landscape, habitats and species scale for providing a decision support tool for politicians and management workers.

The specific objectives are:
1. Identify locally adapted landscape indicators of sustainable use.
2. Identify key habitats in need of attention and protection.
3. Identify key species for conservation, management and restoration.

TASKS AND ACHIEVEMENTS

The selected core areas were: The Tamou Reserve in Niger, the Transboundary Park W (East-Burkina Faso, Benin, and Niger), Boulon & Koflandé forest in West-Burkina Faso and Patako forest in Senegal. Protected areas/nature reserves and their peripheral zones under human impact were considered in order to compare findings about indicators of sustainability at landscape, habitats and species scale related to human impact as well as to environmental gradient.

D5.1. Identifying locally adapted landscape indicators of sustainable use

Vegetation inventories were performed as well as extensive field data collection for the list of indicators. Benin, Niger, Senegal and partially Burkina Faso delivered detailed data to the WP.

*D5.1.1. Trend in forest vegetation areas, trends in cropping areas, degree of artificialization***:** Analyses of the landuse dynamic were performed. In the buffer zone of the National W Park of Niger, the case of the Fauna total Reserve of Tamou was performed between years 1984 and 2006. In total, the map analysis using 9 descriptors (from analyses of Landsat ETM satellite images of 1984 and 2002 and Landuse Monitoring and Analysis) lead to 3 main indicators of sustainability of landuse in the case of Tamou reserve (Niger): trend in forest vegetation areas, trends in cropping areas, degree of artificialization.

D5.1.2. Required data for calculating landscape indicators in WP1 (local scale vegetation dynamics).
These data were completed and compiled in databases (see WP1, WP2, WP4) for the modelling approaches and analysis of vegetation types in relation to ecological conditions and human impact. Moreover, species richness, biomass, were slightly explored.

D5.1.3. Trend in grassland vegetation areas - Quantification of biomass and grass tussock patterns: Results highlighted 5 quantitative indicators, such as fresh and dry biomass, carrying capacity, productivity and hemicryptophytes index. Grass biomass was lower in the landuse area than in the protected area, i.e. 0.45 tDM/ha vs. 1.11 tDM/ha; consequently, the landuse demand was higher in the villages than in the protected area (7.41 ha/TLU vs. 3.03 ha/TLU).

*D5.1.4. Trend in grassland vegetation areas - Quantification of the landuse impact on species structure and spatial distribution***:** The effect of pruning on density, structure and viability of fodder trees as well as the landuse by agriculture impact in the spatial fodders tress distribution were searched. Results showed among the 14 species selected for this purpose, three groups of fodder trees species in the peripheral W National Park different by density, structure and the viability: 5 main species with high mean rank (*Afzelia africana, Pterocarpus erinaceus, Khaya senegalensis, Stereospermum kunthianum, Lonchocarpus laxiflorus*); 3 species with relative average mean rank (*Acacia senegal, Prosopis africana, Sterculia setigera*) and 6 species with low mean rank (*Ficus sp., Bombax costatum, Dichostachys cinerea, Flueggea virosa, Feretia apodanthera*).

D5.2. Identifying key habitats in need of attention and protection

For some habitats (e.g. donga and planes) structures, and gap analysis of each habitat was investigated. A clear difference in the habitat values in terms of species richness, endangered species and use values for local communities was found between the protected sites and agroforestry parks in the core areas in Benin and Niger. The dongas are a clear indication of degradation.

D5.2.1. Local perceptions of soil degradation driving factors (causes and factors): About 136 farmers sampled among 14 villages were interviewed. The driving causes of the erosion and dongas in the core area are the anarchistic establishment of crop fields and the deforestation. Farming techniques are also marked, such as ploughing orthogonally to the slope, the crop rotation and the slope bottom cropping. Poverty acuity and the soil permeability degree, the dry seasonal trees pruning and overgrazing were highly accused by most of farmers.

*D5.2.2. Trends and mapping the spatial distribution pattern of Dongas***:** 8 dongas were sampled for vegetation and soil data. Data treatment is ongoing as part of a PhD project to be finalised very soon.

D5.3. Identifying key species for conservation, management and restoration

A list of key species for conservation, management and restoration is compiled for all core areas. Some examples are given below.

D5.3.1. Frequency of use of plant organs: About 124 plant species distributed in 39 families were listed and mainly used in human consumption, energy production, building, craft industry, pharmacopoeia, animal feeds, cosmetic, the bee-keeping and fishing. Only 49 species in 27 families are used in human consumption, including 13 herbaceous and 36 woody species. Generally, sheets, flowers, roots and tubers are used in a fresh, dry or transformed state. As for the fruits, they are often consumed fresh. About 50 fodder species (24 herbaceous & 26 woody) were listed.

D5.3.2. Preference for species used in industry of fishing machines and dugouts monoxyles is another indicator from fishers in Goroubi, Diamangou and ponds borders by the treatment and the conservation of fish. Five preferential species are used in dugouts (piroque) industry and the machines of fishing: *Khaya senegalensis* and *Lannea microcarpa* for dugouts; *Combretum micranthum* for the bow nets manufacture; *Balanites aegyptiaca* and *Sclerocarya birrea* for the paddles, handles of harpoons.

WP6 GIS

Yvonne Bachmann, Partner 4

Participants: P2 DIAS (2), P3 Dakar (6), P5 Senckenberg (1), P4 Frankfurt and P9 JRC (16)

WP objectives:
To improve and increase effectiveness of ecosystem management by use of a GIS based decision support tool adapted to the needs of different user groups (politicians, environmental managers and scientists).

The specific objectives are:
Integration of georeferenced project data and vegetation maps (W1-5) in a GIS.
Building of a public GIS decision support tool for decision makers.

Deliverables

D6.1 Integration and harmonization of spatial datasets produced by the project.

Work performed:
Nine File Geodatabases were established in the SUN GIS under ESRI®ArcGIS™ 9.3 to organize all of the digital data of the SUN core zones, the participating countries and of West Africa (Deliverable 1: Integration and harmonization of spatial datasets produced by the project). The File Geodatabases exists for: West-Africa, Senegal, Benin, Burkina Faso, Niger, W-National Park, Tamou Reserve, Boulon-Koflandé Forest and Patako Forest. Each File Geodatabase is organized in different Feature Datasets such as Climate, Infrastructure, Hydrology, Soils, Political Administration, Population, Soils, and Vegetation according to the data available for the region, country or core area.
Internationally available data was downloaded, clipped to the regional extent and processed. SUN core area data was gathered from different sources (see data section). For determination of the main vegetation types of two national parks in Benin and Burkina Faso, the spectral information of Landsat images was analyzed and interpreted. As a coordinate system, the geographic coordinate system with WGS84 datum was set for all data. The feature datasets and feature classes were given significant names. Metadata files were generated referring to the Websites of the data origin.
Up till now, very little information has been stored directly produced during the three years of the SUN project, as PhD students are still in the middle of processing their data and preparing their publications. If SUN Ph.D. students want to integrate their data in the existent Geodatabases and/or publish them on the SUN Map Server (see Deliverable 6.2) during the next months and years, they can get in contact with the administration staff of the Geodatabases and the SUN Map Server at the Institute of Ecology, Evolution and Diversity at the University of Frankfurt under the address: sunmapserver@bio.uni-frankfurt.de, explain their matter of concern and send the data.
Integration of data produced during the EU financed UNDESERT project that is executed in the same four core countries as SUN and started in June of 2010 with a project time of five years is also possible. Throughout the entire project time, participants of UNDESERT can contact the above mentioned e-mail address, formulate their requests and send the data they want to include in the Geodatabases and/or publish on the Map Server.

Up till now, the SUN GIS contains the following data:

Datasets for West-Africa in the SUN DATA GIS:

Infrastructure: **Roadnet** (ESRI)

Climate:	**Temperature Change Index** (CCSIt), **Precipitation Change Index** (CCSIp) and **Climate Change Severity Index** (CCSI) (calculated according to ANDERSON 2008 with HADCM3 data for 2000/2050, Scenario a2a), **Mean Temperature** and **Annual Precipitation** (HADCM3 data for 2000)
Political Administration:	**Region** (ESRI), **Countries** (ESRI), **Second Administrative Level** (USAID FEWS NET)
Elevation:	**Elevation model 90 m** (SRTM), **Hillshade** (derived from SRTM), **ASPECT** (derived from SRTM), **SLOPE** (derived from SRTM)
Vegetation:	**Global Land Cover** (EC/GLC 2000), **GLOBCOVER** (ESA 2005/2006), **Biomes** (White 1983), **Vegetation** (White 1983), **Major Vegetation Types** (White 1983), **Ecoregions G200** (WWF), **Terrestrial Ecosystems** (WWF)
Conservation:	**Protected Areas** 2010 (WDPA)
Population:	**Capitals**, **Cities/Villages** (all ESRI), **POPULATION DENSITY** 2008 (Landscan/Oak Ridge Laboratory), **Population Numbers 1960-2000** (UNEP/CIESIN)
Hydrology:	**Rivers** (ESRI), **Drainage** (ESRI), **Big Lakes** (GLWD), **Permanent Waterbodies** (GLWD) and **Hydrological System** (GLWD)
Soils:	**World Soil Resources** (FAO, HWSD)

Datasets for Benin in the SUN DATA GIS:

Infrastructure:	**Roadnet** (ESRI)
Political Administration:	**Second administrative Level** (USAID FEWS NET)
Population:	**Main cities and Villages** (ESRI)
Hydrology:	**Rivers** (ESRI)
Protected Areas:	**Land cover maps from Pendjari National Park** (supervised classification of Landsat images, Goethe University of Frankfurt)

Datasets for Burkina Faso in the SUN DATA GIS:

Infrastructure:	**Roadnet** (Institut Gèographique du Burkina IGB, 1992)
Political Administration:	**Second administrative Level** (USAID FEWS NET)
Population:	**Main cities and Villages** (ESRI)
Hydrology:	**Rivers** (ESRI)
Vegetation:	**Natural Vegetation**, **Landuse** and **Fraction of Wood** (all: Fontès, J. & Diallo, A. & Compaoré, J.A. (1994): Carte de la Végétation Naturelle et de l'Occupation du Sol - Burkina Faso)
Elevation:	**Topography** (Laclavère, G. (1993): Les Atlas Jeune Afrique. Atlas du Burkina Faso. 2nd edition: Paris/France)
Soils:	**Soils** (Carte Pédologique de Reconnaissance de la République de Haute-Volta, 1973)
Protected Areas:	**Land cover maps from Arli National Park** (supervised classification of Landsat images, Goethe University of Frankfurt)

Datasets for Niger in the SUN DATA GIS:

Infrastructure:	**Roadnet** (ESRI)
Political Administration:	**Second administrative Level** (USAID FEWS NET)
Population:	**Main cities and Villages** (ESRI)

Hydrology: **Rivers** (ESRI)

Datasets for Senegal in the SUN DATA GIS:

Infrastructure: **Roadnet** (ISE, 2004, National)
Political Administration: **Second administrative Level** (USAID FEWS NET)
Population: **Main cities and Villages** (Direction des Travaux Géographiques et Cartographiques and Direction de l'Aménagement du Territoire)
Hydrology: **Rivers** (Direction des Travaux Géographiques et Cartographiques and Direction de la Gestion et de la Planification des Ressources en Eau)
Protected Areas: **Protected Forests** (Centre de Suivi Ecologique)
Soils: **Soils** (CILSS, AGHYMET, FAO)
Climate. **Ecogeography** (Forest Commission, Centre de Suivi Ecologique, Agricultural Services)

Datasets for the three parts of W-National Park (Burkina Faso, Benin, Niger):

Population: **Main villages**
Boundaries: **Limits**
Infrastructure: **Main paths** inside and **main roads** outside
Satellite Images: **Landsat image from 2002**; **IRS image from 2008**
Fire: **Fire frequency** and **Fire Areas** for 2009 and 2010 (EC/JRC)
Soils: **Soil types** for W-Burkina Faso (Carte Pédologique de Reconnaissance de la République de Haute-Volta, 1973) and W-Benin (P. Faure & M. Viennot: Office de la Recherche Scientifique et Technique Outre Mer, France, Ed. 1972, Cartes de l'Institut Geographique National de l'Afrique de l'Ouest)
Vegetation: **BOTANICAL DATA**[1] from fieldwork collected during SUN project and potential distribution maps of 50 woody species, NDVI (calculated from Landsat images from 2002)

Datasets for Tamou Reserve

Boundaries: **Limits** (Digitized on Google Earth)
Fire: **Fire Frequency** and **Fire Areas** for 2009 and 2010 (EC/JRC)

Datasets for Boulon-Koflandé Forest

Boundaries: **Limits** (Digitized on Google Earth)
Infrastructure: **Main paths inside** (Digitized on Google Earth)
Fire: **Fire Frequency** and **Fire Areas** for 2009 and 2010 (EC/JRC)

Datasets for Patako Forest

Population: **Main villages outside** (Institut des Sciences de l'Environnement)
Boundaries: **Limits** (Institut des Sciences de l'Environnement)

[1] For the western communal area of W-Burkina Faso georeferenced botanical data is stored in the GIS. The data is composed of 277 botanical samples of different species and 837 samples of *Adansonia digitata*. For W-Benin 87 botanical samples of different species were integrated. For modeling of the potential distribution of 599 species in W-Burkina Faso and its adjacent communal area 20,059 vegetation samples were stored to the database (WP 1, Mapping of spatial vegetation patterns and modeling of phytodiversity in relation to human impact). As these data and the analysis results are part of ongoing doctoral thesis they are still not part of the SUN Map Server data collection (see also Deliverable 6.2).